



Hazardous child labour in smallholder coffee farming systems in Uganda: Prevalence, determinants, and implications for children's education

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1. Introduction

Global food systems are associated with significant environmental and social externalities that remain largely unaccounted for in market prices [1]. While environmental externalities such as land degradation, biodiversity loss, and greenhouse gas emissions are widely discussed, the social costs associated with agricultural production are less visible. In smallholder farming systems, these costs may arise when households face low producer prices, labour shortages, and high seasonal labour demands. Under such conditions, households may rely on family labour, including children, to meet production needs. Child labour can therefore be seen as one of the hidden social costs of agricultural production, particularly when children are exposed to hazardous tasks that affect their health, schooling, and long-term wellbeing. Despite global commitments, such as Sustainable Development Goal 8.7, which aim to eliminate child labour by 2025, recent ILO-UNICEF estimates suggest that 138 million children (7.8%) worldwide remain engaged in child labour [2]. Agriculture is the primary sector for child labour. More than 60 percent of children aged 5–17 years are engaged in farming, fishing and aquaculture, forestry, and livestock production. This share is highest for children aged between 5 and 11 years (68%), highlighting it as a common entry point [2]. Hazardous child labour occurs in all sectors, but in the agricultural sector it accounts for up to 30% of all child labour [2].

Child labour is particularly prevalent in Sub-Saharan Africa, where two-thirds of children engaged in child labour live. The child labour prevalence amounts to approximately 21.5% [2]. Although the regional child labour rate has declined by 10% since 2020, population growth has kept the absolute number of children in child labour unchanged [2]. Uganda is no exception to this trend. As of 2019/20, the prevalence of

child labour was estimated at 28.2%² [3], supporting the general positive trend of declining child labour rates across sub-Saharan Africa, even though the country's rate was above the regional ILO-UNICEF estimate.

Poverty is widely recognized as a key driver of child labour, with low household income or exposure to adverse shocks often associated with a higher prevalence of child labour [4–8]. However, the relationship between economic conditions and child labour is theoretically ambiguous. While higher household income generally allows families to reduce children's work (the income effect), increases in wages or land ownership can sometimes have the opposite effect [9]. Higher wages may raise the opportunity cost of children's time, pulling them into work through substitution effects, and greater land ownership can increase the demand for family labour in agricultural settings, particularly where labour markets are imperfect [10–12].

Various studies have further looked at the effect of child labour on children's education, typically finding a negative association whereby child labour reduces school attendance and learning outcomes [12–15]. Existing studies have primarily examined child labour participation and/or classified coffee production as inherently hazardous. For example, DeGraff et al. [16,17] and Edmonds and Shrestha [18], classify all children working in coffee production as performing hazardous labour. This study advances the literature by identifying specific hazardous exposures within coffee production activities and examining their relationship with education gaps rather than enrolment or attendance which to the best of our knowledge is the first of its kind. Furthermore, this is the first nationally representative-style coffee study in Uganda. Moreover the study uses a detailed primary dataset on hazardous activities performed by children in coffee which is limited in existing literature.

The study uses primary data from 491 coffee producing households

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² For children aged 5 – 17 years.

in Uganda, collected in October 2024. The survey captures hours worked by children in different types of economic and hazardous activities in line with ILO definitions but also includes information on children's physical and psychological well-being, exposure to accidents and injuries, and the use of protective equipment. These data are used to assess the prevalence and determinants of various forms of hazardous child labour among coffee-producing households in Uganda. In addition, the study analyses the association between different forms of hazardous child labour and children's education. Specifically, this study addresses the following research questions:

- (1) What is the prevalence of hazardous child labour and the types of hazardous activities undertaken among smallholder farmers in Uganda?
- (2) What are the drivers of hazardous child labour?
- (3) Is hazardous child labour participation significantly associated with poorer educational outcomes among coffee smallholder households in Uganda?

The aim of this research is to contribute to a better understanding of the prevalence, types and drivers of hazardous child labour participation in smallholder coffee production systems in Uganda. The research further examines the association of hazardous child labour and children's education attainment and identifies points of entry to address the problem of hazardous child labour.

