Early Life

Effect on child cognitive function of increasing household expenditure in Indonesia: application of a marginal structural model and simulation of a cash transfer programme

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Abstract

Background: Parental investments in children are an important determinant of human capability formation. We investigated the causal effect of household expenditure on Indonesian children’s cognitive function between 2000 and 2007. We also investigated the effect of change in mean cognitive function from a simulation of a hypothetical cash transfer intervention.

Methods: A longitudinal analysis using data from the Indonesian Family Life Survey (IFLS) was conducted including 6136 children aged 7 to 14 years in 2000 and still alive in 2007. We used the inverse probability of treatment weighting of a marginal structural model to estimate the causal effect of household expenditure on children’s cognitive function.

Results: Cumulative household expenditure was positively associated with cognitive function z-score. From the marginal structural model, a 74534 rupiah/month (about US$9) increase in household expenditure resulted in a 0.03 increase in cognitive function z-score [β = 0.32, 95% confidence interval (CI) 0.30–0.35]. Based on our simulations, among children in the poorest households in 2000 an additional ~US$6–10 of cash transfer resulted in a 0.01 unit increase in cognitive function z-score, equivalent to about 6% increase from the mean z-score prior to cash transfer. In contrast, children in the poorest household in 2007 did not benefit from an additional ~US$10 cash transfer. We found no overall effect of cash transfers at the total population level.

Conclusions: Greater household expenditure had a small causal effect on children’s cognitive function. Although cash transfer interventions had a positive effect for poor children, this effect was quite small. Multi-faceted interventions that combine nutrition, cash transfer, improved living conditions and women’s education are required to benefit children’s cognitive development in Indonesia.
**Key words**: Household expenditure, cognitive function, Indonesia, marginal structural model, time-varying exposure, time-varying confounder, inverse probability of treatment weighting

### Introduction

Parental investments in children are an important determinant of human capability formation. These investments include economic, learning, social, cultural and behavioural resources that help create the early-life supports for the accumulation of capabilities over the life course. Parental investments rely on the resources in the household that can be deployed and transferred to their children. The unequal distribution of resources in society limits people’s freedom to fully function and may lead to capability deprivation. The Commission on Social Determinants of Health indicated that investing in early childhood interventions was a major driver of improving health disparities over the life course. Even when evidence for intervention effectiveness does exist, effective implementation of early childhood intervention is challenged by capacities in resourcing, targeting, and translating evidence-based policy into practice.

Conditional Cash Transfer (CCT) programmes are a welfare strategy generally aimed at families to alleviate poverty through conditional actions. In relation to children, the cash transfers are commonly conditional on immunization and/or primary school enrolment. Such CCT programmes have been widely used in developing countries, including Indonesia. CCT programmes combine redistribution of resources to poor households and have been shown to promote greater investment in human capital of children, which is expected in turn to reduce long-term poverty. Evidence from Mexico’s CCT programme, Oportunidades, suggests that CCT had both short- and long-term positive effects on children’s cognitive function. The CCT program in Indonesia, Program Keluarga Harapan, successfully increased food consumption expenditure especially on high-protein food and increased participation in local health services, but had little effect on education services.

Our recent study found that among Indonesian children aged 7–14 years, the burden of poorer cognitive function was higher among disadvantaged groups. This inequality, however, reduced markedly between 2000 and 2007. Decreasing inequality in children’s cognitive function was mainly driven by changes in maternal education, use of improved sanitation and improved household per capita expenditure. Decomposition of the inequality showed that household expenditure was the largest single contributor to socioeconomic inequality in 2000 and 2007. The aim of the current study was to estimate the causal effect of household expenditure on Indonesian children’s cognitive function between 2000 and 2007, and then simulate the effect of a hypothetical CCT on change in cognitive function after a plausible intervention.

### Methods

**Data**

We used data from four waves of the Indonesian Family Life Survey (IFLS). IFLS is an ongoing longitudinal survey in Indonesia, which was first conducted in 1993 and subsequently in 1997, 2000 and 2007. The IFLS sample is considered to be representative of 83% of the whole Indonesian population. The sample was collected from households in 13 of the 27 provinces in Indonesia in 1993, and specific details of the sampling methodology are detailed elsewhere. During follow-up, the IFLS tracked not only individuals who resided in the original household in 1993, but also individuals who had moved out from the original household but still lived within the IFLS provinces. For our study, we selected children aged 7 to 14 years in 2000 and still alive at the follow-up in 2007 (n = 6136) (Figure 1). Of 44 children who were reported dead at follow-up, we found no difference in cognitive function score...
at baseline between these children and those who are still alive in 2007 (data not shown).

