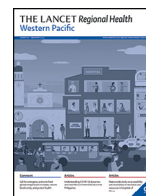




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Research paper

Assessing the Inequality of Early Child Development in China - A Population-Based Study

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ABSTRACT

Background: As a country with the second largest child population in the world, China has little population-level evidence on who has been left behind in early childhood development (ECD). Knowledge of inequalities in ECD will inform the Chinese government in policies on promoting ECD and guide global-level monitoring on ECD progress.

Methods: Using data from the first wave of ECD surveys conducted in China at the least-developed region, most-developed region, and a megacity (Shanghai) in 2017 and 2018, we measured population-level ECD with early Human Capability Index for a total of 63,559 children aged 36–59 months old. A child was classified as developmentally on track if his/her overall development score was above the 20th percentile of the pooled populations. We measured inequalities in ECD with the absolute inequality in five domains: gender/sex, family income, maternal schooling, residential Hukou, and migrant- or left-behind status. Besides observed inequalities, we used a multilevel logistic regression model to generate adjusted inequalities.

Findings: Children developmentally on track ranges from 71% (95% CI 70 to 72%) in the least-developed region, 82% (95% CI 81 to 83%) in the most-developed region, and 86% (95% CI 85 to 87%) in Shanghai. Significant unadjusted inequalities in ECD were observed in all five dimensions. After controlling for other socioeconomic factors, significant differences remained in three dimensions: those living in the poorest families, or with lower maternal schooling, or boys were less likely to be developmentally on track than their counterparts (lower by 10[95% CI 8 to 11]–15[95% CI 13 to 17], 7[95% CI 5 to 10]–10[95% CI 7 to 12], and 5[95% CI 4 to 6]–6[95% CI 5 to 8] percentage points respectively).

Interpretation: Efforts of reducing ECD inequalities in China shall focus primarily on reducing poverty and improving maternal education.

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Research in context

Evidence before this study

The latest global study on inequalities of early childhood development (ECD) in 60 low/middle-income countries (LMIC) estimated that about three-quarters of young children (aged 36-59 months) were developmentally on track, and most of the 60 LMIC had significant disparities in ECD by household wealth and residential area. China accounts for approximately one-eighth of the world's population of young children under age five; 20% (17.43 million) of them were estimated to be at risk of poor development due to living in extreme poverty or being stunted. Using the keywords of "early child development", "China", and "inequality", we searched PubMed (English) and China National Knowledge Infrastructure (Chinese) for studies on ECD inequalities in China from Jan 1, 2010 to date, and our search yielded no publications during the period.

Added value of this study

Using the first waves of China's ECD surveys conducted in three types of regions: the most-developed region, the least-developed region and a megacity (Shanghai) that represent different levels of economic development and geographic locations, our study adds to the body of knowledge by providing the most update evidence on the percentage of young children (aged 36-59 months) developmentally on track and its inequalities by five socioeconomic and demographic dimension (gender, family income, maternal schooling, residential Hukou, and migrant- or left-behind status). Compared to previous studies which usually used 10 survey questions to measure a child's development in four aspects, we adopted the early Human Capability Index (eHCI) in the surveys, which provides a more comprehensive assessment on ECD with 62 survey questions on nine aspects of a child's development. Furthermore, our study produced two groups of inequality estimates, with one on unadjusted inequalities, and the other on adjusted inequalities by controlling for other socioeconomic factors. Adjusted estimates allowed us better understanding the ECD inequalities in China. Sensitivity tests were conducted to check the robustness of findings using different thresholds of defining developmentally on track. We found that young boys, or young children living in the poorest families, or young children with lower maternal schooling were more likely to be developmentally off track compared to their counterparts. The findings not only provide important evidence for making national ECD policy in China, but also contribute to monitoring global progress of achieving Sustainable Development Goals 4.2 on ECD.

Implications of all the available evidence

Together with previous evidence on young children in China exposed to risks of poor development, findings in this study clearly indicate that more efforts are needed to reduce ECD inequalities for young children living in the poorest families with lower maternal schooling. To understand the impact of newly produced government policies on reducing ECD

inequalities, more investments should be made in establishing a national-level ECD monitoring system and conducting nationally-representative micro-level surveys on ECD in all provinces in China.

1. Introduction

Scientific evidence has revealed the importance of early childhood development in shaping an individual's lifetime health, education, social well-being, and labor market productivity.^{1, 2} Disparities of development in early years tend to persist across life course and even being carried into future generations.³⁻⁵ Reducing inequalities in ECD has been considered one of the most cost-effective methods for poverty reduction.⁶ Built upon scientific discoveries, ECD was included in the 2030 Sustainable Development Goals (SDGs): Target 4.2 states that all girls and boys have access to quality early childhood development, care and preprimary education so that they are ready for primary education.⁷ To monitor the progress on reaching the Target 4.2, one of the indicators proposed by the SDGs is the proportion of young children who are developmentally on track in health, learning and psychosocial well-being.⁸ Previous studies in low- and middle-income countries (LMICs) have shown significant inequalities in ECD by residential area, wealth status, and maternal education.⁹⁻¹¹ For most countries, inequalities of ECD by gender/sex, area and wealth not only existed but also persisted over time.⁹

China accounts for approximately one-eighth of the world's population of young children under age five. Since 2000, the country has made remarkable progress in reducing child mortality, child malnutrition, and child at risk of poor development (with the second largest declination rate among the 141 LMICs)¹²⁻¹⁴. However, the gaps of those health indicators between developed and underdeveloped areas in China did not narrow as fast as the reduction of their national prevalence.^{12, 13} To ensure no child left behind in ECD, the Chinese government has included achieving universal ECD in its Healthy China 2030 plan.¹⁵ To guide the government and other stakeholders in making informed and targeted ECD policy, it is necessary to assess ECD inequalities and identify those young children with delayed ECD. Unfortunately, due to data shortage, empirical evidence on ECD inequalities in China, derived from large scaled population surveys, is missing in the current literature.

Using the most recent survey data on ECD collected in China, we conducted the first comprehensive and most up-to-date assessment of the young children (aged 36-59 months) developmentally on track in three types of region that represent the variation in geographic locations and economic development in China. And the aim of this study is to estimate the level and inequalities of ECD by various socioeconomic domains.