2. Literature review: hazardous child labour

2.1. Mechanisms underlying hazardous child labour

2.1.1. Poverty, income constraints and vulnerability to shocks

A central mechanism in the child labour literature is household poverty. Theoretical models often assume an altruistic household framework, in which parents send children to work only when constrained by adverse circumstances (luxury axiom) [5,19]. The theoretical backing goes back to Basu and Van [5], who developed a multiple-equilibrium model in which child labour arises from poverty. In the “good” equilibrium, sufficiently high household incomes lead parents to keep children out of the workforce, whereas in the “bad” equilibrium, low parental wages compel children to work. Empirical evidence largely supports this prediction showing that income improvements tend to reduce child labour, while adverse household and agricultural shocks can increase children's work as families respond to lost income or resources [4,6–8].

2.1.2. Household utility maximisation and time allocation

In addition to household poverty and vulnerability, children's work decisions can be understood within a household utility maximisation and labour allocation framework. Parents or caregivers seek to maximise household welfare by allocating the time and labour of household members, including children, across schooling, work, household production, and leisure, subject to available resources and labour needs.

The allocation of children's time responds to changes in household income and the returns to different activities. Although higher household income generally reduces child labour through an income effect, rising returns to work can also increase the opportunity cost of schooling and pull children into labour when the substitution effect dominates [12].

2.1.3. Labour demand and household production

Labour allocation decisions are especially important in agricultural and informal labour markets, where children's work may be closely tied to household production. Agricultural household models [20] provide a useful framework for understanding how households jointly make consumption, production, and labour-supply decisions, particularly where markets are imperfect or incomplete. In such settings, children's labour

may contribute directly to household production and cannot necessarily be replaced by hired labour.

Assets can buffer income shocks and reduce child labour [6,21], but this protective effect may be weaker where labour markets are imperfect and household production requires additional family labour [22]. Thus, the same economic conditions that reduce non-hazardous work in some households may increase children's exposure to more intensive or hazardous forms of labour in others.

2.1.4. Exposure to hazardous child work

Household constraints and labour demand determine not only whether children work, but also the type, intensity, duration, and conditions of that work. There is a need to distinguish between children's general participation in work and their exposure to harmful forms of work. Non-hazardous child labour is often identified by children's participation in economic activity or household work, whereas, hazardous child labour refers to work that, by its nature or the circumstances in which it is carried out, is likely to harm children's health, safety, or morals, as defined in ILO Convention 182.

Earlier empirical studies often classified hazardous work by sector, with agriculture and coffee production frequently treated as risky activities [16–18]. More recent studies move beyond sectoral classification by using survey measures of exposure to specific hazardous tasks and working conditions, such as dangerous tools, heavy loads, long hours, chemicals, injuries, or unsafe environments [23–26]. This shift is important because it separates children's general participation in work from the specific conditions that make work harmful.

This distinction matters because the determinants of hazardous child labour may operate through more severe household constraints than those associated with non-hazardous work. Hazardous child labour is strongly associated with poverty, parental absence, low parental education, larger sibling groups, and limited household assets. Across contexts, poorer households are more likely to rely on children's work in hazardous activities [23]. Parental absence further increases this risk, particularly where children live without biological parents or extended family support. Edmonds [27] similarly shows that children engaged in the worst forms of child labour in Nepal are more likely to come from households with fewer productive assets and constraints such as paternal disability. Evidence from Brazil confirms these patterns: children in risky occupations are more likely to live without one or both parents and to come from households with lower income, lower parental education, and larger numbers of siblings [16,17].

2.2. Education–work trade-offs and schooling consequences

The allocation of children's time to work can have important consequences for children's education and the accumulation of human capital. Human capital theory [28], conceptualises education as an investment in children's future productivity and earnings. Allocating children's time to work can generate short-term benefits for the household through additional income or labour, but it may also impose long-term costs by reducing human capital accumulation and future earnings [6,28,29]. Parents' time-allocation decisions therefore reflect both short-term household needs and expectations about children's future welfare, including children's potential future earnings and their capacity to support ageing parents.

