

## **Abstract**

Adverse weather shocks negatively affect health and child nutrition and the poorest populations in particular. Conditional Cash Transfer (CCT) programmes have been suggested to mitigate weather shock effects; however, little is known regarding child malnutrition. This study examines whether Program Keluarga Harapan (PKH), Indonesia's flagship CCT programme, mitigated negative impacts of extreme rainfalls caused by the ENSO event (La Niña) in 2010-2011. Specifically, it uses an instrumental variable to evaluate the impact of PKH on stunting (low height-for-age). Subsequently, it is interacted with a dummy variable that defines the weather shock. The results show that PKH is more effective at reducing stunting in the absence of the weather shock. However, PKH mitigates the negative effects of La Niña when the parents of a child are unemployed or illiterate, emphasising the potential of CCT for the most vulnerable.

## 1. Introduction

Child malnutrition is a global issue that primarily affects developing countries. It is estimated that 49% of deaths among children under five years of age are associated with undernutrition (World Health Organization 2021), which reveals vast health disparities. These inequalities between and within countries are reinforced by adverse weather shocks, perpetuating poverty (Gloede, Menkhoff, and Waibel 2015). Social protection programmes such as Cash Transfers (CT) aim to increase the wellbeing of their beneficiaries and have been suggested to mitigate the effects of negative weather shocks.

Among the several sub-forms of undernutrition, stunting is considered the best indicator of children's health and wellbeing as it reveals chronic undernutrition. The adverse effects of stunting (low height-for-age) are not limited to childhood and persist through adulthood (World Health Organization 2021; de Onis and Branca 2016). The negative consequences of stunting not only threaten communities in the short term but also harm countries' human capital in the long run, boosting social inequalities.

While stunting affects one-third of children under five years in developing countries (UNICEF 2007), extensive research has elucidated the factors and mechanisms that foster stunting, among the poor in particular (Vaivada et al. 2020). Consequently, it has been well established that retardation in linear growth is primarily caused by poor health settings, frequent infections, inadequate nutrition, and deficient care (de Onis and Branca 2016). It has also been suggested that weather variability, such as extreme precipitation and flooding, negatively affects children's nutrition, hence causing stunting (Lieber et al. 2022).

Climate change has triggered a shift in precipitation patterns. As a result, extreme hazards such as flooding are becoming more severe, and climate events such as El Niño Southern Oscillation (ENSO) are expected to become more frequent and intense (Hirabayashi et al. 2013; Dimitrova and Mutarak 2020; Cai et al. 2015). Those events can also disrupt crop production, interrupt food supplies, disturb economic systems and damage human health in different pathways (Watts et al. 2018). People living in extreme poverty do not usually have the means and tools to prevent, cope with and adapt to weather impacts; consequently, they are affected the most (Väänänen et al. 2019).

Governments globally have employed various actions to protect their most vulnerable populations from negative weather shocks, including expansion of financial inclusion, natural disaster relief funds, and weather shock insurance (Hallegatte et al. 2017). However, these strategies may not be good at targeting the weakest. Conversely, some social programmes that target the poor, such as CT programmes that hand cash to the poorest aiming to smooth consumption, have shown significant positive effects on nutrition, health, and education. CT are also being studied through the lens of helping vulnerable households and communities cope with weather shocks (Wood 2011; Väänänen et al. 2019).

The literature evaluating the effect of CT programmes in alleviating adverse weather shocks has shown positive results regarding household resilience (Premand and Stoeffler 2020), wellbeing (Carraro and Ferrone 2020), welfare and food security (Haile 2021; Asfaw et al. 2017), children's school attendance (de Janvry et al. 2006), and no increase in children labour (Fitz and League 2021). There are inconclusive results from the two largest CT programmes regarding children's health. For instance, *Bolsa Familia* in Brazil (League and Dylan 2022) has shown positive effects, and *PROGRESA* in Mexico shows no influence (Aguilar and Vicarelli 2022). Therefore, the impact of CT in mitigating the effect of extreme rainfalls or flooding on children's nutrition outcomes remains unknown.

In the last decade, the national prevalence of stunting in Indonesia has persisted at approximately 37% (Beal et al. 2018), which creates a fascinating setting to study. Additionally, the Government of Indonesia presented its first Conditional Cash Transfer (CCT) programme, Program Keluarga Harapan (PKH) in 2007 (Alatas 2011), inspired by successful CCT programmes in Latin America such as *Bolsa Familia* and *PROGRESA*. . During the PKH's pilot programme (2007-2013), Indonesia was hit twice by ENSO cold events (also known as La Niña), namely in 2007-2008 and 2010-2011. The second has been the strongest ENSO cold event in the past eight decades and affected regional precipitation levels (Boening et al. 2012).

This study aims to answer the question: What are the effects of the PKH programme on stunting in children that experienced an adverse weather shock? Additionally, to explore the conditions in Indonesia, this study examines the effects of the PKH programme on stunting and the impact of the La Niña event in 2010-2011 on stunting. Therefore, the CT programme and the weather shock are explored independently and in conjunction. The hypotheses are that PKH reduces the levels of stunting and that a weather shock will increase these levels.

The framework for malnutrition and background of the impact of weather shocks and CT programmes are presented in section 2. Section 3 describes the datasets used for this study and their limitations. Furthermore, section 4 describes the empirical strategy, followed by an examination of the main empirical results in section 5. Section 6 aims to explain those results and identify underlying mechanisms. Additionally, robustness checks for these results are described in section 7. Finally, section 8 concludes this study.

## 2. Background and framework

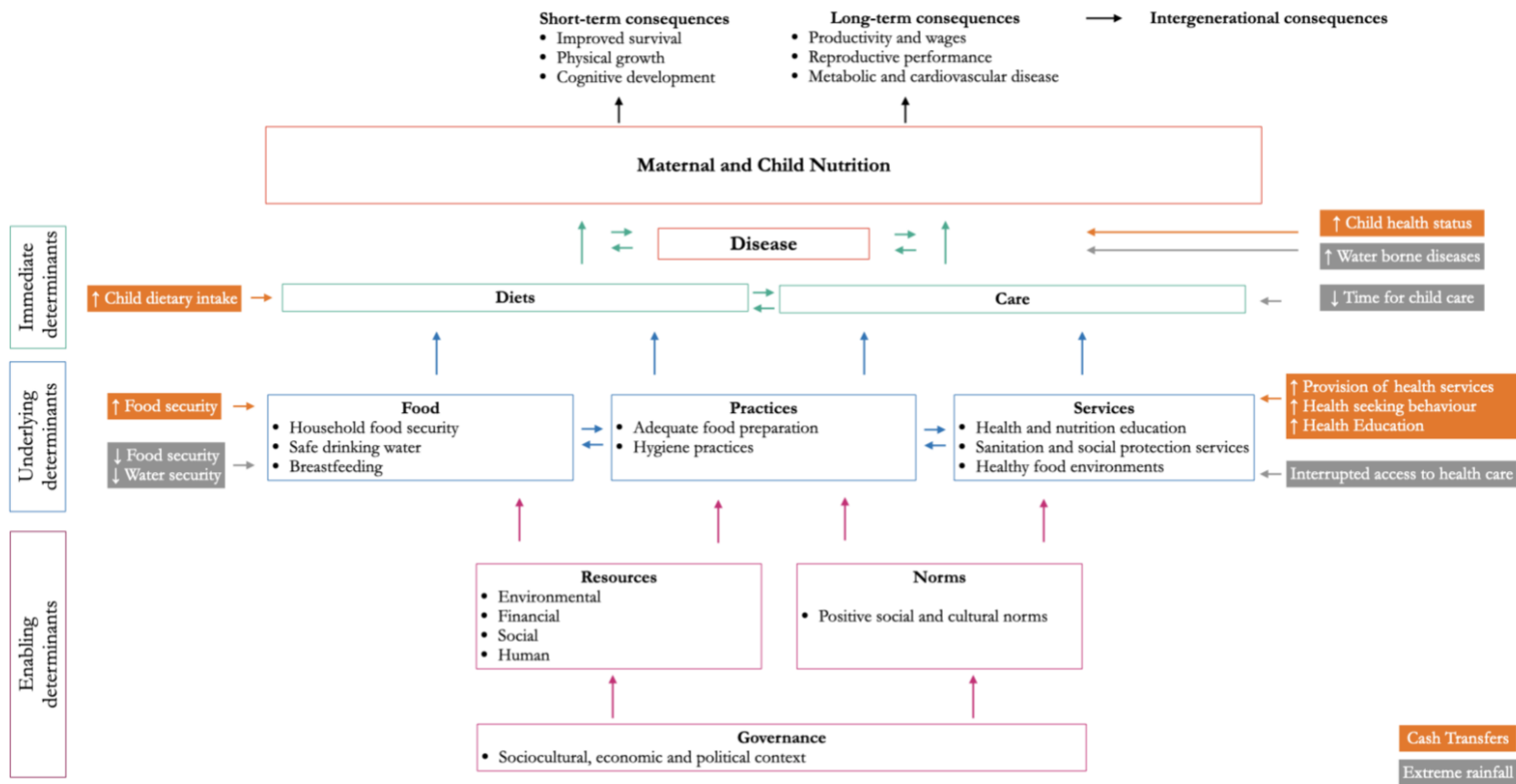
### 2.1 Childhood undernutrition

Childhood malnutrition, commonly referred to as malnutrition, is a health condition resulting from reduced dietary intake, which causes nutritional disequilibrium. It hence disrupts the body's normal functioning, but it is potentially reversible (Márquez-González and García-Sámano 2012). Malnutrition is an umbrella term for different categories of undernutrition predominant in children under five. The acute forms are underweight (low weight-for-the-age) and wasting (low weight-for-the-height). The chronic form of undernutrition is stunting, which is an indicator of linear growth, and stands for low height-for-age (World Health Organization 2021).

Stunting can begin in the first 1000 days after conception. It can start in utero and continue at least until the child is two years old. In this critical window, children who experience growth faltering can catch up with their peers; once the 1000-day threshold is crossed, recovery becomes a slow process (Victora et al. 2010). Low height-for-age is associated with susceptibility to infections, where frequent, successive infections lead to worsening nutritional status, creating a vicious cycle difficult to break (Olofin et al. 2013). Child stunting is frequently associated with male children, premature birth, short maternal height, and nonexclusive breastfeeding. However, other factors such as low maternal education, low socioeconomic status, unhygienic household conditions, and rural areas are also closely associated with low height-for-age (Beal et al. 2018).

The United Nations Children's Fund (UNICEF) developed a conceptual framework to further understand the social determinants and key indicators of maternal and child nutrition, where diets and care services are “immediate” determinants. Moreover, there are “underlying” and “enabling” determinants that play a role in these outcomes (Figure 1). The long-term consequences and intergenerational effects are also included in this framework (United Nations Children's Fund (UNICEF) 2021; Lenters, Wazny, and Bhutta 2016).

Figure 1. Child malnutrition framework



Authors adaptation of UNICEF framework. Orange boxes refer to pathways by which CT interfere in child nutrition. Gray boxes refer to the pathways by which weather shocks interfere in child nutrition

The consequences of stunting have been profusely studied and are not restricted to childhood. In the short term, stunting increases mortality and morbidity, and increases the risk of diseases and infection, particularly diarrhoea and pneumonia (Black et al. 2013; de Onis and Branca 2016). There are also cognitive delays; stunted children have poorer cognitive ability and are more likely to get lower grades and drop out of school (Soliman et al. 2021). Low growth-for-age during adolescence is associated with higher risk of obstetric complications (Özaltın, Hill, and Subramanian 2010). In the long term, there is an increased risk of arterial hypertension, obesity, reduced height, and less developed cognition, memory and locomotor skills (Dewey and Begum 2011).