2. Methods

2.1. Data collection and samples

To generate population-level measure of ECD in China, the first wave of individual-level surveys was designed and implemented in 2017 and 2018 in Shanghai, Gansu, Yunnan, and Zhejiang. In Shanghai, annual data on ECD has been collected since 2016. As Gansu, Yunnan, and Zhejiang had only one wave of the data available, we therefore used four cross-sectional datasets in the most recent years for the four provinces. Among the 31 provinces in mainland China, Shanghai represents the megacity (resident population over 10 million) in China and ranked the 2nd in GDP per capita. Zhejiang (located in the coastal area) ranked 5th in GDP per capita, representing the most-developed region in China. Yunnan (located in the Southwest and ranked 30th in GDP per capita) and Gansu (located in the Northwest, ranked 31th in GDP per capita) represented the least-developed region in China. By choosing the three different types of region, we aim to attain comprehensive evaluation of inequality of ECD in each region so as to better understand the ECD inequalities in regions with different level of economic development.

In each province/city, stratified randomized sampling strategy was adopted for data collection. In Shanghai, all its 16 districts were set as Primary Sampling Units (PSUs). Then, kindergartens' ownership (public vs. private) and their official rating on performance within each type of ownership were used as the Secondary Sampling Units (SSUs). 183 kindergartens were randomly drawn from each rating group by each ownership type. All parents/caregivers of the children in the selected kindergartens were invited to participate in this study. Multi-stage sampling strategy was also used in Gansu, Yunnan, and Zhejiang. The PSUs in each province were districts/counties that were categorized into three different income groups based on their annual GDP/revenue per capita. Counties/districts were randomly selected from each income group. In the second stage, in each selected county/district, kindergartens were randomly selected. All parents/caregivers of the children in the selected kindergartens were invited to participate in this study. More details on sampling process and data collection are presented in the appendix Chapter 1 (pages 1-10). In China, kindergarten program last for three years for 3-6 years old. Our study aims to measure the development of children at younger age (36-59 months), so the sample in this study only includes children in their first year of kindergarten with complete data. Altogether 63,559 children aged 36-59 months old from 1,201 kindergartens in 69 districts/counties were surveyed. Sample size ranges from 23,719 (least-developed region), 18,995 (most-developed region), to 20,845 (Shanghai) (Table 1).

The study was approved by the Institutional Review Board of the Shanghai Children Medical Center, Shanghai Jiao Tong University (SCMCIRB-K2016022-01) and the Institutional Review Board of Peking University (IRB00001052-19056). All parents of children who participated in the study completed informed consent at the beginning of the online survey.

2.2. Measurements

Measuring ECD with Early Human Capability Index (eHCI) score
There are few commonly used tools for measuring ECD at the population level that have done predictive validity. In this study, we adopted the Early Human Capability Index (eHCI), a population-level instrument which was designed to assess the development of children aged 36-59 months across diverse cultures. It is one of the existing measurements that evaluates the school readiness.^{6,16,17} There are total of 62 survey questions in eHCI, reported by parents or caregivers, which cover nine aspects of child develop-

ment (physical health, verbal communication, cultural knowledge, social and emotional skills, perseverance, approaches to learning, numeracy, reading, and writing).¹⁶⁻¹⁸ The design of eHCI allows for a holistic approach to measure child development. Psychometric properties of eHCI has been examined in seven LMICs, including China.¹⁸ The Chinese version of the eHCI has been locally adapted to capture the unique cultural aspects of China. Our previous study on the Chinese version of eHCI indicated that its internal consistency is 0.87, test-retest reliability is 0.63, inter-rater reliability between parents and teachers is 0.63, and criterion-related validity compared with Age and Stages Questionnaire is 0.53.¹⁸ Compared with the Early Child Development Index (ECDI), an instrument included in the Multiple Indicator Cluster Surveys (MICS) conducted in many LMIC, we decided to adopt eHCI data for this study because (1) the Chinese version of the eHCI has been locally adapted to capture the unique cultural aspects of China, and (2) the purpose of this study is not for international comparison, as with the ECDI. Details of eHCI and its comparison to ECDI is presented in the appendix Chapter 2 (pages 11-16).

Measuring a child developmentally on track
We constructed a dichotomous variable indicating a child developmentally on track based on her eHCI score. We first assessed eHCI score for each child, as described in the appendix (page 17). Following previous studies,¹⁹ we then pooled the data from the four provinces and ranked all children according to their eHCI scores. Lastly, previous regional studies in China have demonstrated that, rate of developmental delay was round 10% in urban areas²⁰ and ranged from 20%-50% in rural areas.^{21,22} We therefore defined a child developmentally on track if his or her eHCI score for overall development was equal to or above 20th percentile of the pooled data in a given age group (36-38 months, 39-41 months, 42-44 months, 45-47 months, 48-50 months, 51-53 months, 54-56 months, 57-59 months). We conducted sensitivity analysis by varying the threshold to the 10th or 30th percentile.

Measures of inequality in early childhood development
Inequality in this study was quantified as the absolute differences in percentage of children developmentally on track between the two sub-groups. Following previous work,^{9, 23} we assessed the inequalities in developmentally on track by family income (poorest quintile vs. richest quintile), maternal schooling (middle school or under vs. college or above), and Hukou status (rural vs. urban). Evidence has suggested that girls are likely to have more rapid development than boys in this age group.²⁴ However, in many countries, no significant difference in ECD was observed between boys and girls (36-59 months old),⁹ suggesting that social or cultural factors related to gender/sex may have also impacted the ECD. In China, son preference has been rooted in Chinese culture,²⁵ and parents were found to have lower expectation on girls in terms of their education.²⁶ We therefore investigated gender/sex difference in ECD, which refers to the difference in ECD between boys and girls due to biological, social, and cultural factors. In each region, we ranked income range reported by the parents/caregivers and assigned those in the bottom 20-30% as the poorest group, and those in the top 20% as the richest group. As for Hukou, the Chinese internal migration has always been controlled by the household registration system (known as Hukou). Each person in China is assigned with a Rural- or Urban-Hukou. Hukou is not necessarily relate to the current residential area of an individual. An individual is entitled to access to education and medical insurance in his/her Hukou area. In recent years, children of migrant workers have attracted wide attention for being physically and mentally vulnerable.²⁷ These children can be categorized into two groups: migrant children who leave their original residency but live in cities with their migrant parents (defined as migrant children in this study), and the children who remain in the rural areas and are separated from their parents who work in cities

Table 1

Economic development, population size, selected administrative divisions, selected kindergartens, and sample size in each region

Region ¹	Province	Survey time	Population (millions)	GDP per capita (USD) ²	GDP per capita rank ³	# of districts/ counties in total	# of kindergartens in total	Kindergarten enrollment rate ⁴	# of districts/ counties in analytical sample	# of kindergartens in analytical sample	# of participants in analytical sample
Megacity	Shanghai (Eastern China)	2017.11	24.18	19,199	2/31	16	1,473	97% ^a	16	183	20,845
MDR	Zhejiang (Eastern China)	2017.4	56.57	13,956	5/31	101	8,645	98% ^b	29	360	18,995
LDR	Gansu (Northwestern China)	2018.9	26.27	4,735	31/31	86	7,734	92% ^c	12	344	12,923
LDR	Yunnan (Southwestern China)	2018.11	48.30	5,612	30/31	140	10,156	80% ^d	12	314	10,796

Notes: 1.MDR: Most-developed region. LDR: Least-developed Region.