For non-hazardous child labour, the effect on schooling can vary depending on the intensity, timing, and type of work. The negative association between child labour and school attendance and attainment is well documented [30], with evidence showing lower school attendance, higher dropout rates, and fewer years of schooling completed [13,14,31]. Kruger [12] finds that in coffee-growing regions in Brazil, low- and middle-income boys are less likely to be in school when income opportunities from coffee production rise. Household income shocks can further exacerbate these effects. In Uganda, Björkman-Nyqvist [32] shows that income shocks increase the likelihood that teenage girls are

withdrawn from school to take on additional household work, whereas younger girls and boys are less affected. However, the relationship between child labour and education is not always straightforward: in some contexts, schooling outcomes remain unaffected despite increases in child labour [33], and other studies find positive effects of some forms of work on education [11,34,35].

By contrast, hazardous child labour is expected to have more damaging consequences for education because it combines time displacement with exposure to physical strain, injury, unsafe environments, and other risks that may impair learning and attendance. A growing strand of literature examines these consequences directly. Overall, evidence suggests that hazardous forms of work are more strongly associated with adverse educational outcomes than non-hazardous work. In Brazil, children engaged in risky occupations are less likely to be enrolled in school than other working children [16,17]. Similarly, in Nepal, interventions targeting schooling incentives in sectors such as weaving—a form of hazardous child labour—have been shown to reduce child labour and increase school participation [18]. More recent evidence from cocoa-growing regions in Ghana and Côte d'Ivoire shows that hazardous child labour increases the likelihood of grade repetition, partly mediated by work-related injuries [26]. Taken together, this evidence supports analysing hazardous child labour separately from general child labour, as its determinants, risks, and educational consequences are more severe.

2.3. Theoretical and conceptual framework

Following empirical identification of prevalence and scale of child labour, and hazardous child labour in particular, we address the following hypotheses, that hazardous child labour.

1. Is increased by household poverty,
2. Being more distant relatives or unrelated to household head increases selection of children for work,
3. Reduces schooling and educational outcomes of children,

Hazardous child labour in coffee-producing households can be understood as the outcome of multiple and interacting household, economic, institutional, and socio-cultural factors. Although poverty remains an important driver of child labour, children's involvement in hazardous work cannot be explained by poverty alone. Household decisions about children's work and schooling are also shaped by labour demand, bargaining power within the household, social norms, gendered divisions of agricultural tasks, labour-market constraints, inheritance and family structure, and seasonal production requirements.

At the household level, economic vulnerability influences the allocation of children's time between schooling, domestic responsibilities, and agricultural work. Low income, adverse shocks, and limited access to credit can push households to rely on children's labour as a coping strategy [4–8]. However, the relationship between household resources and child labour is not always linear. In agricultural settings, higher income, wages, or land ownership may reduce children's work through an income effect, but they may also increase children's participation where household production requires additional labour and hired adult labour is difficult to access [4,9–12]. Thus, children's exposure to hazardous labour may increase not only among the poorest households, but also where household production demands are high. This is well illustrated in the luxury and substitution axioms by Basu and Van [5].

Intra-household bargaining further shapes these decisions. Whether children attend school, contribute to farm work, or perform domestic responsibilities depends not only on household income, but also on who controls household resources and whose preferences influence decisions. The distribution of decision-making power within the household can affect whether resources are directed toward schooling, welfare, or labour contributions [36,37]. Evidence that the identity of the person controlling income and assets matters for children's welfare and human

capital investment further supports this argument [38–40]. Hazardous child labour may therefore reflect the interaction between household needs, resource control, and bargaining power as exemplified in the Household Labour Allocation Theory (Becker [28] and Manser and Brown [41]).

Socio-cultural factors further shape children's involvement in hazardous work. In many agricultural communities, children's participation in farming may be viewed as part of socialization, discipline, skills acquisition, and preparation for adulthood [2,42]. These norms may make children's work appear acceptable even when tasks expose them to risk. Gender norms also influence the type and intensity of work assigned to children. Boys may be more likely to undertake physically demanding coffee-related tasks such as digging, spraying, climbing, carrying loads, or transporting produce, while girls may combine agricultural work with unpaid domestic and care responsibilities such as cooking, fetching water, caring for siblings, and post-harvest processing [43–46]. These gendered patterns affect both the amount of work children perform and the specific hazards to which they are exposed, including dangerous tools, agrochemicals, heavy loads, long working hours, and the hidden burden of domestic work [47,48].