Child cognitive function

Cognitive function was measured in 2000 and 2007 using a subset from Raven’s Progressive Matrices that was originally designed to measure general intelligence. In the IFLS, the questions were reduced in number due to logistical constraints. The test comprised 12 shapes with a missing part where children selected the correct part to complete the shape. Each correct answer was coded 1, or 0 otherwise, and scores combined as the total raw score. The total raw score increased with age and had skewed distributions towards the left tail. The total raw scores were then transformed into an age-specific z-score. Because the total scores were skewed, we calculated the mean and the variance of score distributions by taking into account the range, median and the sample size using the formula from Hozo et al. and used the estimated mean and standard deviation to create an age-specific z-score.

Household expenditure

We used the log of household per capita expenditure (PCE) constructed from the monthly total household expenditures divided by the number of household members. The cumulative household PCE was constructed by summing PCE in 2000 and 2007. The PCE was reported in Indonesian rupiah value. To aid interpretation we also report PCE in US dollars (US$) at the year 2000 exchange rates (1 US$ = 8422 rupiah).

Confounding

A series of child, caregiver and household characteristics measured variously in 1993, 1997, 2000 and 2007 was selected a priori based on the directed acyclic graph (DAG) in Figure 2 as representing baseline and time-varying confounding of the associations between household PCE and child cognitive function in 2000 and 2007. Child characteristics included age (continuous) and whether the child was attending school in 2000 and had completed at least 8 years of education by 2007. Caregiver characteristics included maternal age (continuous), the highest level of education attended (categorized as none, primary school, junior high school, senior high school and diploma/university), whether the mother was working in the past week and self-reported mental health. All information about caregiver characteristics was measured in 1993, 1997 and 2000 except for mental health. Maternal self-reported mental health was measured in 2000 and 2007. The measure in 2000 consisted of eight items of feelings experienced in the past 4 weeks, with responses in three categories ranging from never to often. In 2007, the measure was adapted from the shorter version of the Centre for Epidemiological Studies-Depression scales (CES-D) consisting of 10 items of symptoms or feelings experienced in the past week, with responses in five categories ranging from not at all, rarely (<=1 day), some days (1–2 days),
occasionally (3–4 days) and most of the time (5–7 days). For both measures, each item was scored ranging from 0 to 3 and summed as the total mental health score separately for 2000 (scores ranging 0–24) and 2007 (scores ranging 0–30). In the analysis, we used the total mental health score where a higher score indicated poorer mental health.

In 1993, 96% of caregivers were the mothers and the proportion slightly decreased in 1997 and 2000 (92% and 90%, respectively). For each survey round, if a mother was not present in the household either because she was living elsewhere or was reported dead, other family members who took the role as the child’s main caregiver provided information. However, information about caregivers was only collected for children under 15 years of age. In 2007, 5626 (92%) of the study children were between 15 and 22 years of age. Of these, 1116 (20%) did not have associated information on their mothers. In this circumstance, caregiver’s mental health was replaced by the father’s but, when both parents were not present, this information was replaced by the household head’s mental health.

Household characteristics include household size (continuous), the number of economic hardships experienced in the past 5 years (continuous), whether the household had electricity, used piped or pumped well as the main drinking water source and owned a toilet connected to septic tank, and whether the place of residence was categorized as urban or rural. All information about household characteristics was measured in 1993, 1997 and 2000, except for economic hardship. We used information about economic hardship collected in 1993 and 2000.

Missing data

Of the children in the IFLS who were administered the cognitive test, the response rate was 96% and 95% in 2000 and 2007, respectively. The proportion of children with missing information on the exposure was 0.7% in 2000 and 7% in 2007. Of the 6136 children, only 5305 (86%) were recorded as a member of the original household in 1993, whereas 831 children were recorded as either a new member of the original household or a member of the split-off households who were included in 1997 and 2000 surveys. As such, data related to all confounders in 1993 were not available for 831 (14%) children. Additionally, 1669 children were either not present in the household or could not be contacted during the main field survey in 2007. To minimize bias due to attrition and missing responses to questions, we performed the Multiple Imputation by Chained Equation (MICE) procedure in STATA under the assumption that the imputed data were missing at random. We generated 20 imputed datasets using 50 cycles of regression switching. We used Rubin’s rule to combine and analyse imputed datasets. We used all imputed outcomes in our analysis. As a sensitivity analysis, we conducted the method of multiple imputation and then deletion of outcomes as described by von Hippel, and the results did not change.