2. Chinese Statistical Yearbook 2019. GDP per capita was reported in 2018 USD.

3. Hong Kong, Macau and Taiwan are not included when ranking GDP per capita at the provincial level.

4a. Information office of Shanghai Municipality. Press Release for September 20, 2019 Media Briefing by the Shanghai Municipal People's Government. 2019; <http://en.shio.gov.cn/government-news/municipal/5154.shtml>. Accessed Apr 7th, 2021.4b. Zhejiang Bureau of Statistics. 2018 Zhejiang Child Development Planning Statistics Monitoring Report.2018; http://tj.zj.gov.cn/art/2019/10/11/art_1562012_38786871.html. Accessed Apr 7th, 20214c. Gansu Bureau of Statistics. Gansu Issues Guideline on the Implementation of Deepening Reform and Development of Preschool Education. 2019; <http://tj.gansu.gov.cn/HdApp/HdBas/HdClsContentDisp.asp?id=16799>. Accessed Apr 7th, 20214d.Yunnan Education Bureau. Yunnan Statistical bulletin on the development of education in 2018-2019. 2020; <http://www.dhyj.gov.cn/jyj/Attach/1907/311031110065568.pdf>. Accessed Apr 7th, 2021**Table 2**

Number and weighted percentage of young children in each subgroup by region

	Shanghai(N=20,845)	Most-developed region(N=18,995)	Least-developed region(N=23,719)
Gender/sex			
Boys	10,811(52.2%)	10,036(53.2%)	12,430(52.4%)
Girls	10,034(47.8%)	8,959(46.8%)	11,289(47.6%)
Income			
Poorest	3,860 (21.4%)	3,592(17.4%)	6,780(29.8%)
Poorer	3,077 (15.6%)	5,103(26.1%)	6,959(30.1%)
Richer	7,486 (36.4%)	6,026(32.0%)	4,651(19.2%)
Richest	6,422 (26.6%)	4,274(24.6%)	5,329(21.0%)
Maternal schooling			
Middle school or under	1,316(7.6%)	5,295(25.6%)	9,877(43.4%)
High school	2,295(13.1%)	4,750(25.0%)	4,792(20.7%)
Some college	4,769(24.7%)	4,114(22.4%)	3,544(14.4%)
College or above	12,465(54.7%)	4,836(27.1%)	5,506(21.6%)
Hukou			
Rural	Not applicable	12,364(61.7%)	14,510(63.3%)
Urban	Not applicable	6,631(38.3%)	9,209(36.7%)
Migrant(Shanghai)			
Migrant	798(7.1%)	Not applicable	Not applicable
Non-migrant	20,047(92.9%)	Not applicable	Not applicable
Left-behind (for rural Hukou)			
Left-behind	Not applicable	361(1.1%)	1,399(6.8%)
Non-left-behind	Not applicable	12,003(60.7%)	13,111(56.5%)

Notes: Family income categories are region specific and represent relative socioeconomic position in each region

(defined as left-behind children in this study). We compared percentage of children developmentally on track between the migrant children and their urban counterpart in Shanghai, and between the left-behind children and their rural counterpart in the other two types of region. As family income and maternal education are categorical variables, inequality was also measured with the slope index of inequality (SII). The SII represents the difference, in percentage points, between the estimated percentage of children developmentally on track for the top and bottom of the family income or maternal schooling distribution. The SII was estimated through logistic regression.²⁸ Survey questions on these sociodemographic and economic variables, their summary statistics, and our coding system are presented in the appendix (p 18-22). As shown in Table 2, higher proportion of children lived in family with higher maternal schooling in Shanghai and most-developed region than in least-developed region. In Shanghai, migrant chil-

dren accounted for 7.1% of the child population. The left-behind children accounted for 1% in the most developed region and 6.8% in the least developed region.

A large volume of publications quantified the inequality between the two population groups as the unadjusted absolute difference between them.^{9,29} Some other studies, though, defined the inequality as the difference between the two groups after adjusting for other socioeconomic factors.^{30,31} The adjusted inequality enables us better understand the observed inequality. To facilitate a comprehensive understanding on ECD inequality in China, we therefore used the both methods in this study.

2.3. Statistical Analysis

In each type of region, unadjusted inequalities were computed as the absolute differences in percentage of children developmen-

Table 3
Unadjusted and adjusted percentage (and 95% confidential intervals) of children developmentally on track in three regions

	Shanghai Unadjusted	Adjusted	Most-developed Region(MDR) Unadjusted	Adjusted	Least-developed Region(LDR) Unadjusted	Adjusted
Total ¹	86% (85%,87%)	86% (85%,87%)	82% (81%,83%)	82% (81%,83%)	71% (70%,72%)	71% (70%,72%)
Gender/sex						
Male	84% (83%,85%)	86% (85%,87%)	80% (79%,80%)	79% (77%,81%)	68% (67%,69%)	67% (62%,71%)
Female	88% (87%,89%)	91% (91%,92%)	85% (84%,86%)	84% (83%,86%)	74% (73%,75%)	73% (69%,77%)
Income						
Poorest	76% (74%,78%)	83% (81%,85%)	72% (70%,74%)	77% (74%,79%)	58% (56%,59%)	63% (58%,68%)
Richest	93% (92%,94%)	92% (92%,94%)	89% (87%,90%)	86% (85%,88%)	87% (85%,88%)	78% (74%,82%)
Maternal schooling						
Middle school or under	74% (71%,78%)	83% (81%,85%)	74% (72%,75%)	78% (76%,80%)	60% (59%,61%)	65% (61%,70%)
College or above	89% (88%,90%)	91% (90%,91%)	89% (88%,90%)	85% (83%,87%)	84% (83%,85%)	75% (70%,80%)
Hukou						
Rural	Not applicable	Not applicable	78% (77%,79%)	81% (79%,82%)	65% (64%,66%)	69% (65%,74%)
Urban	Not applicable	Not applicable	0.88 (87%,89%)	83% (82%,85%)	0.82 (81%,82%)	71% (66%,75%)
Migrant						
Migrant children	68% (63%,73%)	85% (82%,89%)	Not applicable	Not applicable	Not applicable	Not applicable
Non-migrant children	87% (87%,88%)	89% (88%,90%)	Not applicable	Not applicable	Not applicable	Not applicable
Left-behind						
Left-behind children	Not applicable	Not applicable	67% (62%,74%)	72% (67%,78%)	54% (50%,58%)	61% (56%,65%)
Non-left-behind children	Not applicable	Not applicable	79% (78%,79%)	79% (77%,81%)	66% (65%,67%)	65% (61%,70%)