Stunted children mainly belong to low socioeconomic status. As mentioned before, they are less likely to develop their cognitive skills thoroughly, and as adults are more likely to have lower incomes. Additionally, those children whose mother was stunted in her childhood are at higher risk of being stunted themselves. Stunting hence contributes to the intergenerational cycle of poverty (World Health Organization 2018), underlining the importance of maternal nutrition especially during pregnancy.

Despite the efforts to fight malnutrition in recent decades, prevalence of stunting remains high across low- and middle-income countries (LMIC) globally (World Health Organization 2018; Victora et al. 2010). It reflects overall children's wellbeing and reveals social inequalities (de Onis and Branca 2016).

## **2.2 Role of Cash Transfers in children's nutrition**

Malnutrition is a multifactorial entity; various underlying and enabling determinants are involved in the development of stunting, and several characteristics typical of poverty play an essential role. Therefore, programmes implemented in isolation might not reduce the stunting prevalence significantly. Tackling stunting programmes requires a holistic approach.

Some governmental strategies to reduce poverty and social vulnerability are social protection programmes that promote access to social and care services, social transfers and policies that guarantee equity (de Groot et al. 2015). These programmes help reduce chronic poverty, increase resilience among vulnerable households, support beneficiaries to meet their basic needs, and provide access to healthcare, nutritional support, and education. These programmes, specifically

CT, have been accepted as an important strategy to promote child nutrition by directly and indirectly addressing various malnutrition-related factors (Ruel and Alderman 2013).

CT programmes address several immediate and underlying determinants of undernutrition. They provide cash to poor and vulnerable households upon the beneficiaries meeting certain conditions. Cash recipients are commonly required to use healthcare and prevention services and maintain school-aged children in school, aiming to enhance human capital formation and break the intergenerational transmission of poverty (Leroy, Ruel, and Verhofstadt 2009).

After the success of CCT programmes in Mexico and Brazil, CCT soon became popular among governments and stakeholders and were replicated in other LMICs. However, the transfer value and requirements for the beneficiaries vary according to the capacity and budget of each government. For instance, cash transfer programmes in Latin America (LA) are usually tied to behaviours described previously. In contrast, programmes are typically unconditional in Sub-Saharan Africa (SSA) (de Groot et al. 2017).

Extensive research has evaluated the results of CT on health, nutrition, education, wellbeing, spillovers, women empowerment, et cetera. Literature has increasingly found positive results regarding nutritional outcomes. Therefore it is worth understanding the mechanisms by which CT programmes reduce stunting. De Groot et al. (2015) established a framework to explain these. They propose that CT programmes affect underlying determinants via three elements: increasing food security, health (increasing health-seeking behaviours and provision of health care services) and care (health education and women empowerment). On the intermediate determinants level, CT programmes help increase child's dietary intake and improve child health status (Figure 1).

For instance, it has been documented that CT improve household consumption in SSA and Latin America, showing increased intake of fruits, vegetables and protein-rich foods (de Groot et al. 2017). These programmes have also positively affected local markets by increasing demand of basic products (Mohammadi-Nasrabadi 2016). Moreover, children and pregnant women from households receiving CT benefits are more likely to attend preventative healthcare visits and general increase usage of the health care services (Lagarde, Haines, and Palmer 2009). In terms of care, the mental health of the caregiver is a relevant factor for children wellbeing, and it has been found that CT have a small impact on subjective wellbeing and mental health (McGuire, Kaiser, and Bach-Mortensen 2022).



As opposed to the underlying determinants, the intermediate determinants are factors concerning the individual's condition. There has been limited research to explore whether CT improve child dietary intake, and given the diversity of programmes, results are mixed (de Groot et al. 2017). Furthermore, it has been found that children beneficiaries of CT are less likely to be ill and indicate better health overall (de Groot et al. 2017). Finally, CT have been estimated to decrease diarrhoea incidence (Manley, Alderman, and Gentilini 2022).

Overall, CT reduce stunting prevalence by 1.4%, and the impacts on height-for-age z-score (HAZ) scores are small but statistically significant (Manley, Alderman, and Gentilini 2022). However, the child's age seems to play an important role; the effect appears larger in children under two years old. Each CT programme meets different criteria, length, conditionalities, and transfer size. Those characteristics should be considered when comparing CT programmes to each other.

### **2.3 Adverse weather shocks**

The impact of weather shocks on human health has been studied for decades. For example, exposure to rainfall and temperature variability early in life has adverse effects on cognitive development and education (Adhvaryu et al. 2018), worsens mental health (Adhvaryu et al. 2015) and increases risk of unemployment (Adhvaryu et al. 2018). Remarkably, exposure to extreme rainfall and flooding significantly increases the risk of stunting (Lieber et al. 2022; Phalkey et al. 2015). Individuals who experienced a weather shock in utero or during childhood preserve those negative effects through adulthood (Cornwell and Inder 2015).

Sudden weather-related disasters might affect children's health in three ways: 1) physical health, including lack of food security, increased of infectious diseases, contaminated drinking water and disrupted access to health care; 2) mental health; and 3) abandoning education and being forced into labour (Kousky 2016). Most of these factors can be integrated into UNICEF's framework for child nutrition (Figure 1).

Variation in rainfall and flooding affects crop harvest and decreases the productivity of the land, hence causing shortages of food (Phalkey et al. 2015). Consequently, regional food systems may increase food prices, leading to food insecurity for the poorest households (Brown and Kshirsagar 2015). However, weather-induced disruptions to children's nutrition can also occur even if there is no disruption of agriculture (Thiede and Gray 2020). For instance, disasters can interrupt access to medical care because of damage to clinics or road infrastructure (Kousky 2016). Also, it has

been found that flooding leads to water contamination and therefore water insecurity (Rosinger 2018). Similarly, the increase of rainfall boosts the prevalence of vector-borne diseases such as malaria and dengue (Campbell et al. 2015). Additionally, shocks may alter domestic roles and labour supply. In rural contexts with gendered division of labour, the demand for women's labour is increased and reduces the time available for childcare (Thiede and Gray 2020).

It is worth noting that the groups most vulnerable to natural hazards are those that have high exposure to them. In general, they tend to be the poorest, women, children, and marginal communities (Tirado et al. 2013).

Finally, climate change has caused an alteration in precipitation patterns and increased the frequency and magnitude of floods (Hirabayashi et al. 2013). Climate phenomena such as the El Niño Southern Oscillation (ENSO) are notable fluctuations in the climate worldwide causing tropical rainfall variability. ENSO has two conditions: cold (La Niña) and warm (El Niño). While this event occurs intermittently (every 2-7 years), it has had devastating consequences for agriculture and infrastructure, and displaced many people in vulnerable areas. Predictions are that climate change will only increase the frequency and intensity of this phenomenon (Cai et al. 2015; Rodysill et al. 2019; Tang et al. 2018).

#### **2.4 The function of Cash Transfers in mitigating weather shocks**

Weather-related disasters have direct economic effects on households that rely on farm activities for income; this increases their vulnerability to droughts and floods. The most evident consequences are the destruction of property, cattle, productive assets and infrastructure (Wisana 2015). Poor households do not have the means to cope with shocks. Additionally, they receive less support from financial instruments, private remittances and social protection programmes (Hallegatte et al. 2017). They have developed mechanisms to smooth their consumption, such as increasing family labour supply, reducing investments in education and health, selling assets, and activity diversification. However, these strategies do not promote sustainable development and create a vicious cycle of poverty (Schäfer et al. 2016).

There are numerous instruments used to protect households at risk of weather shocks. One of them is enhancing financial inclusion, aiming to diversify vulnerable households' assets and economic activities. For instance, credit promotes a fast reconstruction of assets, private insurance against disasters offers protection to families at risk. However, these tools have substantial

limitations among the poorest. CT have been contemplated as a way to compensate for those limitations and improve resilience among the poorest (Hallegatte et al. 2017).

Wood (2011) postulates a framework by which CT can provide relief in weather-related shocks, and this is adapted into the child nutrition framework (Figure 1). CT can support vulnerable households by 1) helping them meet existing needs and reducing the impacts of weather shocks since CT cover basic needs, the provision of food security and access to health care is ensured; 2) CT provide the financial means to endure shocks; 3) CT reduce the pressure for households to engage in negative strategies, such as cutting budget for healthcare. Furthermore, Carraro and Ferrone (2020) propose that CT can influence children's nutritional status directly via the income effect or indirectly via the household's coping capacity (reducing food security, increasing child labour or promoting migration of the working age members).

The literature evaluating the effect of CT programmes in alleviating shocks has shown positive results. Children's school attendance was not disrupted by unemployment or illness of family members in the presence of CT (de Janvry et al. 2006). Multidimensional deprivation is not affected in the case of a self-perceived shock (Carraro and Ferrone 2020). In the case of weather shocks, CT have positively impacted household resilience (Premand and Stoeffler 2020), welfare, food security (Haile 2021) and consumption smoothing (Vicarelli 2011) in the case of droughts. Other studies assessing both edges of extreme rainfall variation (wet and dry) have found that CT increase food security (Asfaw et al. 2017), improve school grades, and prevent children from dropping out of school and moving into labour (Fitz and League 2021).

However, few studies evaluate the impact of extreme rainfall and floodings on children's health, and their results are inconclusive. A study examining the effects of *Bolsa Familia* in Brazil showed positive effects on reducing stunting, obesity, and other adverse health outcomes. It is also found that the CCT is most effective on children when the shock happened in utero (League and Dylan 2022). Conversely, a study evaluating the effect of extreme rainfall caused by the phenomenon "El Niño" on beneficiaries of *PROGRESA* in Mexico shows that children's cognitive development is not protected by the CCT program (Aguilar and Vicarelli 2022). Thus, the effect of CCT in mitigating the impact of negative weather shocks such as extreme rainfall or flooding on child nutrition remains unclear.

## 2.5 Indonesia – case study

One region in the world that has high prevalence of stunting is East Asia and the Pacific, where 21 million children under five years old are stunted (Drummond, Watson, and Blankenship 2021). Among those countries, Indonesia shows a prevalence of stunting much higher than other countries (Soekatri, Sandjaja, and Syauqy 2020). Despite the efforts to fight malnutrition, high disparities between provinces persist and the national prevalence of stunting continued at approximately 37% in the recent decades (Beal et al. 2018).

The high prevalence of stunting in Indonesia is also reflected in the country's poverty incidence and vice versa. In 2007, 16.65% of inhabitants lived in relative poverty, and 39 million citizens lived in absolute poverty, primarily in rural areas (Aji 2015). In that same year, the Government of Indonesia presented its first CCT programme, Program Keluarga Harapan (PKH), to improve the wellbeing of the poorest. The PKH programme was assessed using a randomised control trial. Three hundred sixty subdistricts evenly divided into control and treatment groups were surveyed. Follow-up surveys took place in 2009 and 2013 (Alatas 2011).

During the PKH's pilot programme (2007-2013), Indonesia was hit twice by the ENSO phenomenon “La Niña”, in 2007-2008 and 2010-2011. The second has been the strongest ENSO cold event in the past eight decades and affected regional precipitation levels (Boening et al. 2012). In Indonesia, the drier conditions of the ENSO phenomena occur during El Niño and wet conditions during the La Niña (The World Bank 2021). Given its location on the equator, precipitation is the element of weather that has the most variation in Indonesia, and the temperature barely fluctuates (Levine and Yang 2014). Therefore, this weather shock is associated with rainfall only.

The consistent high prevalence of stunting, the PKH pilot implementation, and the La Niña event create a natural experiment in Indonesia. This serves to evaluate the effect of extreme rainfall caused by La Niña on CCT beneficiaries, particularly stunted children.

### 3. Data and descriptive statistics

The present study uses two large datasets to evaluate heterogeneous impacts of CCT programmes on children's health in populations affected by negative weather shocks. The datasets are Indonesia's CCT's pilot dataset and the monthly precipitation per district data.