Analysis

We used observational data to investigate a potential causal link between household PCE and children’s cognitive function. The direct acyclic graph (DAG) representing the relations between confounders, household per capita expenditure and child cognitive function is shown in Figure 2. The exposure is household per capita expenditure, the outcome is child cognitive function z-score, and the confounders include caregiver’s age, education, employment status, household size, economic hardship, household had electricity, used piped or pumped well as the main drinking water source, owned toilet with septic tank, and residential area. The causal path and the biasing path are shown in the DAG.
cognitive function. For this analysis we used the inverse probability of treatment weighting (IPTW) of a marginal structural model (MSM) based on the assumptions of consistency, no unmeasured confounders (exchangeability) and positivity.\textsuperscript{24,25} Under the assumption of no unmeasured confounders, the causal DAG\textsuperscript{26} shown in Figure 2 presents the association between confounders, exposure and outcome. This causal graph was drawn using DAGitty program version 2.0.\textsuperscript{27} Both the exposure and the outcome were measured at two time points (2000 and 2007), whereas a series of baseline confounders were measured in 1993, 1997 and 2000. The confounders included: caregiver’s age, education and employment status; household size; economic hardship; housing conditions (access to electricity, the main drinking water source and type of toilet); and place of residence. The use of confounding information measured at three survey rounds allowed for the situations where a child was raised by a different caregiver, or lived in different housing environments over the course of the study period. This model specification may also help to reduce measurement error by having multiple indicators over time. In the DAG, the child’s current schooling and caregiver’s mental health in 2000 were included because they indicate the presence of time-varying confounding so that, given past household PCE, current schooling and maternal mental health predict subsequent exposure and outcome. In addition, the DAG reflects the proposition that a child’s current schooling affects completion of at least 8 years of education and also affects cognitive function in 2007. Similarly, caregiver’s mental health in 2000 affects mental health and in turn affects child’s cognitive function in 2007.

In the presence of time-varying confounding, the use of conventional regression lacks a causal interpretation and may introduce collider stratification bias.\textsuperscript{26,28} Therefore in this study, we use an MSM to estimate the causal effect of household PCE on children’s cognitive function.

Construction of the inverse probability of treatment weighting

We used the inverse probability of treatment weighting (IPTW) to adjust for confounding in the marginal structural model.\textsuperscript{24} The weighting method creates a pseudo population, based on the child’s potential exposure at each time point. The weight was estimated based on the probability of an individual having the observed exposure given their covariates. Because the exposure variable was in continuous form, we used stabilized weight (SW) to reduce large variance in the weight.\textsuperscript{24,29} The weight was calculated separately for 2000 and 2007, which can be defined as follows:

\begin{equation}
SW_{2000} = \frac{f(X_{2000})}{f(X_{2000}|C_i)}
\end{equation}

\begin{equation}
SW_{2007} = \frac{f(X_{2007}|X_{2000})}{f(X_{2007}|X_{2000}, C_i, L_i)}
\end{equation}

where the numerator in equation 1 is the marginal density of the exposure in 2000 ($X_{2000}$), and the denominator is the conditional density function of $X_{2000}$ given the history of confounders ($C_i$) up to 2000 including caregiver and household characteristics. The numerator in equation 2 is the conditional density function of the exposure in 2007 ($X_{2007}$) given $X_{2000}$, and the denominator is the density function of $X_{2007}$ given $X_{2000}$, history of confounders ($C_i$) and time-varying confounders ($L_i$). This includes the child attending school and their caregiver’s mental health in 2000, and the child’s completion of at least 8 years of education and their caregiver’s mental health in 2007. The mean weight was expected to be around one, suggesting no misspecification of the weight model (nonpositivity).\textsuperscript{29} To test whether there is a bias in our causal estimation due to nonpositivity, we truncated the weight at the 1st and the 99th percentiles as well as at the 5th and the 95th percentiles of the weight distributions.\textsuperscript{29}