Notes:
Difference of total percentage of children developmentally on track is statistically significant with pos-hoc comparison between Shanghai and MDR (P<0.0001), Shanghai and LDR (P<0.0001), MDR and LDR (P<0.0001) at a significance level of .05.

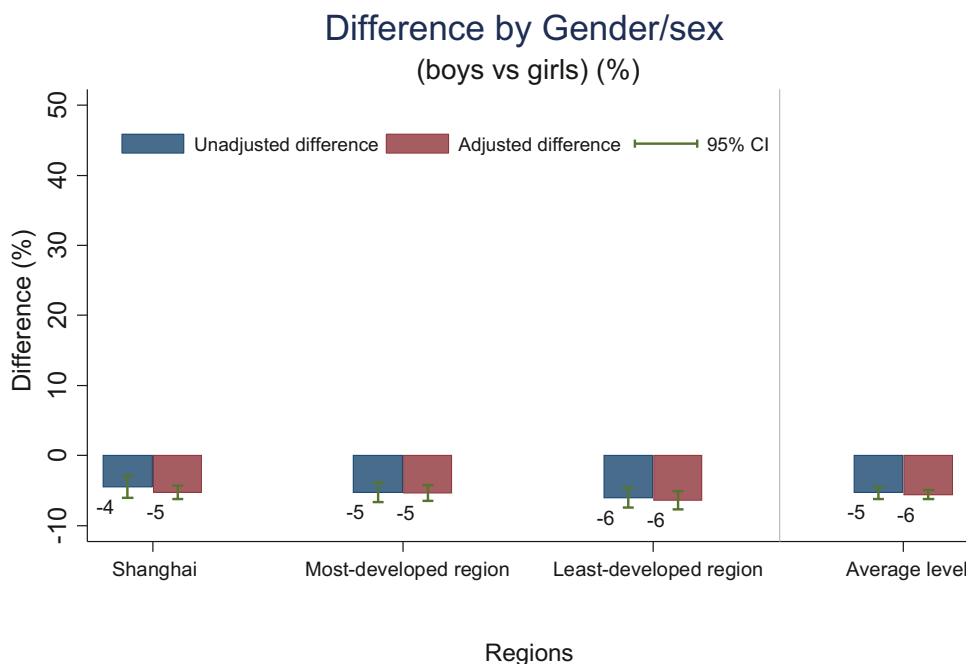


Figure 1. Absolute difference in developmentally on track between boys and girls

tally on track between the two groups. We estimated the percentage of children developmentally on track in each region using sampling weights to ensure that estimates are regionally representative. The estimates were also generated by gender/sex, family income, maternal schooling, Hukou and migrant/left-behind status.

To obtain adjusted inequalities in each province, we applied multilevel logistic regression analysis with random intercepts by county/district, controlling for clustering effects at the county/district level. Taking inequality by family income in Shanghai as an example. Dichotomous variable on a child's status of development was used as outcome variable. Income is used as exposure. Other socioeconomic variables (e.g. gender/sex, maternal education, Hukou, etc.) were included in the regression as covariates. Covariates used in each region are listed in Table A14 in the appendix (page 23). An independent covariance matrix was ap-

plied to account for the clustering effect of children within districts/counties. Using regression analysis in each region, we were able to obtain (1) the adjusted likelihood (and their 95% confidence intervals [CI]) of developmentally on track for poorest and richest children, respectively; and (2) adjusted inequalities (and their 95% CI) between the two groups.

For both unadjusted and adjusted inequalities, a positive value indicates existence of inequality, favoring the advantaged group (boys, richest quintile, higher maternal schooling, urban hukou, non-migrant/non-left-behind children). A higher value indicates a larger gap between the two groups.

To generate aggregate-level estimates across the three regions, we followed previous studies and used random effects meta-analysis by pooling levels of disparity estimates across regions.³² We also assessed the difference of inequalities across the three

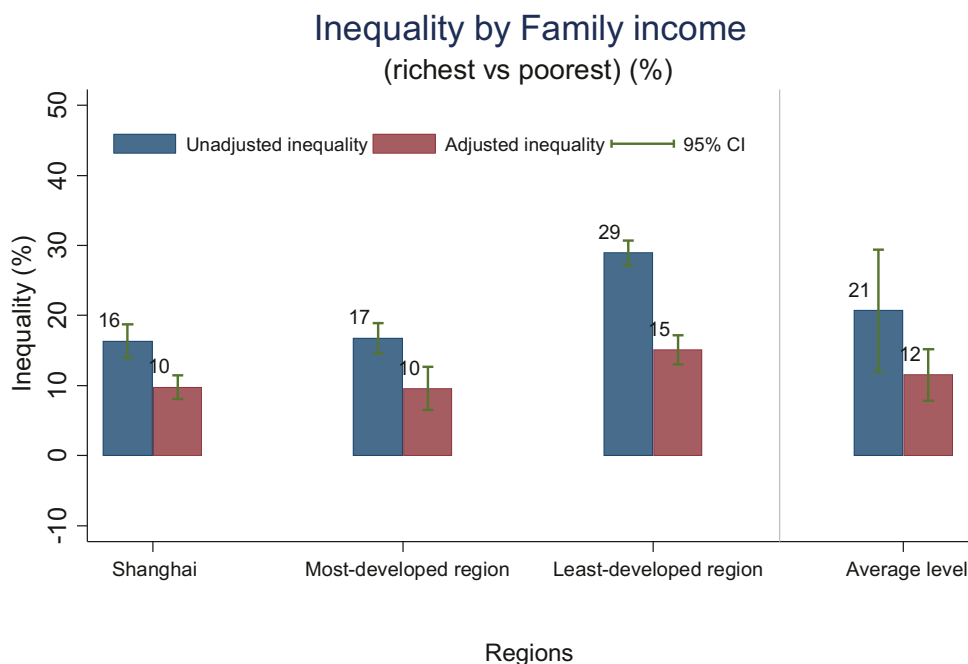


Figure 2. Absolute inequality in developmentally on track between the children in the richest and poorest families