#### 3.1 PKH programme

In 2007, the Government of Indonesia launched its first CCT programme, PKH. This social programme aimed to reduce poverty by improving the welfare of extremely poor households. The nature of its design promoted low-income families to escape intergenerational poverty (Alatas 2011). In addition, the initiative stimulated the development of human capital (especially children and pregnant women) by encouraging beneficiaries to attend school and visit health clinics regularly (Dulkiah, Avid, and Irwandi 2018).

The PKH's pilot program was implemented in seven provinces\*, and this selection ensured diversity of the regions for national representativity. The targeted regencies (*kapupaten*) were those with a high incidence of poverty and malnutrition and a low transition rate of education from primary to secondary school. Districts (*kecamatan*) that were "supply-side ready" were randomly selected for participation in the pilot program (Alatas 2011); 438 subdistricts were assigned to treatment and 298 to control. Consequently, targeted households were those listed in other social programme catalogues and classified as extremely poor using a proxy-means test. Lastly, households that met the eligibility criteria such as having children aged 0-15 years, and/or children less than 18 years old but that had not yet completed nine years of basic education, and/or pregnant/lactating women, were included in the pilot programme (Sparrow 2008).

The female head of the eligible household received quarterly cash transfers based on the number of children, their ages, and if there was a pregnant or lactating woman in the household. The maximum transfer per household was 2,200,000 rupiah (approximately 150 USD today) per year. It was aimed to provide the equivalent of 15-20% of the estimated yearly consumption of poor households (Alatas 2011).

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\*The administrative subdivisions of Indonesia are provinces composed of regencies (kabupaten). Regencies are divided into districts (kecamatan), these are made of villages (desa or kelurahan).

The beneficiaries received cash transfers conditional on meeting the requirements stated at the beginning of the programme. For homes with children up to 6 years old, the conditions focused on ensuring children's healthy development, including complete immunisation, vitamin A uptake twice a year and growth and health check-ups. Figure 2 outlines the complete list of conditionalities (Sparrow 2008).

**Figure 2. Conditionalities of the PKH**

<b>Household Members</b>	<b>Conditionality</b>
<b>Households with pregnant/lactating women</b>	Complete 4 pre-natal visits and take iron tablets during pregnancy Give birth assisted by a trained professional Lactating mothers: complete 2 post-natal care visits
<b>Households with children aged 0-6 years</b>	Ensure children have all immunizations and take Vitamin A twice a year Children are taken for growth monitoring check-ups. (Monthly for those up to 11 months old, quarterly for children 1-6 years old)
<b>Households with children aged 6-15 years</b>	Enrol child in primary/secondary school and ensure minimum of 85%.
<b>Households with children aged 16-18 years</b>	Enrol child in an education programme to complete 9 years of schooling

*Source: Adapted from Alatas (2011)*

The raw survey data of the PKH's pilot is publicly available, provided by Cahyadi et al. (2020). Data regarding children's health, household and village characteristics of control and treatment groups are used for this study. This data set collects the baseline survey before the CCT was implemented (2007), the evaluation survey by the World Bank two years after (2009), and a third survey wave by Cahyadi et al. (2020) following the same structure as the former waves. Household attrition was low; 95.1% of the household surveyed at baseline were still found in the last survey (Cahyadi et al. 2020) (See section 7.4).

At baseline, the final sample is balanced across a wide range of key variables between the control and treatment groups. Column 4 of table 1 shows the average differences between these groups. The standard error is clustered by sub-district according to the level of randomisation as suggested in the literature (Colin Cameron and Miller 2015). None of these variables show statistically significant differences at the 10 per cent level, suggesting no difference between the groups.

**Table 1. Balance test of the PKH randomization**

	(1) Observations	(2) Control Mean	(3) Treatment Mean	(4) Treatment Effect (No controls)
<i>Panel A</i>				
Number of doctors per subdistrict per capita	2,704	0.000	0.000	0.000 (0.000)
Number of nurses per subdistrict per capita	2,711	0.000	0.001	0.000 (0.000)
Number of primary schools per subdistrict per capita	2,708	0.001	0.001	0.000 (0.000)
Rural village	2,723	0.897	0.922	0.025 (0.028)
Household expenditure per capita (log)	14,326	12.034	12.020	-0.014 (0.019)
Household size	14,326	5.155	5.115	-0.040 (0.079)
Household's total of livestock owned	14,326	3.360	3.148	-0.212 (0.240)
Female	6,153	0.483	0.495	0.012 (0.013)
Age (years)	6,152	0.841	0.864	0.023 (0.024)
Height-for-age (z score)	6,003	-2.141	-1.841	0.300 (0.144)
Stunting	6,003	0.504	0.466	-0.037 (0.018)
Severe stunting	6,003	0.330	0.282	-0.048 (0.019)
Complete immunization by age	6,088	0.339	0.346	0.008 (0.021)
Diarrhoea last month	6,139	0.261	0.275	0.014 (0.015)
Fever or cough last month	6,142	0.623	0.645	0.021 (0.017)
<i>Panel B</i>				
<i>Weather shock (ZSI&gt;1.5)</i>	6,080	0.722	0.722	0.00 (0.049)
<i>Weather shock (ZSI&gt;2)</i>	6,080	0.549	0.551	0.002 (0.054)
<i>Weather shock. (ZSI&gt;3)</i>	6,080	0.180	0.195	0.016 (0.044)

*This table reports the balance test for the randomization of the programme at baseline (2007). Standard errors, in parentheses, are clustered by sub-district. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$*

The main outcome of interest is stunting, which is a widely used indicator for impaired growth and children's development (World Health Organization 2015). Height-for-age z-score (HAZ) is calculated according to the age and gender of the child using STATA macro "igrowup" (World Health Organization 2022). Z-scores in malnutrition are used to illustrate the individual status of the child in relation to the population used as the reference standard. Moderate stunting takes z-score values between -2 and -3, and severe stunting less than -3 (Mehta et al. 2013). Even though stunting is the primary outcome variable, HAZ scores are also explored to visualise the spectrum for low height-for-age, as described by Ledlie et al. (2018).

This extensive panel data set is therefore fundamental for this study. Table 2, panel A shows summary statistics for the most relevant variables of the study sample: those who were CCT beneficiaries by the end of the PKH's pilot programme.

**Table 2. Summary statistics of key variables**

VARIABLES	(1) N	(2) Mean	(3) Standard Deviation	(4) Min	(5) max
<i>Panel A. PKH variables</i>					
Age (years)	3,858	1.635	1.442	0	5
Female	3,858	0.503	0.500	0	1
Complete immunization	3,551	0.469	0.499	0	1
Height-for-age z score (HAZ)	3,858	-1.240	1.815	-5.970	5.830
Stunting (HAZ score < -2)	3,858	0.346	0.476	0	1
Severe stunting (HAZ score < -3)	3,858	0.141	0.348	0	1
Had diarrhoea last month (<5 years)	3,852	0.219	0.413	0	1
Had fever or cough last month (<5 years)	3,858	0.541	0.498	0	1
Household has clean drinking water	3,858	0.115	0.319	0	1
Household has electricity	3,858	0.884	0.320	0	1
Head of household work in agriculture	5,075	0.622	0.485	0	1
Monthly household expenditure per capita (log)	5,075	11.45	2.569	0	13.78
Household size (log)	5,075	1.592	0.496	0	3.135
Caretaker is literate	5,075	0.757	0.429	0	1
<i>Panel B. Weather shocks</i>					
Weather shock if ZSI >1.5	5,075	0.683	0.465	0	1
Weather shock if ZSI >2	5,075	0.556	0.497	0	1
Weather shock if ZSI >2.5	5,075	0.196	0.397	0	1

*Note: this table reports summary statistics of the sample used (2013)*

### 3.2 Precipitation data

Extreme rainfall impact on PKH beneficiaries is evaluated in this study using a dummy variable that is constructed as follows.

Firstly, monthly precipitation data is provided by the Climate Research Unit Time Series (CRU-TS) of the University of East Anglia (Harris et al. 2020), which provides total monthly precipitation data on a 0.5° latitude by 0.5° longitude resolution statistically interpolated. This gridded data has the advantage that it does not contain any missing observations at certain locations (Auffhammer et al. 2013). Data from 1980 to 2013 is spatially matched to Indonesian districts and extracted using IPUMS-Terra (Ruggles et al. 2018).

This study uses the "standardised anomaly" or Z-score index (ZSI), a versatile tool that analyses wet and dry periods and shows the extent to which precipitation varies from its average state. It compares a given observation to the same location's long-run average precipitation and is



normalised by the standard deviation (Y. Li et al. 2019). It is calculated using the following equation:

$$Z = \frac{X_i - \bar{X}}{\sigma} \quad (1)$$

Where  $X_i$  is the observed precipitation in district  $d$ , in year  $t$ ;  $\bar{X}$  is the long-term average; and  $\sigma$  is the standard deviation of the long-term frame (Noor et al. 2020). For the wet spectrum, a ZSI > 1.44 is considered wet, while ZSI > 1.96 is extremely wet (X. Li, Zhang, and Ye 2013). This index has been used inconsistently in the literature. Some studies use a standard deviation above one to identify positive rainfall shocks (League and Dylan 2022). In contrast, other studies use this same threshold to define flood shocks (Carrillo 2020; Adhvaryu et al. 2018). Lastly, a study evaluating extreme rainfall on corn production defines extreme rainfall conditions as a precipitation anomaly of 2.5 (Y. Li et al. 2019). As a result, this study uses an arbitrary ZSI of >2 as a threshold to determine an adverse rainfall shock, to avoid including positive effects of precipitation.

Note that when calculating the annual rainfall average, this study uses wet-dry season years instead of calendar years, which is closely related to agricultural cycles. Since the primary production of rice and corn is aligned with the seasonality of the rain (International Production Assessment Divison n.d.), the significant link between rainfall and crop production has been well documented (Naylor et al. 2007). For that reason, in this study, the "year" starts with the first month of the "dry" season of a given province and finishes the last month of the wet season. The definition of season year per province is provided by Maccini and Yang (2009).

The last cold ENSO event categorised as 'strong' happened in 1999-2000. It is assumed that if there was rainfall variability caused by the La Niña in 2010-2011, it will be reflected in the ZSI. Therefore if 2010 or 2011 season years had a ZSI >2, a value of 1 is assigned to the "weather shock" variable. This new variable is set at the district level, and it is matched to the individuals according to the district of residence, available in the PKH dataset.

Table 3 shows the balance test for the individuals who experienced the weather shock and those who did not. Column 1 shows the summary statistics of the most relevant variables for the population who suffered the weather shock, and column 2 shows those who did not. None of the variables are statistically significant. Consequently, it can be assumed that a weather shock is a

random event. Panel B of table 2 shows that weather shocks affected the population in the PKH pilot, regardless of the assignment of treatment or control.