The last step was the creation of the final weight:

\begin{equation}
IPTW = SW_{2000} \times SW_{2007}
\end{equation}

Marginal structural mean model

Since we have repeated measures on both the exposure and the outcome, we used the generalized estimating equations model (GEE)\textsuperscript{30} to estimate the effect of household PCE on cognitive function. We specified an independent working correlation structure and calculated the 95% confidence interval (CI) using a robust variance estimator. Use of the independent correlation structure is preferable in the GEE when using IPTW because, although there is potential that the working correlation structure is mis-specified, the independent correlation structure still gives consistent estimation.\textsuperscript{31,32} All analyses were conducted using STATA 13.\textsuperscript{33}

The marginal structural mean model can be defined as:

\begin{equation}
E[\bar{Y}_t|cum_{ex}] = \beta_0 + \beta_t \cdot cum_{ex}
\end{equation}

where $\bar{Y}_t$ is the expected mean potential outcome of cognitive function z-score given the observed cumulative household PCE($cum_{ex}$). We present three types of GEE models. The first model is the standard (unadjusted) regression
GEE model estimating the effect of cumulative household PCE on cognitive function. The second model estimated the effect of cumulative household PCE on cognitive function using standard regression-adjusted covariates. Finally, we present the GEE from an MSM estimating the causal effect of cumulative household PCE on cognitive function, accounting for confounding by the IPTW.

Hypothetical intervention in household PCE

We used the Indonesian CCT program, Program Keluarga Harapan (PKH or Hopeful Families Programme), as a hypothetical intervention to estimate the effect of change in household PCE on mean cognitive function after a plausible cash transfer intervention. The PKH provided cash transfer to very poor households with children aged 0–6 years, conditional on their participation in the local health service to ensure the child was fully immunized, took Vitamin A capsules a minimum of twice a year and attended growth monitoring check-ups. The PKH also provided cash transfer to very poor households with children ages 6–15 years, conditional on enrolment in school and ensured attendance for minimum of 85% of school days. Lastly, PKH provided cash transfer to very poor households with children aged 16–18 years who had not completed nine years of basic education, conditional on their school enrolment to finish a full 9 years of education. In PKH, the money was transferred quarterly. The compliance with conditions was monitored and verified through health and education service providers’ reports. Non-compliance with these conditions would result in a warning, 10% discount of benefit and even discontinuity of the cash transfer.10

For this study, we modelled the hypothetical intervention on the PKH education programme which targeted very poor households with children aged 6–15 years and also those aged 16–18 years who had not completed 9 years of education. This programme provided a fixed amount of 200,000 rupiah/household/year and an additional 400,000 rupiah/year for each child aged 6–12 years and 800,000 rupiah/year for each child aged 13–15 years.34 Based on results from a World Bank report, the first batch of PKH beneficiaries in 2007 increased their income from the CCT was invested in the child’s education.36 Therein the poorest households were defined as those having children living in the bottom 40% of PCE. We simulated the intervention in both 2000 and 2007, to examine whether a CCT at ages 7–14 had a larger effect than in adolescence at ages 14–18 years.37 In step one, we targeted the poorest households in 2000 who had children aged 7–14 years. Of the total population, 2456 (40%) children were eligible to receive a CCT in 2000. In 2000, all eligible children received 200,000 rupiah/year. In addition, each child aged 7–12 received 400,000 rupiah/year and each child aged 13–14 received 800,000 rupiah/year. Assuming this money was transferred monthly, each child aged 7–12 received 50,000 rupiah/month (about US$6) whereas each child aged 13–14 received about 83,333 rupiah/month (about US$10). In step two, we targeted the poorest households in 2007 who had children aged 14–15 years as well those who had children who were aged 16–18 but who had not completed 9 years of education. Of the total population, 961 (16%) children were eligible to receive a CCT in 2007. In 2007, each eligible child received 200,000 rupiah/year and an additional 800,000 rupiah/year. Similar to step one, assuming this money was transferred monthly each child received 83,333 rupiah/month (about US$10). Our hypothetical intervention assumed that all the increased income from the CCT was invested in the child’s education.