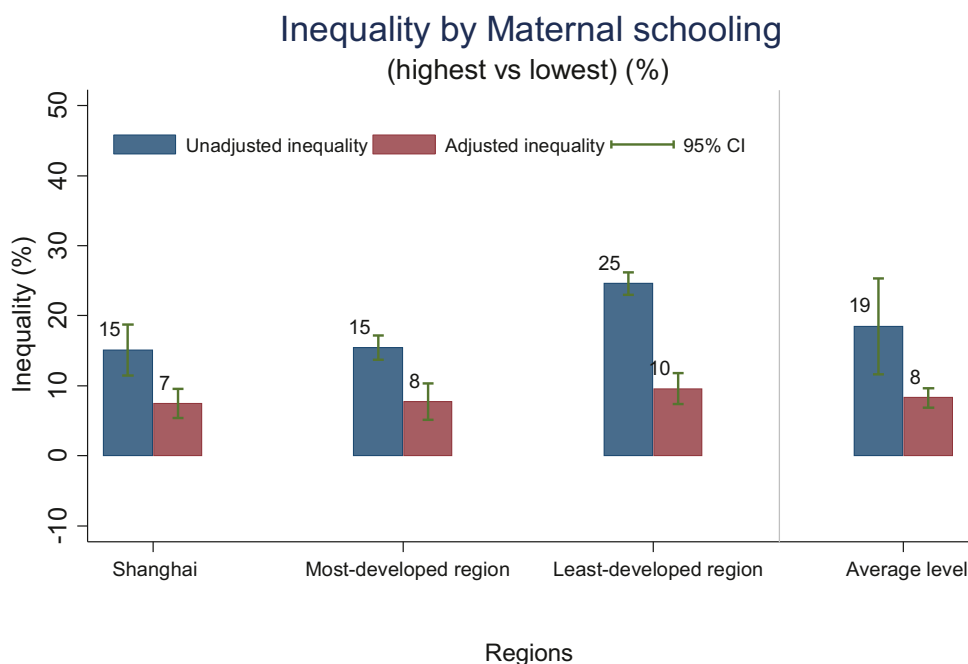


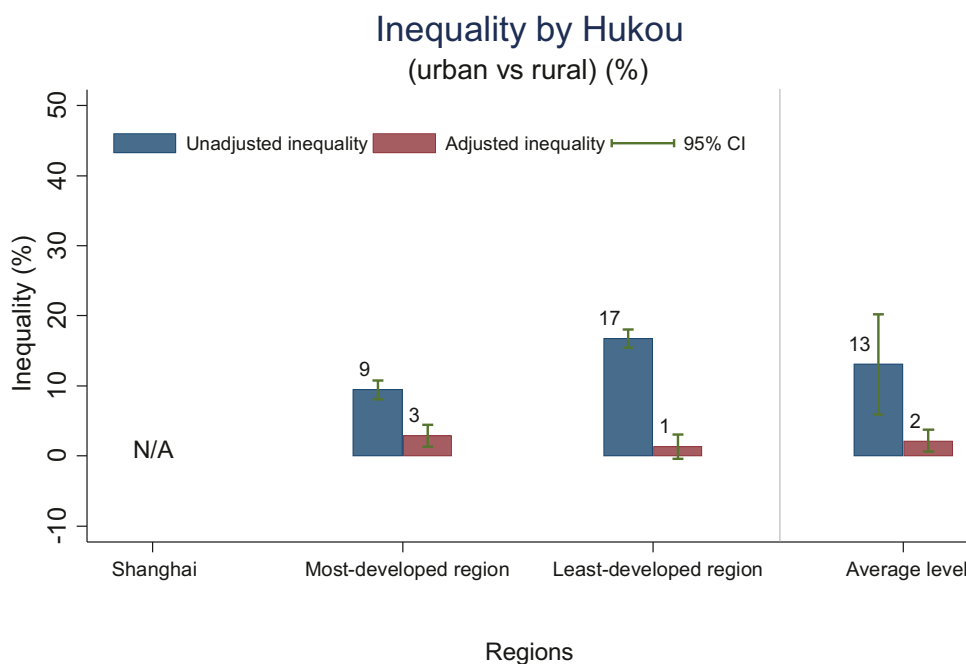
Figure 3. Absolute inequality in developmentally on track between the children with highest and lowest level of maternal schooling

types of regions using Cumming and Finch’s “rule of thumb” for comparing two independent means.³³ For example, we compared family income inequality in Shanghai to that in underdeveloped region as described below. First, we calculated proportion of the overlap as the overlap of the 95% CI between the two estimates divided by the average marginal errors between the two estimates. When sample sizes of two samples are both at least 10, and the margins of error between the two estimates do not differ by more than a factor of two, a proportion overlap less than 0.5 indicates a significant statistical relationship at the 0.05 level (i.e. $p < 0.05$).

Statistical analysis was performed using STATA/SE 15.1. A significance level of 5% was used, with no allowance for multiplicity.

2.4. Role of the funding source

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. Corresponding authors had full access to all the data in the study. Corresponding authors and senior author had final responsibility for the decision to submit for publication.



Note: N/A indicates not applicable

Figure 4. Absolute inequality in developmentally on track between children with urban and rural Hukou