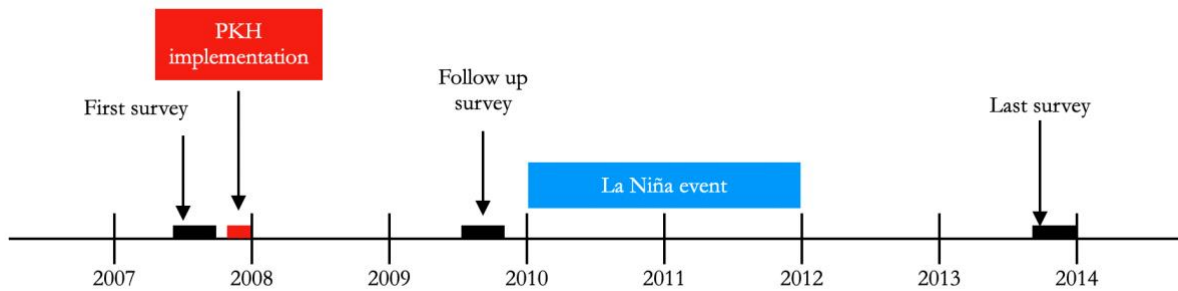
**Table 3. Balance test of Weather Shock ( $ZSI > 2$ )**

	(1) Observations	(2) Control Mean	(3) Weather shock Mean	(4) Treatment Effect (No controls)
Number of doctors per subdistrict per capita	6,028	0.000	0.000	0.000 (0.000)
Number of nurses per subdistrict per capita	6,051	0.001	0.001	0.000 (0.000)
Number of primary schools per subdistrict per capita	6,042	0.001	0.001	0.000 (0.000)
Rural village	6,080	0.872	0.939	0.067 (-0.03)
Monthly household expenditure per capita (log)	6,080	11.94	11.921	-0.019 (-0.021)
Household size	6,080	5.986	5.855	-0.131 (-0.11)
Household's total of livestock owned	6,080	2.847	3.67	0.822 (-0.311)
Female	6,080	0.499	0.481	-0.019 (-0.013)
Age (years)	6,069	0.86	0.841	-0.019 (-0.024)
Height-for-age (z score)	5,936	-1.834	-2.12	-0.286 (-0.114)
Complete immunization by age	6,015	0.326	0.353	0.027 (-0.021)
Diarrhoea last month	6,066	0.274	0.261	-0.013 (-0.015)
Fever or cough last month	6,069	0.665	0.605	-0.06 (-0.017)

*This table reports the balance test for the randomization of the programme at baseline (2007). Standard errors, in parentheses, are clustered by sub-district. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$*

### 3.3 Data pitfalls and assumptions

The WHO measures malnutrition z-scores for children up to 5 years old (World Health Organization 2006). Thus, low height-for-age z-scores obtained in the last survey represent children born between 2009 and 2013 and those children screened in 2007 are not included. However, the pathways in which weather shocks affect children's health and nutrition do not necessarily need to occur in the post-birth stage. Therefore, this study assumes that the weather shock that happened in 2010-2011 also affects those born after. Figure 3 visually explains the order of events.

*Figure 3. Timeline of the events studied*

Moreover, enrolment into the PKH programme did not strictly follow the initial random assignment. First, there were further household screenings to determine PKH eligibility after randomisation. Additionally, by 2013 the programme was active in 99% of the treatment and 39% of control group (Cahyadi et al. 2020). Therefore, enrolment into the PKH programme may be correlated with other confounders at the household-level. Thus, this variable may suffer from endogeneity, and additional treatment is necessary.

Additionally, the verification systems in charge of validating compliance and recalculating benefits (including new-borns, excluding those who turned 18, etc.) were not operating until 2010; therefore, compliance was not enforced. Nevertheless, the World Bank report states facilitators ensured that the beneficiaries acknowledged the conditions and were aware of the risk of losing their payments (Alatas 2011). However, Cahyadi et al. (2020) state that conditions were not always enforced even after verification systems were functional. The inconsistent verification of compliance could lead to different behaviours among beneficiaries. Yet, "labelled cash transfers" have been found to yield similar outcomes to those programmes that actively enforce conditionalities (Heinrich and Knowles 2020; Benhassine et al. 2015). This study assumes that the roll-out of verification systems and facilitators' skills to share the purpose of the cash was uniform in all villages.

The PKH data set does not provide names and locations of villages and districts to safeguard the identity of the respondents; therefore, the rainfall must be matched at the regency level. Additionally, rainfall data might suffer from aggregation bias which suggests that such temporal and spatial aggregation might not reflect the weather conditions appropriately in the entire district (Auffhammer et al. 2013). However, other studies in Indonesia have faced this issue yet found a significant effect of rainfall on children's health (Cornwell and Inder 2015).

## 4. Empirical strategy

First, this study evaluates the effect of the PKH programme on children's stunting. Then, it explores the impact of extreme rainfall on stunting in Indonesia. Finally, it examines the capability of PKH to mitigate weather shock effects on stunting.

### 4.1 Effect of the PKH

As explained above, the variable that accounts for receiving the PKH benefits suffers from endogeneity, given that compliance with the original randomisation assignment was not completely satisfied. Thus, an instrumental variable (IV) addresses this endogeneity. Initial random allocation is used to instrument the enrolment into the PKH programme as specified in the evaluation of the PKH pilot programme (Cahyadi et al. 2020) and suggested for randomised experiments elsewhere (Angrist and Krueger 2001).

Therefore, the correlation between stunting and receiving PKH's benefits is estimated using a 2-Stage Least Squares (2SLS) approach. To assess if a child  $i$ , in household  $h$ , in a village  $v$ , in subdistrict  $s$ , in district  $d$ , is a PKH recipient ( $PKH_{ihvsd}$ ), the regression for the first stage is as follows:

$$PKH_{ihvsd} = \alpha + \beta_1 Randomisation_s + \delta X_i + \eta X_h + \gamma X_v + \mu_d + \varepsilon_{ihvsd} \quad (2)$$

Where  $Randomisation_s$  stands for the original randomisation assignment and indicates whether the household was assigned into the treatment group. To increase the precision in the results, individual controls ( $X_i$ ), household controls ( $X_h$ ) and village controls ( $X_v$ ) are included. Individual controls account for the age and gender of the child. Household controls and village controls comprise variables that may influence children's health (social determinants of health); these values are obtained from the first wave, before the pilot programme was implemented as suggested in the literature (Cahyadi et al. 2020). Such controls are the natural logarithm for household size and expenditure, whether the caretaker is literate and is employed in agriculture, access to clean drinking water, and whether the household has access to electricity and improved latrine. At the village level, the average of stunted children, and whether the village is considered rural or urban are variables controlled for.  $\mu_d$  are regency (kabupaten) fixed effects that control for potential additional programmes, policies, and other state factors. Standard errors are clustered at the district level, which is the level of randomisation of the programme (Colin Cameron and Miller 2015).

The estimation of  $PKH_{ihvsd}$  is used in the second stage regression as follows:

$$Y_{ihvsd} = \alpha + \beta_1 \widehat{PKH}_{ihvsd} + \delta X_i + \eta X_h + \gamma X_v + \mu_d + \varepsilon_{ihvsd} \quad (3)$$

Where  $Y_{ihvsd}$  is the dummy variable "stunting" that takes a value of 1 if the HAZ score is between -2 and -3 standard deviations and 0 otherwise, of a child  $i$ , in household  $h$ , living in a village  $v$  of subdistrict  $s$ , of district  $d$ , as. The primary outcome to be analysed is stunting; however, extreme stunting and HAZ scores are also explored to account for changes in each category (Kandpal et al. 2016). The same controls as in the first stage are used for consistency and precision.

#### 4.1.1 Instrument validity

Two assumptions must be met for an instrument to be valid, namely 1) it must be relevant and cause variation in the treatment variable, and 2) it should not have a direct effect on the dependent variable (only via the treatment variable). This allows the researchers to estimate the level of exogenous variation (Newhouse and McClellan 1998).

The first assumption proves valid in table 4, showing the first stage results. It is found that households initially assigned to the treatment group are 40.5% more likely to have received the PKH benefits after six years. The high value of the F-test provides the confidence to reject the null hypothesis that the instrument is weak.

**Table 4. First stage results**

VARIABLES	(1) Received CCT
Initial randomization assignment	0.405*** (0.149)
Constant	-1.919*** (0.085)
Observations	5,075
R-squared	0.1986
Adjusted R-squared	0.1942
F- test	242.739

*Standard errors and F-test are clustered by regencies (districts).  
Standard errors are in parenthesis \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

The second assumption implies that the instrument must be exogenous, and that the randomisation assignment should not be correlated with the prevalence of stunting but only via CCT receipt. Here, there are two main potential concerns: across and within districts spillovers.

During the PKH's pilot sample selection, subdistricts that statistically had sufficient health and education services were included in the sample (Sparrow 2008), therefore those services are contained within each subdistrict, and spillovers are not likely to occur in this context. Randomisation was performed at this level for this reason (Cahyadi et al. 2020). Spillovers across subdistricts are also unlikely in this setting given the specific targeting of the PKH programme. Hence a small portion of households in the standard village assigned to control were treated (6.5% of households). General equilibrium effects such as overcrowding health clinics and schools are likely to be small in this scenario (Cahyadi et al. 2020).

These arguments support the two assumptions to corroborate that initial randomisation assignment into the PKH's pilot program is a valid instrumental variable for PKH treatment.

## 4.2 Effect of adverse weather shocks

The evaluation of the impact of weather shocks on the health of children under five years using the following regression for child  $i$ , in household  $b$ , in a village  $v$ , in subdistrict  $s$ , in district  $d$ :

$$Y_{ihvsd} = \alpha + \beta_1 Shock_d + \delta X_i + \eta X_h + \gamma X_v + \mu_s + \varepsilon_{ihvsd} \quad (4)$$

Where  $Y_{ihvsd}$  is the health outcome as defined before.  $Shock_d$  is a dummy variable that takes the value of 1 if the district suffered from extreme precipitation in 2010-2011 and 0 otherwise. Extreme precipitation is considered if the ZSI >2. The controls and fixed effects are used as in the previous models in this study.

## 4.3 Full model

To assess the interaction between receiving the benefits of PKH and the negative weather shock on children's nutrition, the full model is used:

$$Y_{ihvsd} = \alpha + \beta_1 Shock_d + \beta_2 \widehat{PKH}_{ihvsd} + \beta_3 Shock_d \widehat{PKH}_{ihvsd} + \gamma X_i + \delta X_h + \delta X_d + \varepsilon_{ihvsd} \quad (5)$$

Where,  $Y_{ihvsd}$  represents if a child  $i$  living in household  $h$ , in a village  $v$ , in subdistrict  $s$ , in district  $d$  is stunted.  $Shock_d$  represents the dummy variable explained above.  $\widehat{PKH}_{ihvsd}$  is the instrumented PKH receipt.  $Shock_d \widehat{PKH}_{ihvsd}$  represents the interaction term between rainfall shocks and receiving PKH benefits. The standard errors are clustered at the regency level, the highest level of randomisation defined by rainfall.

$\beta_1$  coefficient measures the effect of the rainfall shock on stunting on those who were not CCT beneficiaries, which is expected to be positive (i.e. increase stunting). Whereas  $\beta_2$  coefficient represents the effect of receiving PKH on the outcome variable and that population did not experience the weather shock, which is estimated to be negative.

Lastly, the coefficient of interest,  $\beta_3$  estimates the additional effect of receiving cash transfer in the presence of a negative rainfall shock.  $\beta_3 > 0$  indicates that PKH is more effective on those who had not experienced the La Niña 2010-2011, and  $\beta_3 < 0$  indicates that PKH is more effective on those who were affected by the weather shock. Additionally, if  $\beta_1 + \beta_3 > 0$  there is partial recovery of stunting and if  $\beta_1 + \beta_3 > 0$  there is full recovery.

#### 4.3.1 Proving similar conditions

This study assumes that the weather shock is a source of exogenous variation, given that this event was the strongest in Indonesia in decades. The balance test of the weather in table 3 and Panel A of table 2 demonstrates that the group that experienced the weather shock has similar characteristics to the group that did not, affecting equally the treatment and the control group of the PKH's pilot programme.

To increase the robustness of this assumption, a t-test (Table 5) was performed on the HAZ score in the sample at baseline. The p-value lower than 0.05 demonstrates that there were no significant differences in baseline between the group that was later affected by a weather shock and the one that did not. Furthermore, the distribution of the HAZ score is normal and similar in those who experienced the weather shock and those who did not (Table A1).