Sensitivity analysis for unmeasured confounding

We conducted a sensitivity analysis to estimate bias in the causal effect of household PCE on cognitive function, due to unmeasured confounding (U). In the sensitivity analysis, we defined U as a binary variable and assumed that the association between U and cognitive function did not vary across levels of household PCE. Following VanderWeele and Arah,38 we defined the sensitivity parameter δ as the effect of U on cognitive function and the sensitivity parameter γ as the prevalence of U. The magnitude of bias d_{x_i} was then estimated as the product of δ and γ.

Results

Table 1 shows the characteristics of study participants in all survey rounds based on multiple imputed data. The median of cognitive function z-score was 0.41 [interquartile range (IQR) −0.29 to 0.82] in 2000 and was 0.53 (IQR 0.10 to 0.83) in 2007, suggesting improvement. In the same period, the mean of log PCE also increased from 11.91 (SD 0.71) to 12.94 (SD 0.70), equivalent to 49,985 rupiah/month/year (about US$6), slightly higher than the national average (Figure 3).
The median age of caregiver in 1993 was 31 years (IQR 23 to 39). In terms of education, we found a small number of caregivers improved their education, for example the proportion of caregivers with a diploma or who attended university increased from 2% in 1993 to 3% in 1997 and 5% in 2000. Among mothers who were found in the follow-up, we found some discordance in the level of education reported. To test whether bias in reporting education was affecting the estimates of our MSM, we conducted sub-group analysis for children whose caregivers’ reporting was consistent, and the result showed no substantial difference. We also tested whether using education as a continuous instead of a categorical variable changed the estimate, and the result suggested no substantial difference.

The proportion of caregivers who reported working in the past week increased substantially from 31% in 1993 to 51% in 1997 and steadily increased to 56% in 2000. The substantial increase found between 1993 and 1997 might be influenced by the economic crisis that hit Indonesia in 1997, forcing more women to participate in the labour force.

The median mental health score was 2 (IQR 0 to 7) and 3 (IQR 1 to 5) in 2000 and 2007, respectively.

At the household level, the proportion of children who had access to electricity, drinking water from piped water or a pumped well, and improved sanitation increased over the years. However, in 2000 about half of the children still did not have access to piped or pumped water as their main drinking source and only 43% had access to improved sanitation.

Table 2 shows estimates for the stabilized weight and the IPTW. The mean stabilized weight was 1.58 (SD 0.79) for 2000 and was 1.18 (SD 0.39) for 2007. Table 3 shows estimates for the effect of cumulative household PCE on

| Table 1. Characteristics of study participants, IFLS 1993, 1997, 2000 and 2007, multiple imputation (n = 6136) |
|---|---|---|---|
| Cognitive function z-score, median (IQR) | 0.41 (−0.29–0.82) | 0.53 (0.10–0.83) |
| Exposure |  |  |  |  |
| Log of per capita expenditure/month (PCE), mean (SD) | 11.91 (0.71) | 12.94 (0.70) |
| − PCE in rupiah, median (IQR) | 142231 (91831–227202) | 394682 (254286–644316) |
| − PCE in US$ (1US$=8422 rupiah), median (IQR) | 17 (11–27) | 47 (30–77) |
| Log of cumulative PCE, mean (SD) | 13.29 (0.65) |
| -cumulative PCE in rupiah, median (IQR) | 560852 (374714–887050) |
| -cumulative PCE in US$, median (IQR) | 67 (44–105) |
| Covariates |  |  |  |  |
| Children’s characteristics |  |  |  |  |
| Gender: male, n (%) | 3129 (51) |
| Age in years, mean (SD) | 3.76 (2.33) | 7.71 (2.29) | 10.53 (2.30) | 17.89 (2.36) |
| Currently attending school, n (%) | 5461 (89) |
| Completed at least 8 years education, n (%) | 4503 (73) |
| Caregiver’s characteristics |  |  |  |  |
| Caregiver’s age in years, median (IQR) | 31 (23–39) | 35 (26–45) | 37 (33–42) |
| Highest education attended, n (%) | 3129 (51) |
| − None | 2270 (37) | 1391 (23) | 858 (14) |
| − Primary (grade 1–6) | 2635 (43) | 3009 (49) | 3434 (56) |
| − Junior high school (grade 7–9) | 533 (9) | 806 (13) | 761 (12) |
| − Senior high school (grade 10–12) | 544 (9) | 723 (12) | 805 (13) |
| − Diploma/university | 154 (2) | 207 (3) | 278 (5) |
| Working in the past week, n (%) | 1901 (31) | 3319 (54) | 3472 (56) |
| Mental health scores, median (IQR) | 2 (0–7) |
| Mental health scores (CES-D), median (IQR) | 3 (1–5) |
| Household’s characteristics |  |  |  |  |
| Household size, mean (SD) | 5.93 (2.21) | 5.76 (2.04) | 5.59 (1.93) |
| Economic hardship in the past five years, mean (SD) | 0.43 (0.70) | 0.46 (0.71) |
| Had electricity, n (%) | 3970 (65) | 5043 (82) | 5412 (88) |
| Drinking water source: piped or pump well, n (%) | 1984 (32) | 2623 (43) | 3037 (50) |
| Owned toilet with septic tank, n (%) | 1652 (27) | 2426 (39) | 2611 (43) |
| Place of residence: urban, n (%) | 2576 (42) | 2516 (41) | 2540 (41) |
cognitive function from standard GEE models (top panel) and an MSM (lower panel). Cumulative household PCE was associated with an increase in the cognitive function z-score. From the standard unadjusted model, for every 10% increase in household PCE (74,534 rupiah/month or US$9) there was an associated 0.27 x ln(1.10) = 0.02 unit increase in the cognitive function z-score or 0.09 unit increase in raw score. From the second adjusted regression model, a 74,534 rupiah (US$9) increase in cumulative household PCE was associated with 0.11 x ln(1.10) = 0.01 unit increase cognitive function z-score or 0.04 unit increase in raw score after conventionally adjusting for all covariates in the analysis. From the MSM, a 74,534 rupiah (US$9) increase in cumulative household PCE was associated with 0.32 x ln(1.10) = 0.03 unit increase cognitive function z-score or 0.11 unit increase in raw score. Use of truncation weights did not substantially change the result.