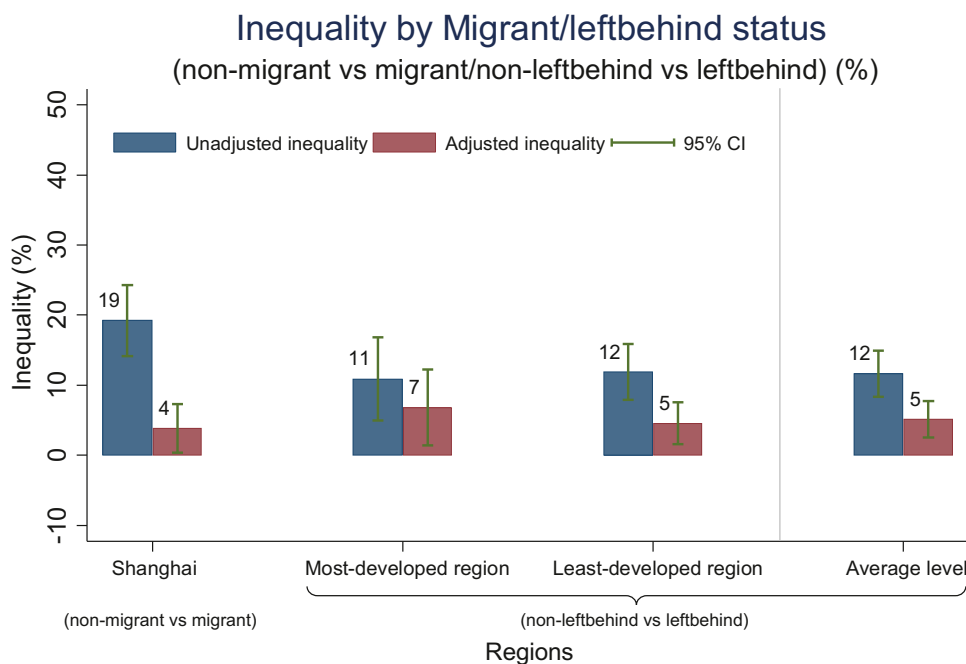


Figure 5. Absolute inequality in developmentally on track between migrant/left behind children and their counterparts

3. Result

3.1. Percentage of young children developmentally on track in difference regions

Percentage of young children developmentally on track was the highest in Shanghai (86% with 95% CI 85 to 87%), followed by most-developed region (82% with 95% CI 81 to 83%) and lowest in least-developed region (71% with 95% CI 70 to 72%). The differences across the three regions were statistically significant (Table 3). This pattern remains consistent for cross-region comparisons between the subgroups, especially for those children with disadvantaged socioeconomic status. For example, for children liv-

ing in the poorest families, those in Shanghai had the highest percentage on track (76% with 95% Confidence Intervals [CI] 74 to 78%), followed by most-developed region (72% with 95% CI 70 to 74%) and least-developed region (58% with 95% CI 56 to 59%). The difference in the level of development between the poorest children in Shanghai and those in the least-developed region is much larger compared to the difference between their counterparts in the two regions (Table 3).

3.2. Gender/sex difference in children developmentally on track

Unadjusted differences between boys and girls were statistically significant in all three regions, from negative four PPs (95%CI -

6 to -3 PPs) in Shanghai to negative six PPs (95% CI -7 to -5 PPs) in least-developed region, in favor of girls. After adjusting for other socioeconomic factors, the magnitudes of gender/sex difference in the three regions remain stable and statistically significant (Figure 1). Average level for adjusted difference over three regions was negative six PPs (95% CI -6 to -5 PPs). The difference of adjusted differences across the provinces were not statistically significant.

3.3. Income inequalities in children developmentally on track

Unadjusted inequalities between children in the richest and poorest income groups were statistically significant in all three regions, from 16 PPs (95% CI 14 to 19 PPs) in Shanghai to 29 PPs (95% CI 27 to 31 PPs) in least-developed region. After adjusting for other socioeconomic factors, the magnitude of income inequalities reduced by approximately 50%, but remained to be the largest among the five socioeconomic dimensions. Adjusted inequality between the two groups was statistically significant in all three regions, from 10 PPs (95% CI 8 to 11 PPs) in Shanghai, 10 PPs (95% CI 7 to 13 PPs) in most-developed region, to 15 PPs (95% CI 13 to 17 PPs) in least-developed region (Figure 2). Average level for adjusted inequality over three regions was 12 PPs (95% CI 8 to 15 PPs). The size of inequality estimates with SII are larger than the ones using only two groups, but the pattern is consistent (appendix page 24 Table A15). The difference of adjusted inequalities between the least-developed region and the other two regions were statistically different (appendix page 24 Table A16).

3.4. Inequalities in children developmentally on track by maternal schooling

Unadjusted inequalities between children with lower maternal schooling (middle school or below) and those with higher maternal schooling (college or above) were statistically significant in all three regions, from 15 PPs (95% CI 11 to 19 PPs) in Shanghai to 25 PPs (95% CI 23 to 26 PPs) in least-developed region. After adjusting for other socioeconomic factors, the magnitude of income inequalities in each region reduced more than 50%. Adjusted income inequality was statistically significant in all three regions, from seven PPs (95% CI 5 to 10 PPs) in Shanghai, eight PPs (95% CI 5 to 10 PPs) in most-developed region to ten PPs (95% CI 7 to 12 PPs) in least-developed region (Figure 3). Average level for adjusted inequality over three regions was eight PPs (95% CI 7 to 10 PPs). The size of inequality estimates with SII are larger than the ones using only two groups, but the pattern is consistent (appendix page 24 Table A15). Significant difference of adjusted inequalities was not found between the regions (appendix page 24 Table A15).

3.5. Inequality in children developmentally on track by Hukou

In both most- and least-developed regions, unadjusted inequalities between rural and urban hukou were statistically significant from nine PPs (95% CI 8 to 11 PPs) in most-developed region to 17 PPs (95% CI 15 to 18 PPs) in least-developed region. After adjusting for other socioeconomic factors, the magnitude of Hukou inequality reduced in both regions, and only marginally significant in most-developed region (3 PPs with 95% CI 1 to 4 PPs) (Figure 4). Average level for adjusted inequality over the two regions was two PPs (95% CI 1-4 PPs).

3.6. Inequalities of children developmentally on track by migrant/left-behind status

In both most- and least-developed regions, unadjusted inequalities between those left-behind children and their rural counterpart

Table 4
Multilevel logistic regression results for generating adjusted inequalities - Shanghai