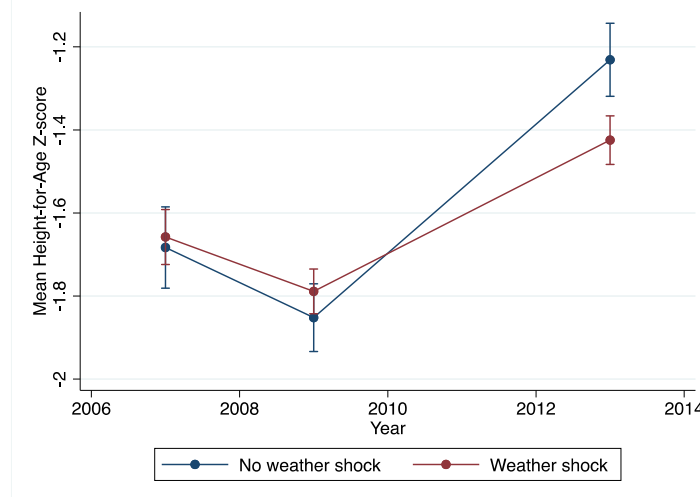
**Table 5. T-test on HAZ score at baseline**

	Observations	Mean	Standard Error	Standard deviation	95% confidence interval	
No weather shock	2,504	-1.551	0.040	1.984	-1.628	-1.473
Weather shock	3,008	-1.760	0.039	2.154	-1.837	-1.683
Combined	2,794	-1.665	0.028	2.081	-1.720	-1.610
Difference		0.209	0.056		0.099	0.320
			$t = 3.7247$			
			$p\text{-value} = 0.0002$			

*This test looks only at beneficiaries of the PKH programme.*

Additionally, both groups followed almost parallel trends regarding HAZ levels through 2007 and 2009 (Figure 4). However, there are not enough data points to create a robust difference in difference identification strategy.

**Figure 4. Mean HAZ scores through the years of study.**



Thus, there were similar child nutrition conditions at the baseline and during the second survey in both groups. These considerations provide strong arguments to suggest that the weather shock is a source of exogenous variation, and it is highly correlated to nutritional outcomes.



## 5. Results and discussion

This section describes the empirical results of the strategy previously described. The first section presents the summary statistics of stunting. The second section explores the isolated effect of the PKH programme on the outcome variable, followed by the isolated effects of negative rainfall shocks on stunting. Finally, section four evaluates adverse weather shocks' interaction with CCT recipients.

### 5.1 Low height-for-age in Indonesia

Several studies have identified the risk factors associated with stunting in Indonesia (Beal et al. 2018; Torlesse et al. 2016). These factors are briefly explored to understand the heterogeneity of the results of this study.

The summary statistics for stunting at the end of the pilot programme are shown in table 6. It is found that the oldest children in the sample are the most stunted. Additionally, children living in households where the caretaker is literate and employed in the agricultural sector are less stunted than children from an opposite situation. Infants that do not have access to an improved latrine, clean drinking water or electricity services are more stunted than children with better household conditions. These findings are consistent with other studies in and outside Indonesia (Beal et al. 2018; Torlesse et al. 2016; Utami, Setiawan, and Fitriyani 2019) and other LMICs (Amadu et al. 2021; Danaei et al. 2016).

The child's gender is relevant as girls are less stunted than boys. This result is expected given that boys are more vulnerable to infectious diseases such as respiratory infections, diarrhoea, and malaria and are more likely to be preterm at birth, increasing male morbidity, mortality, and weight loss. Also, boys have a higher calorie that requires more resources to meet (Wamani et al. 2007). However, how those biological mechanisms interact with social conditions and affect stunting has not been sufficiently studied (Thurstans et al. 2020).

**Table 6. Summary statistics for stunting and HAZ**

Variable	Category	Frequency (%)	Stunting		HAZ	
			Mean	Standard deviation	Mean	Standard deviation
Age (months)	0-12	24%	0.161	0.367	-0.355	1.865
	13-24	20%	0.390	0.488	-1.404	1.902
	25-36	18%	0.427	0.495	-1.655	1.530
	37-48	20%	0.452	0.498	-1.828	1.488
	48-60	17%	0.471	0.499	-1.880	1.417
Sex	Male	50%	0.385	0.487	-1.423	1.791
	Female	50%	0.350	0.477	-1.303	1.752
Access to improved latrine	No	53%	0.386	0.487	-1.406	1.812
	Yes	47%	0.347	0.476	-1.315	1.726
Access to clean drinking water	No	88%	0.376	0.484	-1.381	1.778
	Yes	12%	0.307	0.462	-1.227	1.727
Access to electricity	No	14%	0.492	0.500	-1.768	1.793
	Yes	88%	0.350	0.477	-1.307	1.762
Caretaker is literate	No	24%	0.376	0.485	-1.388	1.835
	Yes	76%	0.365	0.481	-1.355	1.752
Head of household work in agriculture	No	48%	0.345	0.476	-1.266	1.775
	Yes	52%	0.388	0.487	-1.452	1.766
Total		100% (5075)	0.368	0.482	-1.363	1.772

*Sample is composed of those CCT beneficiaries in 2013. Stunting is defined as HAZ >2 &lt; 3*

## 5.2 Effect of the PKH programme

The empirical strategy in equation 3 aims to explore the effect of the PKH pilot programme on child nutrition. Table 7 shows the results of the 2SLS.

It was found that stunting and severe stunting are reduced significantly by the CCT. For example, receiving PKH reduces stunting by 7 percentage points, while severe stunting does so by 9 pp, with a confidence level of 90 and 95%, respectively (columns 1 and 2). Similar results were found in the Philippines' flagship CCT programme, where there was a higher significant reduction in severe stunting than stunting (Kandpal et al. 2016).

Moreover, HAZ increased by 0.37 units for children who received cash transfers. When disaggregating HAZ by sex (columns 4 and 5), it is found that girls benefit more than boys. This result is statistically significant and is consistent with the literature (Manley, Gitter, and Slavchevska 2012).

**Table 7. Effect of CCT on children's health outcomes**

	(1)	(2)	(3)	(4)	(5)
	Stunting	Severe stunting	HAZ Total	HAZ Girls	HAZ Boys
CCT beneficiary♦	-0.076* (0.0384)	-0.089** (0.0281)	0.372** (0.135)	0.365* (0.184)	0.338 (0.183)
Constant	0.416*** (0.0579)	0.232*** (0.0579)	-1.116*** (0.251)	-0.571 (0.330)	-1.499*** (0.448)
N	5074	5074	5074	2535	2539
adj. R <sup>2</sup>	0.062	0.023	0.111	0.114	0.106
Individual controls	Yes	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes
Regency Fixed Effects	Yes	Yes	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the district level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ >2 &lt; 3*

The first 1,000 days of life are a potentially critical window for chronic undernutrition; this time frame corresponds from the period in utero until the child is 24 months old. Table 8 disaggregates the effects of stunting by age in months. Columns 1 and 2 show the first and second years of life, and it is found that CCT reduce stunting by 7 and 5 percentage points, respectively. Nevertheless, these results are not statistically significant.

Column 3 shows that children just above the critical window (25-36 months old) do not benefit from the PKH to reduce stunting. This could be associated with the remark that interventions outside this critical window may not have meaningful effects (Ruel 2010). Nevertheless, Leroy and Frongillo (2019) argue that delays in linear growth continue after the first 1,000 days and that some cognitive skills that are dependent on nutritional status keep developing until adolescence. Therefore, special interventions should be addressed for this age group to ensure healthy growth. Children that are four and five years old are still helped by the CCT, albeit to a lesser extent than their younger peers.

**Table 8. Effect of CCT on children <5 stunting by age (months)**

	(1)	(2)	(3)	(4)	(5)
	Stunting <12 months	Stunting 13 – 24 months	Stunting 25 – 36 months	Stunting 37-48 months	Stunting 49-60 months
CCT beneficiary♦	-0.0786 (0.0597)	-0.0573 (0.0826)	0.0517 (0.0802)	-0.160* (0.0767)	-0.0541 (0.0972)
Constant	0.580*** (0.125)	0.659*** (0.190)	0.402*** (0.117)	0.470* (0.199)	1.000*** (0.128)
N	1227	1029	931	1001	886
adj. R <sup>2</sup>	0.011	0.048	0.006	0.017	0.034
Individual controls	Sex	Sex	Sex	Sex	Sex
Household controls	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes
Regency Fixed Effects	Yes	Yes	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the district level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ >2 &lt; 3*

### 5.3 Effect of the adverse weather shock

The effect of the cold ENSO event in 2010-2011 on children's nutritional outcomes is evaluated using equation 4. The results are displayed in the following table.

**Table 9. Effect of a negative weather shock on children's health outcomes**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HAZ	Stunting	Severe stunting	Stunting		Stunting	
				Girls	Boys	Rural Village	Urban Village
Weather shock	-0.0282 (0.120)	0.149 (0.081)	-0.0381 (0.074)	0.200* (0.078)	0.0948 (0.128)	0.176* (0.080)	-0.260 (0.187)
Constant	-0.834*** (0.137)	-0.377** (0.144)	-0.999*** (0.143)	-0.778*** (0.176)	-0.155 (0.183)	-0.971*** (0.133)	-0.693 (0.535)
N	5074	5074	5074	2535	2539	4643	427
adj. R <sup>2</sup>	0.116						
Individual controls	Yes	Yes	Yes	Age	Age	Yes	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes	Stunting at baseline	Stunting at baseline
Regency Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the regency level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. Stunting is defined as HAZ >2 &lt; 3*

The weather shock decreases HAZ by 0.03 units, which is reflected in an increase of stunting of 14 percentage points. Though not significant, these results align with Tanzania's literature that evaluated extreme rainfall effects on stunting (Nsabimana and Mensah 2020). Counterintuitively, extreme rainfall seems to positively affect severe stunting, reducing it by 0.04 percentage points. However, these results must be treated with care as they are not statistically significant.

Additionally, the results for stunting are disaggregated by sex and location of the villages (columns 4-7). Female children who experienced a weather shock increased stunting by 20 percentage points (statistically significant at 90%), while stunting in male children rose by 10 percentage points (not significant). These results suggest that girls are more affected by extreme rainfall shocks, which is consistent with a study in India that analyses the effect of extreme precipitation, where stunting increases in girls exposed to the weather shock (Dimitrova and Muttarak 2020).

Furthermore, experiencing the weather shock increased stunting by 18 percentage points in rural villages (statistically significant). This is consistent with literature studying seasonal droughts in Ethiopia (Dimitrova 2021) and cumulative exposure to dry weather shocks in Tanzania (Nsabimana and Mensah 2020). However, in urban settings, weather shocks seem to decrease stunting by 26 percentage points, proposing a positive effect on stunting reduction, though this result is not statistically significant. These results are compatible with earlier findings by Nsabimana

and Mensah (2020), who found that shocks have little and even positive impact on stunting when evaluating urban areas.

To further investigate the effect of the La Niña in 2010-2011. The results are disaggregated by age in months (Table 10). For babies up to 12 months, the weather shock is associated with a decrease in stunting, suggesting a positive effect (column 1). On the other hand, extreme rainfall increases stunting in children 13 months old and older (columns 2-5).

**Table 10. Effect of extreme rainfall on stunting by age (months)**

	(1) <12 months	(2) 13 – 24 months	(3) 25 – 36 months	(4) 37-48 months	(5) 49-60 months
Weather shock	-0.215 (0.188)	0.0173 (0.179)	0.127 (0.121)	0.338** (0.103)	0.309 (0.168)
Constant	0.118 (0.332)	0.308 (0.383)	-0.174 (0.269)	-0.485* (0.247)	-0.908*** (0.193)
N	1192	1029	928	982	883
Individual controls	Sex	Sex	Sex	Sex	Sex
Household controls	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes
Regency Fixed effects	Yes	Yes	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the regency level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. Stunting is defined as HAZ >2 &lt; 3*

Children aged 3-4 years old at the time of the survey (which took place between September and December 2013) were in their first or second year of life when the La Niña occurred. For them, stunting increased significantly by 33 percentage points (column 4). Indeed, literature finds that weather shocks occurring during the first year of life have the strongest effects on children's outcomes, particularly height (Maccini and Yang 2009; Rabassa, Skoufias, and Jacoby 2014; Nsabimana and Mensah 2020) or within the first 24 months (Dimitrova 2021).