Application of a hypothetical CCT intervention

Of 2458 children aged 7–14 from the poorest households in 2000, the average household PCE in that year was 81,190 rupiah/month (US$10). An additional 50,000 (about US$6) or 83,333 rupiah/month (about US$10) of CCT, depending on the child’s age, increased the average household PCE by about 70%. This cash transfer increased the average cognitive function z-score from 0.18 (95% CI 0.17–0.20) to 0.19 (95% CI 0.18–0.21). Of the 961
children from the poorest households in 2007 aged 14–15 or those aged 16–18 who had not completed 9 years of education, the average household PCE in that year was 219,847 rupiah/month (US$28) and the average cognitive function z-score was 0.17 (95% CI 0.16–0.19). An additional 83,333 rupiah/month (about US$10) of CCT, representing about 38% increase in household PCE, had no effect on cognitive function z-score. Moreover, we found no effect of CCT for the total population using these two scenarios.

Sensitivity analysis

Table 4 presents results of the sensitivity analysis. Our findings suggest that the unmeasured confounder could eliminate the effect of household PCE on cognitive function if the effect size of U was 1.43 and the prevalence of U was 0.40 or higher, where U is an early childhood intervention and it seems possible to have the unmeasured confounder with an effect size of 1.43. According to a meta-analysis by Nores and Barnett, the average effect size found across early childhood interventions on cognitive function was 0.31 (SD 0.20, minimum −0.05, maximum 1.43). However, to have prevalence of U ≥ 0.40 makes it implausible to have U that can eliminate the effect of household PCE on cognitive function.

Discussion

Our results suggest that cumulative household expenditure has a small causal effect on cognitive function in Indonesian children aged 7–14 and 14–22 in 2000 and 2007. Our findings are consistent with evidence suggesting that CCT programmes have a positive but small effect on children’s cognitive function.8,9 From our hypothetical intervention, a CCT involving increased household expenditure of 50,000 (about US$6) to 83,333 rupiah/month (about US$10) in 2000 increased the average cognitive function score by 0.01 SD: a small effect size by traditional metrics. This represents about 6% increase from the average cognitive function z-score prior to cash transfer. We also found that a CCT in 2000 had a larger effect than a CCT in 2007, possibly because a CCT in 2000 had a larger contribution to the average household PCE (70% vs 38%) and higher levels of coverage of children in the population (40% vs 16%). According to the World Bank, one of the reasons PKH had a small effect on participation in education services, such as enrolment rates and transitions to higher grades, was partly because the cash transfer was too small to benefit the target children.10 For example, to send a student to secondary school in Indonesia costs on average 2.8 million rupiah/year for education (equivalent to about US$28/month), which represents about 30% of the total household expenditure for those living in the poorest quintile of households.