	Odds Ratio (95%CI)	p value
Individual-level indicators		
Age month	1.00 (0.99,1.01)	0.8094
Gender/sex		
boy	Ref	
girl	1.74 (1.58,1.93)	<0.0001
Family annual income		
less than 100,000 RMB	Ref	
100,000-150,000 RMB	1.29 (1.06,1.57)	0.0113
150,000-300,000 RMB	1.74 (1.46,2.07)	<0.0001
more than 300,000 RMB	2.69 (2.34,3.11)	<0.0001
Maternal schooling		
middle school or under	Ref	
high school	1.20 (1.03,1.40)	0.0162
some college	1.50 (1.23,1.84)	0.0001
college or above	1.99 (1.70,2.32)	<0.0001
Divorce family		
non-divorced family	Ref	
divorced family	0.64 (0.51,0.81)	0.0002
Primary caregiver		
parents	Ref	
grandparents or others	0.62 (0.53,0.71)	<0.0001
Migrant children		
non-migrant children	Ref	
migrant children	0.70 (0.53,0.94)	0.0162
_cons	2.71 (1.49,4.92)	0.000
District-level indicators		
District/county	1.02 (1.00,1.03)	0.0443
Sample	All	
Observations	20,845	
Number of groups	16	

were statistically significant (11 PPs with 95% CI 5 to 17 PPs) in most-developed region, and 12 PPs (95% CI 8 to 16 PPs) in least-developed region]. After adjusting for other socioeconomic factors, the magnitude of inequalities reduced in both regions, and only marginally significant. Average level for adjusted inequality by left-behind status over the two regions was five PPs (95% CI 3 to 8 PPs). In Shanghai, the unadjusted inequality was statistically significant (19 PPs with 95% CI 14 to 24 PPs) between the migrant and non-migrant children. After adjusting for other socioeconomic factors, the difference between the two groups was only marginally significant (4 PPs with 95% CI 0 to 7 PPs) (Figure 5).

Regression results in each region for gender/sex, family income, maternal schooling, Hukou, and migrant/left-behind status are presented in Table 4-6. Gender/sex, family income, maternal schooling, primary caregiver and migrant/left-behind status were found to be significantly associated with child development status in all regions, and children living in households with higher level of income/maternal schooling were more likely to be developmentally on track.

Table 5
Multilevel logistic regression results for generating adjusted inequalities, Most-developed region

	Full sample Odds Ratio (95%CI)	p value	Rural sample Odds Ratio (95%CI)	p value
Individual-level indicators				
Age month	0.98 (0.97,1.00)	0.0129	0.99 (0.97,1.00)	0.0642
Gender/sex				
boy	Ref		Ref	
girl	1.45 (1.35,1.56)	<0.0001	1.43 (1.33,1.55)	<0.0001
Family annual income				
less than 60,000 RMB	Ref		Ref	
60,000-100,000 RMB	1.24 (1.10,1.40)	0.0004	1.21 (1.07,1.36)	0.0016
100,000-150,000 RMB	1.48 (1.27,1.73)	<0.0001	1.44 (1.23,1.67)	<0.0001
more than 150,000 RMB	1.96 (1.60,2.39)	<0.0001	1.88 (1.54,2.29)	<0.0001
Maternal schooling				
middle school or under	Ref		Ref	
high school	1.30 (1.13,1.50)	0.0003	1.36 (1.19,1.56)	<0.0001
some college	1.41 (1.22,1.62)	<0.0001	1.42 (1.22,1.66)	<0.0001
college or above	1.69 (1.41,2.04)	<0.0001	1.63 (1.39,1.91)	<0.0001
Divorced family				
non-divorced family	Ref		Ref	
divorced family	0.91 (0.74,1.12)	0.3902	0.99 (0.79,1.24)	0.9489
Hukou				
urban	Ref			
rural	0.83 (0.74,0.92)	0.0007		
Primary caregiver				
parents	Ref			
grandparents or others	0.64 (0.56,0.72)	<0.0001		
Leftbehind children				
non-leftbehind children			Ref	
leftbehind children			0.69 (0.54,0.89)	0.0100
_cons	5.56 (3.68, 8.42)	<0.0001	3.83 (2.42, 6.06)	<0.0001
District-level indicators				
District/county	1.06 (1.02,1.09)	0.0005	1.07 (1.03,1.11)	0.0005
Sample	All		Rural	
Observations	18,995		12,364	
Number of groups	29		29	

3.7. Sensitivity analysis

When using the 10th and 30th percentile to classify “developmentally on track”, the main findings on inequalities remain unchanged. When using the 30th percentile as threshold, difference in adjusted inequalities was not statistically significant across regions in all domains. When using the 10th percentile as threshold, difference in adjusted inequalities by gender/sex, family income and maternal schooling was statistically significant between the least-developed region and the other two regions. (appendix pages 25-28 Chapter 7).

4. Discussion

Using data collected from three types of region in China in 2017 and 2018, we provided the very first report on socioeconomic inequalities of ECD among young children (aged 36-59 months) in China. The estimated percentage of children developmentally on

track ranged from 71% to 86% across the regions, with lower level in the less developed region. Unadjusted inequalities in the five socioeconomic dimensions were statistically significant in all regions. After adjusting for other socioeconomic factors, significant difference was found by gender/sex, family income, and maternal schooling: those living in the poorest families, or with lower maternal schooling, or boys were less likely to be developmentally on track than their counterparts.

Though using different index for measuring ECD, findings on unadjusted ECD inequalities in this study are consistent with those in other studies. A recent study used ECDI to assess ECD inequalities in 60 LMICs and demonstrated significant ECD inequalities by gender/sex (in favor of girls), residential area (in favor of urban children), and wealth (a favor of rich children). The socioeconomic inequalities in higher income countries were smaller than that in lower income countries, and the same pattern was also found in between-region comparisons in China. The magnitude of gen-

Table 6
Multilevel logistic regression results for generating adjusted inequalities, Least-developed region

	Full sample Odds Ratio (95%CI)	p value	Rural sample Odds Ratio (95%CI)	p value
Individual-level indicators				
Age month	0.98 (0.97,0.99)	0.0003	0.98 (0.97,0.99)	0.0001
Gender/sex				
boy	Ref		Ref	
girl	1.40 (1.31,1.49)	<0.0001	1.38 (1.29,1.47)	<0.0001
Family annual income				
less than 30,000 RMB	Ref		Ref	
30,000-60,000 RMB	1.32 (1.20,1.45)	<0.0001	1.43 (1.27,1.60)	<0.0001
60,000-100,000 RMB	1.60 (1.42,1.79)	<0.0001	1.73 (1.52,1.97)	<0.0001
more than 100,000 RMB	2.20 (1.97,2.46)	<0.0001	2.33 (2.05,2.65)	<0.0001
Maternal schooling				
middle school or under	Ref		Ref	
high school	1.39 (1.28,1.52)	<0.0001	1.37 (1.24,1.52)	<0.0001
some college	1.50 (1.36,1.66)	<0.0001	1.44 (1.31,1.58)	<0.0001
college or above	1.64 (1.44,1.87)	<0.0001	1.44 (1.14,1.82)	0.0025
Divorced family				
non-divorced family	Ref		Ref	
divorced family	0.83 (0.72,0.96)	0.0103	0.76 (0.65,0.90)	0.0009
Hukou				
urban	Ref			
rural	0.93 (0.85,1.02)	0.1442		
Primary caregiver				
parents	Ref			
grandparents or others	0.85 (0.74,0.97)	0.0163		
Leftbehind children				
non-leftbehind children			Ref	
leftbehind children			0.81 (0.71,0.94)	0.0046
_cons	2.91 (2.02,4.20)	<0.0001	2.94 (1.80,4.80)	<0.0001
District-level indicators				
District/county	1.25 (1.11,1.42)	0.0003	1.23 (1.09,1.38)	0.0006
Sample	All		Rural	
Observations	23,719		14,510	
Number of groups	24		24	