Children between 4 and 5 years old (column 5) could have experienced the effect of the La Niña 2008-2009 in utero or during their first year of life. Despite knowing that event was less strong, a new dummy variable is created where 1 is assigned if the district had ZSI>2 during 2008 and 2009, and otherwise 0. However, this phenomenon is not reflected by this dummy variable as shown in Table A2. Therefore, it is assumed that the effects of that event are not observed in this sample.

#### 5.4 Effect of the PKH programme and weather shocks

Finally, the full model accounts for the interaction between weather shocks and the impact of the CCT on stunting. Equation 5 is performed to explore this relationship. Results from the second stage are shown in table 11.

**Table 11. Effect of the PKH programme and weather shock on stunting**

	(1) Stunting	(2) Stunting Girls only	(3) Stunting Boys only
Weather shock	0.0102 (0.0701)	0.0361 (0.0538)	-0.0145 (0.108)
CCT beneficiary♦	-0.150 (0.146)	-0.116 (0.117)	-0.175 (0.203)
Interaction term	0.115 (0.145)	0.092 (0.117)	0.133 (0.205)
Constant	0.469*** (0.131)	0.293** (0.107)	0.587** (0.183)
N	5074	2535	2539
adj. R <sup>2</sup>	0.056	0.060	0.048
Individual controls	Yes	Yes	Yes
Household controls	Yes	Yes	Yes
Village controls	Yes	Yes	Yes
Regency Fixed Effects	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the regency level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ >2 <math>\psi</math> <3*

The effects on stunting are shown in column 1. Those who experienced the weather shock and did not receive CCT had increased stunting by 1 percentage point, yet this change is minor and insignificant. In contrast, receiving CCT benefits and not enduring a weather shock reduced stunting by 15 percentage points. These two results align with the hypotheses of this study. The interaction of these two treatment factors increases stunting by 11 percentage points, suggesting that PKH is more effective against stunting when the beneficiaries experience no weather shock and mitigates weather shocks poorly. However, none of these results is statistically significant and should be treated with care.

The difference between girls and boys has been discussed prior and appears to play an essential role in this interaction. Columns 2 and 3 show these results disaggregated by sex (statistically insignificant). Consistent with earlier results of this study, girls are the most affected by weather shocks in households that are not beneficiaries of CCT, whereas boys seem to benefit from this situation and benefit more from the PKH in case of an extreme weather shock than girls. Indeed, it has been recognised that in crisis settings coping mechanisms occur in families prioritising boys, and women and girls may suffer from a lower food intake than their male counterparts (Inter-Agency Standing Committee (IASC) 2017). However, this data set does not contain individual food intake to explore this mechanism.

The previous section indicated that rural areas are negatively affected by the La Niña. To isolate this effect further, table 12 stratifies the results by the age of children living in rural villages.

Consistent with previous results of this study, weather shocks play a positive role for babies <12 months old, reducing stunting by 15 percentage points (significant at 90%). Similarly, children aged 2-3 years are not helped by the PKH. The interaction terms are ambiguous and unclear; hence the interaction term has no heterogeneous effect on stunting by age. A potential explanation is that those children were not born, nor in utero by the time of the shock.

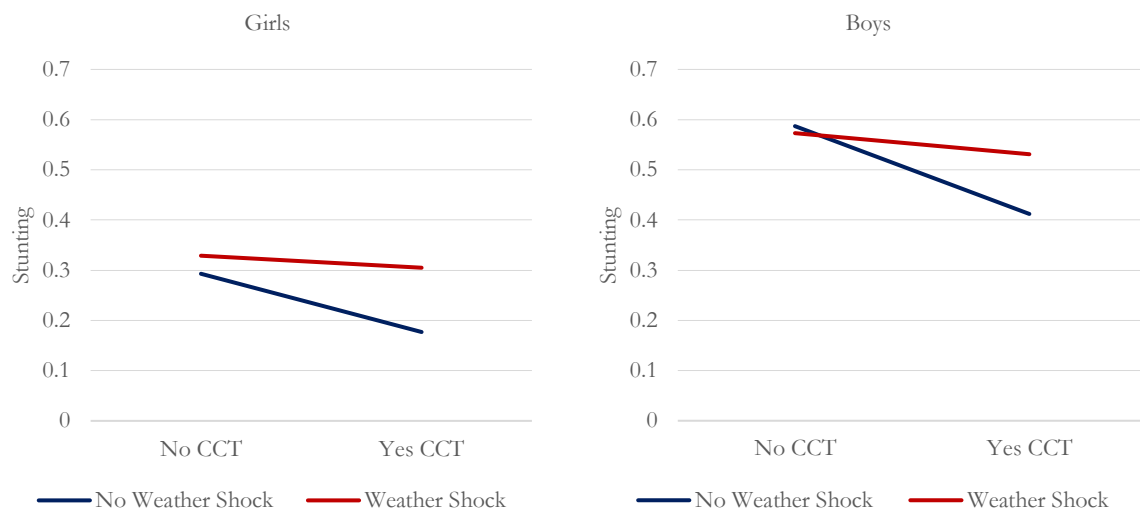
**Table 12. Effect of the PKH programme and weather shock on stunting (by age)**

	(1) Stunting <12 months	(2) Stunting 13 – 24 months	(1) Stunting 25-36 months	(2) Stunting 37 – 48 months	(3) Stunting 48 – 60 months
Weather shock	-0.151* (0.0729)	0.0262 (0.119)	0.0859 (0.0997)	0.0208 (0.125)	0.0302 (0.126)
CCT beneficiary ♦	-0.240 (0.160)	-0.0406 (0.267)	0.101 (0.191)	-0.331 (0.263)	-0.197 (0.273)
Interaction term	0.252 (0.144)	-0.0245 (0.261)	-0.0895 (0.198)	0.243 (0.262)	0.219 (0.271)
Constant	0.694*** (0.135)	0.646** (0.231)	0.374* (0.155)	0.628* (0.249)	1.056*** (0.169)
N	1227	1029	931	1001	886
adj. R <sup>2</sup>	-0.028	0.047	0.004	-0.011	0.027
Individual controls	Sex	Sex	Sex	Sex	Sex
Household controls	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes
Regency Fixed Effects	Yes	Yes	Yes	Yes	Yes

*Standard errors, in parentheses, are clustered at the regency level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ >2 &lt; 3*

Overall, the PKH programme appears to be more effective (reduces stunting more) for those children who did not experience the weather shock compared to those that experienced the La Niña (Figure 5), independent of the sex of the child.

**Figure 5. Predictive margins of Weather shock interacted with PKH programme**





## 6. Potential mechanisms

Thus far, this study has found that that PKH did not help mitigate the negative effects on nutrition caused by the La Niña in 2010-2011.

Moreover, there are characteristics of the population that may enhance the efficiency of the PKH in the lack of a weather shock (Table A3). For instance, rural households with access to clean water and improved latrines show more significant improvements in stunting when they do not experience a weather shock. However, in case of weather shock, households with access to clean drinking water benefited from this feature, acting as a protective mechanism against extreme rainfall. These characteristics highlight the importance of hygiene and sanitation in reducing stunting in children under five years old, as described elsewhere (Ademas et al. 2021; Torlesse et al. 2016).

Conversely, PKH was effective at mitigating the effects of La Niña in rural households where the head was unemployed. CCT allowed children to catch up fully ( $B1+B3<0$ ). Emphasising the capacity of CT as a form of insurance against risk in those without a stable income. A similar situation occurs when in a rural setting the caretaker was illiterate. Nevertheless, these results are not statistically significant (Table A4), and more research is required to comprehend these mechanisms fully.

As proposed in the UNICEF framework, household environment and sanitation are essential components for children's nutrition and health. Extreme rainfall can put those elements at risk (Bhavnani et al. 2014). To explore the characteristics that play a role in this setting, additional analysis is done. It is found that children living in household with no electricity access benefit more from PKH, but have higher stunting after a weather shock, which could be related to the overall decreased wealth of the village (Fujii, Shonchoy, and Xu 2016). Additionally, children exposed to floors made from soil have higher chances of being stunted in case of extreme rainfall. Soil-transmitted helminthiasis is more likely to occur in those settings, increasing the risk of stunting and diarrhoea (Fauziah et al. 2022). All these results are statistically significant (Table A5).

The primary mechanism by which literature suggests that weather shocks affect child nutrition is via harming the agricultural systems. To explore this mechanism further, table A6 shows the heterogeneity of the weather shock on variables associated with agriculture and farming. It is found

that owning a rice field increases the chances of stunting in case of extreme rainfall by 20 percentage points. In contrast, those households whose income comes from the agricultural sector benefited from the shock. A possible explanation is that the timing of the extreme rainfall might have affected rice growing or harvesting but other crops were intact. Therefore, agriculture may not have been the main pathway by which La Niña event impacted stunting levels. Lastly, those owning more livestock (children living in households owning the highest 20<sup>th</sup> percentile) had lower likelihood of being stunted after the La Niña event compared to those who held the least (all these results are significant). It has been suggested that owning livestock could be related to stunting reduction (Mosites et al. 2015). Additionally, these findings support that owning livestock is a potential coping mechanism for shocks (Ansah, Gardebrock, and Ihle 2021).

The pathway in which CCT reduce stunting is usually associated with increased income and through the CCT conditionalities. Table A7 explores the effect of PKH on different outcomes. CCT increase overall monthly expenditure and spending on protein-rich foods such as milk and egg. However, overall food expenditure did not increase. None of these results are significant and this can be associated with a failure in the design and implementation of the programme, as suggested in the literature (Bastagli et al. 2019).

PKH also increased health-seeking behaviours such as higher complete immunisation by age and higher frequency of weighing in the last three months at the community clinic. These results are consistent with other cash transfer programmes (Bastagli et al. 2019). Despite the conditionality of administering vitamin A to children, the intake of this vitamin was lower in the CCT recipients. Additionally, the PKH programme did not report a decrease in acute illnesses such as diarrhoea, fever, or cough in the month before the survey. However, Cahyadi et al. (2020) argue that chronically ill children would have more low-growth pathways, resulting in stunting, which is not the case.

## 7. Robustness checks

Robustness tests are used in empirical studies to evaluate how much an estimate from different model specifications is supported by estimates from a baseline model (Neumayer and Plümer 2017). Several of these tests are conducted to support the results of this paper.

### 7.1 Varying intensity in rainfall

In theory, it is not very well defined whether more extreme weather rainfall has worse or lesser effects on stunting. It is possible that larger weather shocks have greater effects; for instance, death of people, infrastructure damage and major food security problems (Atanga and Tankpa 2021). However, in case of larger weather shocks, there are a more significant mobilisation of supplies, more extreme coping mechanisms, and in some situations, an intensification of social programmes (Andalón et al. 2016).

This study uses a ZSI value of 2 standard deviations above the yearly-specific mean. New variables using different cut-off ZSI values (1.5 and 2.5 standard deviations) are calculated to investigate the sensitivity of the threshold used for this study. Columns 1 and 2 of table A8 show the full model results using a milder and stronger weather shock. ZSI of 1.5 standard deviations reduces stunting (not significant), and ZSI >2.5 remain substantively similar to the baseline model.