Given the effect size of hypothetical cash transfer in this study, a cash transfer would need to be much larger than those used to have a substantial impact on children’s cognitive function. Under our first scenario, the estimated amount of cash transfer to shift the average cognitive function score of the poorest children in 2000 to the average population score is about 825,356 rupiah/child/month (about US$98). The national statistics show that the average annual growth of PCE between 2000 and 2013 has been about US$5/month (Figure 3). At current levels of national growth in PCE, assuming that household expenditure remains consistent across groups and assuming that the remainder of the population stay at current levels of cognitive ability, then it will take 20 years to reduce cognitive inequality between children in the bottom 40% of households and those in the reminder of the population. However, since it is unlikely that expenditure growth is equally distributed across the population, it may take longer for the poorest children to increase their cognitive score to the average level. For this reason, investment in child human capital through cash transfer alone could be very expensive. It is important to find other types of intervention programmes that may be more efficient in closing the inequality in children’s cognitive function. Our recent study found that in addition to household PCE, the largest contributors to inequality in Indonesian children’s cognitive function include access to improved sanitation and maternal education.11 Numerous studies suggest that early

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*aSensitivity parameter δ is the effect of unmeasured confounder (U).
*bSensitivity parameter γ is the prevalence of U.
*c dsc is the magnitude of bias, which is a product of δ and γ.
intervention programmes that have an educational component for children, caregivers or both, have a positive effect on various cognitive development outcomes in both low- and middle-income countries, as well as in high-income countries.

Another potential intervention that benefits child cognitive function is nutrition programmes, which may involve nutrition supplementation and nutrition education. Evidence from Nores and Barnett suggests that nutrition interventions had a larger effect on child cognitive function than cash transfer programmes (mean effect size was 0.26, SD 0.16 for nutrition, and was 0.17, SD 0.06, for cash transfer). They also found that provision of an integrated early childhood programme may yield greater benefit than a single intervention. However, a recent systematic review by Grantham-McGregor et al. failed to find any evaluations of programmes delivered at scale, in which the effects on children’s growth and development of integrating psychosocial stimulation into health and nutrition services were assessed. They argued that this is an urgent need. An integrated intervention programme that combined provision of nutrition, cash transfer, improved living conditions and educational components especially for young women may yield a greater effect in improving Indonesian children’s cognitive function. To a large extent, such an integrated intervention programme could also become part of a strategic plan to promote a better understanding of the social determinants of health and improving health equity in Indonesia.

Our study is subject to limitations. First, our measure of cognitive function was limited to data that were available in the IFLS, which might not be the best measure to capture the true cognitive ability of Indonesian children. Second, our findings should be interpreted with care. Use of standard regression models to estimate the effect of household PCE does not generally have a causal interpretation and may yield biased effect estimates. The first GEE model presented a crude association between household PCE and cognitive function, assuming there were no other factors that potentially confounded this association. Although the second model included all potential measured confounders, use of standard regression could not control the potential bias in the presence of time-varying confounding. Therefore our use of the MSM presents a more robust estimation with causal interpretation. However, estimates for our causal inferences are only true under the assumption of consistency, exchangeability and positivity, which are not guaranteed by design when using observational data. Third, it is plausible that there are variables that confound the relationship between household PCE and cognitive function that were not included in the analysis. To address the issue of potential bias in effect estimation due to unmeasured confounding, we conducted the sensitivity analysis. Fourth, our estimates assume that financial investments in children’s capability are drawn from their household’s expenditure. In our hypothetical CCT, we assume that targeted families would spend their CCT funds on their children’s education. When considering these two assumptions together, it is important to point out that the effect sizes could indeed be different if increases in household income were not invested in their children’s education (as we have assumed with the CCT).

In summary, household expenditure had a small positive effect on children’s cognitive function. Although a hypothetical cash transfer intervention had a positive effect on children’s cognitive function, the effect was very small. Interventions that combine cash transfer, improved living conditions and educational opportunities especially for young women may have greater benefit for the future of children’s cognitive development in Indonesia.

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