der/sex difference in our study was comparable to the aggregate-level estimation in the 60 LMIC (4%, in favor of girls).⁹ The finding that girls performed significantly better than boys suggests that, though observed gender/sex differences in ECD is, in general, a result of biological, social and cultural influences, in the three regions of China, biological factor outweighed other factors and was the major contributor to gender/sex difference in ECD. As girls usually attain basic social or self-control related skills earlier than boys,²⁴ they could achieve better development score than boys in early years. Income inequality in the least-developed region (29 PPs) in China was much higher to that in the lower-middle income countries with similar level of GDP per capita (12.5 PPs) or the in East Asia and Pacific countries (13.7 PPs). However, direct comparison should be cautious due to different instrument. In addition, our study also observed significant inequalities in all three regions between children with high and low maternal schooling, which was not reported in previous studies with ECDI.

One important contribution of this study is to compare the adjusted socioeconomic inequalities with the unadjusted ones, which could provide insights on the contributors to the unadjusted inequalities. For example, unadjusted inequalities by child vulnerable status (migrant/left-behind) ranged from 12% to 19%. After adjusting for other socioeconomic factors such as income and maternal education, the size of these two inequalities became much smaller or statistically insignificant, suggesting that the observed disparities are largely contributed by factors such as income and maternal education. These two factors have been considered as major barriers for ECD in China and prompted various interventions targeting children in the poorest areas. For example, a nutrition supplement program was launched in 2001 and gradually extended to cover infants and young children in all 823 poverty counties in 2019.³⁴ Stunting prevalence among the young children had a big reduction from 33.4% in 1990 to 8.1% in 2013.¹³ Investments were also made in strengthening early education in the poor areas; as a result, the

coverage of children receiving preschool education reached 83.4% in 2019.³⁵ However, scientific evidence showed limited progress in rural young children's development outcomes, particularly in cognitive function that may impact their school performance and labor market productivity.³⁶ Our study suggested that the key strategy for improving ECD among rural children with vulnerable status could lie in poverty reduction and maternal education improvement. Global evidence also shown that women's education and empowerment has been positively associated with children's development.^{23, 37} In recent years, Chinese government has put forward a series of strategies to eliminate poverty in poor rural areas. Strategies should also be developed to prevent high school dropout rate, especially in rural poor areas.

Our study has several limitations. First, even though we have included the least- and most-developed provinces in the first wave of the survey, the estimates were not representative at the national-level. We hope that, with increasing financial and administrative support from the central and provincial governments, we will be able to include more provinces in the future surveys. Second, using cross-sectional data, we were not able to establish trend analysis to identify policy impact. We hope that, with more data available from the four provinces, we will be able to assess the progress in ECD over time. Third, the current sample only included young children aged 36–59 months. Estimates on children below 36 months were not available. Fourth, the surveys in this study were kindergarten-based. Those children who were not able to attend kindergarten, usually living in poor or remote areas, were not included in the sample. Kindergartens with low response rate or refusing to participate in the study, were usually in poor rural areas and excluded from the study. In addition, performing online survey could leave out those parents or caregivers who lacked knowledge of using internet or lacked access to internet, and they were most likely to be in rural remote areas or poor families. The exclusion of children in above situations from the study could lead to overestimation of level of development on track among the rural or poor children and underestimation of inequalities of ECD by income, maternal education, or Hukou, especially in the least developed region. Fifth, when using the 20th percentile as the threshold for defining children developmentally on track, one of the limitations is that its predictive validity has not been determined. We hope that with longitudinal data available in future, we could validate the threshold used in this study. Currently, the threshold was established on the basis of existing evidence and was tested with sensitivity analysis using 10th and 30th percentile as threshold. Lastly, given the different ECD measurements and cut-offs used in our study and in others, we need to be cautious when making comparison across the studies. We hope that, current global efforts in developing ECD measures could yield valid and country-comparable instruments and be adopted in our future surveys.

Despite these limitations, this study provides the first comprehensive assessment on socioeconomic inequalities in ECD in the three types of regions of China, using both adjusted and unadjusted inequality estimates. The findings could inform the policy makers in the four provinces or in China when making ECD policies. Our study indicated that ECD inequalities by income and maternal schooling were large whether in most-developed or least-developed areas. This finding suggests that China's policy and efforts on eliminating poverty in poor and remote areas could greatly improve young children's ECD in those areas. Meanwhile, we should not ignore young children living in the poorest families in urban areas. Strategic planning and intervention development for poverty elimination and maternal education promotion in both rural and urban areas should be considered. With many ECD programs or projects implemented in China at the multiple levels, a national-level monitoring framework and evaluation system should be established to track inputs and outputs. With a growing

momentum surrounding ECD metrics,³⁸ we should regularly collect and analyze nationally-representative ECD data in China to enhance the accountability and policy advocacy for meeting the SDGs Target 4.2.

5. Contributors

YZ was responsible for survey design in Shanghai, conducted data analysis, took responsibility for the integrity of data analysis, and wrote the first draft of the manuscript; LK cleaned the survey data for Gansu, Yunnan and Zhejiang, participated in data analysis; JZ collected and cleaned the survey data for Shanghai; YS was the PI for survey design and implementation in Gansu, Yunnan and Zhejiang; FJ conceptualized the study, was the PI for survey design and implementation in Shanghai. CL conceptualized the study, designed the analysis plan, mentored data analysis, and revised the manuscript critically for important intellectual content. All authors made contributions to data interpretation and manuscript writing. All authors approve the manuscript for submission.

Data sharing statement

Survey data were examined after importing from online survey system and are held and managed by the research group at Shanghai Children's Medical Center and Peking University with the format of STATA file (.dta). There is an application process for using the data. After the application is approved by the Publication Committee, deidentified data can be shared with collaborators for research purposes.

Declaration of Competing Interest

We declare no competing interests.

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Supplementary materials

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