### 7.2 Using a different rainfall variable

Weather shocks can also be defined as cumulative exposure to extreme rainfall instead of an isolated event (Nsabimana and Mensah 2020). Therefore, a new weather shock is created. It counts the years between 2007 and 2013 with a ZSI >2. Column 3 of Table A8 shows the results of the main empirical model. The results remain essentially the same, which suggests that during that time frame, only the La Niña event had such an impact on the population.

### 7.3 Increasing the size of the sample

The population was limited to children under 5 years old because z-scores above that age are constructed on the CDC measure charts. Such charts are based on children in the United States and overestimate the prevalence of stunting (Moelyo, Candrarukmi, and Rachma 2022). Column 4 of Table A8 includes all children in the sample, the age range is 0-16. The effects of weather

shocks are almost minimal, but CCT keep proving effective. The interaction term coefficient is fairly similar to the baseline model.

#### 7.4 Attrition

This randomised control trial is implemented in 2007 and the last follow-up survey was conducted in 2013. As result, this study might suffer from attrition, i.e. loss of participants throughout the study (Nunan, Aronson, and Bankhead 2018). However, by the last survey, 95.1% of the households surveyed at baseline were still found. This tendency is similar for treatment and control groups (Table 13). The low levels of attrition of the PKH programme suggest that full families do not migrate, and children remain at the same address. As a consequence, they experienced the weather shocks in the subdistrict where they were surveyed (Cahyadi et al. 2020).

**Table 13. Household attrition of the PKH**

	Control Households	% of Baseline	Treatment households	% of Baseline	Total of Households	% of Baseline
Baseline	7,131	100	7,196	100	14,326	100
2- Year	6,947	97.4	7,024	97.6	13,971	97.5
6- Year	6,768	94.9	6,851	95.2	13,619	95.1

## 8. Limitations and scope for further research

This analysis has limitations additional to the data constraints (section 3.2). The primary critical concern is whether this analysis allows for causal inference. The evaluation of the PKH programme on nutritional outcomes uses an instrumental variable to deal with endogeneity, fixed effects to deal with omitted variable bias, and various levels of controls that otherwise might confound the results. This approach supports causal interpretation. However, proving causal effects of rainfall on stunting is not possible. Therefore, the empirical strategy using the interaction of weather shock and CT may not be able to prove causality. However, the exogenous nature of the precipitation increases the robustness of the results.

Additionally, the suggested mechanisms by which CCT mitigate (or not) extreme precipitation shocks are only considerations and not the aim of this study. The literature has suggested various mechanisms using isolated pathways (agriculture, household characteristics, health characteristics, etc). However, strict research exploring those mechanisms must be in the agenda of those studying CCT, weather shocks and public health.

Internal validity in this research is prioritised and achieved by focusing on 1) one country, 2) a very specific population (people living in poverty), and 3) a specific weather shock. However, this might compromise external validity, given that the relationships and conclusions cannot be generalised to other settings (Steckler and McLeroy 2008). Even though CCT are gaining popularity, conditionalities and the amount of cash transferred vary according to the budget and objectives of the delivery institutions.

## 9. Conclusion

As governments work to mitigate and resolve persistently omnipresent child malnutrition, their most vulnerable citizens are increasingly threatened by severe weather shocks due to climate change. Some mitigation strategies are already well recognized and widely implemented, but they are not always accessible for the poorest. Nevertheless, CCT are successful social programmes that have been proven to mitigate weather shocks to a certain extent.

This study investigated the effects of the PKH CCT programme in Indonesia on stunting in children under 5 years old, as well as the impact of the 2010-2011 La Niña ENSO cold weather shock on nutritional outcomes. Principally, this research aimed to explore the effects of this CCT programme on stunting in children that had experience this weather shock. Additionally, several mechanisms were explored to understand the pathways by which PKH and weather shocks affect child nutrition according to the UNICEF conceptual framework on child and maternal nutrition.

The analysis reveals that PKH was effective at reducing stunting in all children, particularly girls. Furthermore, the La Niña event correlates with increased stunting particularly in rural areas, mostly girls and children who experienced the event in their first and second year of life. While boys have a higher prevalence of stunting, they are less affected by weather shocks.

When analysing the interaction of the shock and CCT, it was found that PKH did not help mitigate the negative effects on nutrition caused by La Niña event. In fact, PKH is better at reducing stunting levels in the absence of weather shocks, particularly in household with better hygiene resources.

Remarkably, PKH was found effective at -fully- mitigating the effects the La Niña in children whose parents were unemployed or illiterate, in rural areas. These results are not statistically significant and must be interpreted with care. Nevertheless, this emphasises the potential of CCT to act as insurance against risk in those without a stable income.

To the author's knowledge, only one study has explored the capability of CCT as a mitigation tool for wet weather shocks focusing on nutritional outcomes such as stunting. League and Dylan's (2022) evaluation of Bolsa Familia in Brazil seems to protect beneficiaries against mild weather shocks in utero. This study contributes to the literature by studying children's nutritional outcomes

in settings outside Latin America, by focussing on a recurrent severe weather event and by not focussing on in utero shocks only.

Further efforts studying how CCT could mitigate extreme rainfall and effects on child nutrition is required to effectively plan weather mitigation programmes or indeed redesign CCT with the purpose of relieving the most vulnerable.

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## APPENDICES

Figure A1. Distribution of HAZ score by weather shock

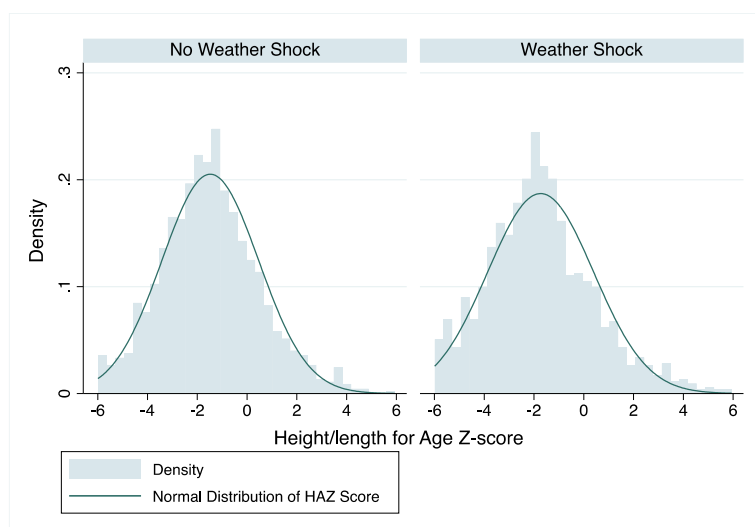


Table A2. Districts with extreme rainfall in 2008-2009

	ZSI >2 in 2008-2009		ZSI >2 in 2008-2009
Kab. Alor	0	Kab. Minahasa selatan	0
Kab. Bandung	0	Kab. Minahasa utara	0
Kab. Bangkalan	0	Kab. Mojokerto	0
Kab. Banyuwangi	0	Kab. Nganjuk	0
Kab. Boalemo	0	Kab. Ngawi	0
Kab. Bogor	0	Kab. Pamekasan	0
Kab. Bojonegoro	0	Kab. Pasuruan	0
Kab. Bolaang mengondow	0	Kab. Pohuwato	0
Kab. Bondowoso	0	Kab. Ponorogo	0
Kab. Bone bolango	0	Kab. Probolinggo	0
Kab. Cianjur	0	Kab. Rote ndao	0
Kab. Cirebon	0	Kab. Sampang	0
Kab. Ende	0	Kab. Sidoarjo	0
Kab. Flores timur	0	Kab. Sikka	0
Kab. Garut	0	Kab. Situbondo	0
Kab. Gorontalo	0	Kab. Subang	0
Kab. Gresik	0	Kab. Sukabumi	0
Kab. Indramayu	0	Kab. Sumba barat	0
Kab. Jember	0	Kab. Sumba timur	0
Kab. Jombang	0	Kab. Sumedang	0
Kab. Karawang	0	Kab. Sumenep	0
Kab. Kediri	0	Kab. Tasikmalaya	0
Kab. Kuningan	0	Kab. Timor Tengah Selatan	0
Kab. Lamongan	0	Kab. Timor Tengah Utara	0
Kab. Lembata	0	Kab. Trenggalek	0
Kab. Madiun	0	Kab. Tuban	0
Kab. Magetan	0	Kab. Tulungagung	0
Kab. Majalengka	0	Kota Bitung	0
Kab. Malang	0	Kota Gorontalo	0
Kab. Manggarai	0	Kota Jakarta Utara	0
Kab. Manggarai barat	0	Kota Kupang	0
Kab. Minahasa	0	Kota Manado	0



**Table A3. Effect of the PKH programme and weather shock on stunting (by access to clean drinking water and improved latrine)**

	(1) Stunting Access to clean drinking water	(2) Stunting No access to clean drinking water	(3) Stunting Access to improved latrine	(4) Stunting No access to improved latrine
Weather Shock	-0.488 (0.484)	-0.000720 (0.0787)	0.00369 (0.101)	-0.00910 (0.105)
CCT beneficiary♦	-1.218 (0.849)	-0.150 (0.161)	-0.310 (0.266)	-0.161 (0.162)
Interaction term	1.102 (0.848)	0.122 (0.162)	0.295 (0.269)	0.0921 (0.158)
Age (months)	0.00707*** (0.00151)	0.00596*** (0.000508)	0.00562*** (0.000550)	0.00623*** (0.000540)
Sex	-0.0166 (0.0518)	-0.0294 (0.0156)	-0.00870 (0.0208)	-0.0460* (0.0199)
Access to improved latrine	0.0275 (0.0804)	-0.0255 (0.0222)	-0.0323 (0.0276)	0.0129 (0.0439)
Access to clean drinking water	-0.0890 (0.0832)	-0.0337 (0.0286)	-0.0352 (0.0312)	-0.0332 (0.0327)
Access to electricity	0.000360 (0.108)	-0.0701** (0.0242)	0.0226 (0.0263)	-0.115*** (0.0288)
Caretaker is literate	0.00719 (0.0946)	-0.00905 (0.0168)	-0.0333 (0.0339)	0.00914 (0.0198)
Head of household works in agriculture	0.00317 (0.0557)	0.0151 (0.0124)	0.0139 (0.0175)	0.00974 (0.0192)
Overall expenditure/month (log)	-0.00863 (0.0224)	-0.000951 (0.00372)	0.00254 (0.00642)	-0.00476 (0.00452)
Household size (log)	-0.0909 (0.0895)	0.0308 (0.0272)	0.00877 (0.0384)	0.0267 (0.0273)
Average stunting in the district	-0.258 (0.236)	0.0609 (0.0390)	0.112 (0.0839)	-0.0454 (0.0668)
_cons	0.959 (0.551)	0.232* (0.0979)	0.120 (0.132)	0.355* (0.141)
N	471	4172	2075	2568
adj. R <sup>2</sup>	.	0.061	0.030	0.071
Regency Fixed Effects	Yes	Yes	Yes	Yes

Standard errors, in parentheses, are clustered at the regency level. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$ . All household and village controls are at baseline. This is rural population only. Access to clean water and improved latrine measured in 2013. ♦ CCT beneficiaries in 2013. Stunting is defined as HAZ  $> 2$  &  $< 3$

**Table A4. Effect of the PKH programme and weather shock on stunting (by literacy and employment of the parents)**

	(1) Stunting Caretaker is literate	(2) Stunting Caretaker is illiterate	(3) Stunting Head of household is employed	(4) Stunting Head of household is unemployed
Weather Shock	-0.0422 (0.0955)	0.108 (0.113)	-0.0359 (0.0786)	0.0568 (0.211)
CCT beneficiary♦	-0.284 (0.195)	0.0548 (0.222)	-0.276 (0.170)	0.438 (0.307)
Interaction term	0.258 (0.193)	-0.149 (0.221)	0.241 (0.169)	-0.390 (0.347)
Age (months)	0.00587*** (0.000479)	0.00674*** (0.000852)	0.00600*** (0.000528)	0.00356*** (0.00108)
Sex	-0.0265 (0.0188)	-0.0327 (0.0266)	-0.0237 (0.0165)	-0.0304 (0.0472)
Access to clean drinking water	-0.0592 (0.0319)	0.0483 (0.0451)	-0.0423 (0.0307)	-0.129 (0.137)
Access to improved latrine	-0.0243 (0.0287)	0.0158 (0.0454)	-0.0277 (0.0237)	-0.117* (0.0500)
Access to electricity	-0.0624* (0.0279)	-0.0947* (0.0464)	-0.0545* (0.0221)	0.104 (0.154)
Head of household works in agriculture	0.0147 (0.0136)	-0.0304 (0.0357)	0.0150 (0.0138)	-0.0671 (0.0690)
Overall expenditure/month (log)	-0.0604** (0.0186)	0.00667 (0.00561)	-0.00106 (0.00422)	-0.0236 (0.0170)
Household size (log)	-0.00929 (0.0455)	-0.00326 (0.0374)	0.0115 (0.0280)	0.0599 (0.0919)
Average stunting in the district	0.0157 (0.0583)	0.126 (0.0958)	0.0595 (0.0478)	0.0392 (0.234)
_cons	1.051** (0.373)	0.0870 (0.151)	0.236* (0.100)	0.530 (0.284)
N	3527	1116	4152	237
adj. R <sup>2</sup>	0.041	0.074	0.047	0.024
Regency Fixed Effects	Yes	Yes	Yes	Yes

Standard errors, in parentheses, are clustered at the regency level. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$ . All household and village controls are at baseline. This is rural population only. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ  $> 2$  &  $< 3$

**Table A5. Impact of the weather shock and PKH (isolated) on stunting according to different welfare characteristics**

	(1) Stunting Electricity in the household	(2) Stunting No electricity in the household	(3) Stunting Clean water in the household	(4) Stunting No clean water in the household	Stunting Floor made of soil	Stunting Floor made of better materials	Stunting Household owns a latrine	Stunting Household doesn't own a latrine
Weather Shock	0.046 (-0.096)	0.659* (-0.297)	0.344 (-0.267)	0.107 (-0.0806)	0.227* (-0.111)	0.163* (-0.077)	0.128 (-0.121)	0.114 (-0.127)
Constant	-0.341* (-0.162)	-1.967* (-0.880)	-0.385 (-0.637)	-0.108 (-0.113)	-0.697** (-0.264)	-0.546*** (-0.151)	-0.316 (-0.247)	-0.428* (-0.189)
N	4456	606	587	4484	1029	4015	2864	2210
CCT beneficiary♦	-0.058 (-0.043)	-0.166** (-0.056)	-0.147 (-0.1)	-0.0603 (-0.0404)	-0.0884 (-0.051)	-0.0597 (-0.047)	-0.109* (-0.053)	-0.0374 (-0.055)
Constant	0.418*** (-0.063)	-0.265* (-0.115)	0.467* (-0.196)	0.506*** (-0.0797)	1.009*** (-0.147)	0.340*** (-0.064)	0.456*** (-0.099)	0.373** (-0.117)
N	4456	618	590	4484	1059	4015	2864	2210
adj. R <sup>2</sup>	0.047	0.128	0.03	0.065	0.111	0.057	0.061	0.063
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regency fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors, in parentheses, are clustered at the regency level for weather shocks and at the district level for CCT. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$ . Each row in the table represents a separate regression, the specifications are indicated in the column's header. All household and village controls are at baseline. ♦ CCT beneficiaries in 2013. Stunting is defined as  $HAZ > 2$  &  $< 3$

**Table A6. Rainfall mechanisms (Agriculture)**

	(1) Stunting Employed in agriculture	(2) Stunting Not employed in agriculture	(3) Stunting Household owns rice fields	(4) Stunting Household does not own rice fields	(5) Stunting Total Livestock 1 <sup>st</sup> quintile	(6) Stunting Total Livestock 5 <sup>th</sup> quintile
Weather shock	0.252** (0.0911)	-0.0371 (0.129)	-0.0565 (0.0678)	0.196* (0.0963)	0.182 (0.113)	0.0801 (0.249)
Age (months)	0.0170*** (0.00139)	0.0165*** (0.00202)	0.0225*** (0.00294)	0.0159*** (0.00173)	0.0162*** (0.00226)	0.0143*** (0.00330)
Sex	-0.0687 (0.0701)	-0.139*** (0.0416)	0.0192 (0.112)	-0.114** (0.0387)	-0.150** (0.0507)	-0.129 (0.0882)
Access to improved latrine	-0.0348 (0.0823)	-0.0455 (0.0608)	-0.205 (0.125)	-0.0351 (0.0541)	-0.0291 (0.0760)	-0.0887 (0.0846)
Access to clean drinking water	-0.212* (0.0920)	-0.0608 (0.109)	-0.232 (0.234)	-0.130 (0.0979)	-0.164 (0.141)	-0.0420 (0.177)
Access to electricity	-0.133 (0.0699)	0.0310 (0.0644)	-0.162 (0.111)	-0.0923 (0.0717)	-0.270* (0.121)	-0.0266 (0.134)
Caretaker is literate	0.0267 (0.0819)	-0.0754 (0.0547)	0.162 (0.146)	-0.0430 (0.0536)	-0.0489 (0.0694)	0.0266 (0.120)
Head of household works in agriculture	-0.0504 (0.0550)	0.0501 (0.0515)	0.214 (0.129)	-0.0234 (0.0382)	-0.0197 (0.0608)	0.133 (0.117)
Overall expenditure/month (log)	0.00892 (0.0135)	-0.0220 (0.0131)	0.000944 (0.0547)	-0.00561 (0.00796)	0.0126 (0.0139)	-0.0249 (0.0316)
Household size (log)	-0.0126 (0.0921)	0.162* (0.0686)	0.0113 (0.188)	0.0806 (0.0599)	0.130 (0.116)	0.0216 (0.127)
Average stunting in the district	0.204 (0.215)	0.234 (0.189)	0.257 (0.362)	0.205 (0.120)	0.255 (0.157)	0.130 (0.349)
Rural	0.000749 (0.301)	0.00375 (0.154)	-0.0932 (0.480)	0.0391 (0.153)	-0.0246 (0.108)	0.0281 (0.263)
Constant	-1.034*** (0.121)	-0.434* (0.195)	-1.057* (0.496)	-0.362* (0.176)	-0.419 (0.231)	-0.846** (0.310)
N	2653	2419	681	4378	2105	896

Standard errors, in parentheses, are clustered at the regency level. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$ . All household and village controls are at baseline. ♦ CCT beneficiaries in 2013. Stunting is defined as  $HAZ > 2$  &  $< -3$

**Table A7. Effect of PKH on various outcomes**

	(1) Total expenditure per month (log)	(2) Food expenditure per month (log)	(3) Complete immunizati on by the age	(4) Time weighted last 3 months	(5) Total vitamin A intake	(6) Diarrhoea last month	(7) Fever or cough last month
<i>CCT beneficiaries in 2013</i>	0.0152 (0.0551)	-0.00201 (0.0553)	0.0627 (0.0607)	0.148 (0.203)	-0.106 (0.224)	0.00201 (0.0378)	0.0244 (0.0502)
Age (months)	0.000186 (0.000334)	0.000636 (0.000363)	0.00536*** (0.000486)	-0.00848*** (0.00190)	0.0916*** (0.00642)	-0.00297*** (0.000331)	-0.00163*** (0.000454)
Sex	0.00807 (0.0122)	0.00923 (0.0130)	0.00844 (0.0168)	0.0310 (0.0632)	-0.0749 (0.0753)	-0.0262* (0.0126)	-0.0219 (0.0147)
Access to improved latrine	0.0517** (0.0179)	0.0157 (0.0186)	0.0394 (0.0211)	-0.124 (0.0747)	0.0573 (0.0909)	0.0155 (0.0168)	0.0208 (0.0199)
Access to clean drinking water	0.0581* (0.0262)	0.0599* (0.0296)	0.0392 (0.0289)	-0.0166 (0.121)	-0.0312 (0.104)	0.0139 (0.0201)	0.0125 (0.0238)
Access to electricity	0.134*** (0.0310)	0.0650* (0.0309)	0.0528 (0.0341)	0.0409 (0.124)	-0.138 (0.122)	0.0280 (0.0211)	0.122*** (0.0303)
Caretaker is literate	0.00430 (0.0179)	-0.0237 (0.0200)	0.0185 (0.0214)	-0.0284 (0.0851)	-0.0543 (0.0971)	0.0114 (0.0167)	-0.00370 (0.0203)
Head of household works in agriculture	-0.00935 (0.0177)	0.00734 (0.0189)	-0.0571** (0.0196)	-0.100 (0.0825)	-0.236* (0.107)	-0.0285 (0.0162)	-0.0319 (0.0186)
Overall expenditure/month (log)	0.0224*** (0.00524)	0.0212*** (0.00527)	0.00364 (0.00542)	0.0265 (0.0229)	0.0578** (0.0215)	-0.00837 (0.00435)	-0.00588 (0.00538)
Household size (log)	-0.182*** (0.0236)	-0.148*** (0.0246)	-0.0350 (0.0229)	-0.198* (0.0994)	-0.123 (0.0923)	0.0297 (0.0192)	-0.0311 (0.0237)
Average stunting in the district	-0.0620 (0.0731)	-0.0398 (0.0727)	0.0528 (0.0734)	0.409 (0.245)	0.0789 (0.223)	0.0435 (0.0422)	0.0221 (0.0599)
Rural	-0.113* (0.0457)	-0.0718 (0.0540)	0.0964 (0.0569)	0.475* (0.187)	-0.100 (0.195)	0.00195 (0.0321)	0.0170 (0.0389)
Constant	12.55*** (0.0982)	12.00*** (0.0886)	-0.106 (0.111)	1.749*** (0.308)	0.472 (0.360)	0.436*** (0.0564)	0.746*** (0.116)
N	5074	5074	3718	4049	1439	4046	4052
adj. R <sup>2</sup>	0.101	0.068	0.067	0.035	0.106	0.041	0.026

*Standard errors, in parentheses, are clustered at the district level. \*p<0.01 \*\*p<0.05 \*\*\*p<0.001. All household and village controls are at baseline. ♦CCT beneficiaries in 2013. Stunting is defined as HAZ >2 &lt; 3*

**Table A8. Robustness tests**

	(1) Stunting (ZSI >1.5)	(2) Stunting (ZSI >2.5)	(3) Stunting (Cumulative)	(4) Stunting (Full sample)
Weather Shock	-0.0519 (0.0842)	0.0210 (0.0745)	0.0102 (0.0701)	0.00452 (0.0709)
CCT beneficiary♦	-0.194 (0.198)	-0.0908 (0.0672)	-0.150 (0.146)	-0.169 (0.150)
Interaction term	0.163 (0.195)	0.0486 (0.0677)	0.115 (0.145)	0.133 (0.148)
Constant	0.495** (0.161)	0.433*** (0.0817)	0.469*** (0.131)	0.530*** (0.135)
N	5074	5074	5074	5143
adj. R <sup>2</sup>	0.053	0.061	0.056	0.054
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
Village controls	Yes	Yes	Yes	Yes
Regency Fixed Effects	Yes	Yes	Yes	Yes

Standard errors, in parentheses, are clustered at the regency level. \* $p < 0.01$  \*\* $p < 0.05$  \*\*\* $p < 0.001$ . All household and village controls are at baseline. ♦ CCT beneficiaries in 201. Stunting is defined as HAZ > 2 &lt; 3