Labour-market constraints and seasonal production requirements are also important. Agricultural household models suggest that when rural labour markets are imperfect, household production and consumption decisions become closely linked, and households may rely more heavily on family labour, including children to meet production needs [20]. In labour-intensive crops such as coffee, the demand for labour may rise sharply during peak production periods. When households cannot easily hire or afford adult labour, children may be drawn into farm work to fill labour gaps [9,11,49]. As a result, children may experience increased work intensity, school absence, or involvement in more hazardous tasks during seasonal peaks.

Household composition, kinship relations, inheritance expectations, and family structure may also influence children's work and schooling. A child's relationship to the household head can affect the allocation of resources because biological children, grandchildren, stepchildren, fostered children, and other related children may not receive equal investments in schooling and welfare [50,51]. Inheritance arrangements and expectations may also shape children's access to household resources, perceived obligations to contribute to family production, and the value placed on schooling relative to work [9,42]. Taken together, hazardous child labour in coffee-producing households emerges as a multidimensional outcome shaped by economic vulnerability, labour demand, intra-household bargaining, social and gender norms, labour-market constraints, seasonal production pressures, and family structure. These interacting factors provide a basis for examining how household decisions and the wider conditions of coffee production are jointly associated with children's work, schooling, and exposure to hazardous tasks.

3. Methodology

3.1. Data and data sources

This study is based on primary household-level data collected in Uganda's major coffee-producing regions. The study covers the five regions of Tooro, Elgon, Southwest, Buganda South and Buganda North identified in the UNHS 2019/2020 as the largest coffee producers. A multi-stage cluster sampling method was used to select the study sample.

The study relied on the ILO-IPEC Interactive Sampling Tool developed for sampling for household-based survey of child labour [52] to generate a sample size of 570 households that was adjusted upwards to 600 households assuming a lower response rate. At regional level, we used Probability Proportional to size (PPS) sampling method to distribute/allocate the precalculated 120 households per region. Three districts with the highest number of coffee-producing households were

purposively selected from each of the five regions to generate 15 districts in total. These districts include Wakiso, Rakai, Masaka, Mukono, Luweero, Mubende, Mbale, Sironko, Namisindwa, Kasese, Kamwenge, Kyenjojo, Isingiro, Mbarara and Kiruhura districts. At district level, all city divisions, town councils and municipalities were eliminated to focus only on rural areas where coffee producing households were likely to be found. Within the district, enumeration areas (EAs) with the largest number of coffee-producing households were purposively selected. All coffee producing households in the selected enumeration areas were listed to construct an EA sampling frame. At the final stage, simple random sampling was used to select the actual households interviewed in the enumeration area. While the target sample was 600 coffee growing households, only 491 were interviewed. The deficit numbers in reference to the planned are due to cases of migration, death, failed identification of households and or change in major income generating activity at household level. Our anecdotal evidence shows that there are no systematic differences between the interviewed households and attrition cases. Overall, there were a total of 2963 children aged 0-17 years old, and 1252 children aged between 5 and 17 years old included in the survey. Fig. 1 below visualizes the distribution of sampled households.

Data were collected face-to face over a period of 20 days from October 9th to October 28th 2024 by a team of 18 enumerators using a Computer-Assisted Personal Interviewing (CAPI) method using the SurveyCTO platform. The target respondents were household heads and children aged 5-17 years old engaged in activities considered as child labour [3]. Data were collected using a structured, pretested household questionnaire covering various aspects including household demographics; crop production (coffee and non-coffee crops); household consumption expenditures; access to agricultural information and credit; housing conditions; child involvement in coffee related activities and labour use, among others.

Informed consent was obtained from all respondents who signed on a

pre-designed consent form that was translated in local languages. Parents were requested to consent on behalf of the children and parental permission was sought to interview children. The study was approved by the College of Agricultural and Environmental Sciences (CAES) Research Ethics Committee (REC) under Protocol NO: CAES-REC-2024-102.

3.2. Definition of key variables

The study defines hazardous child labour conceptually in accordance with Article 3(d) of ILO Convention No. 182 as work which, by its nature or the circumstances in which it is carried out, is likely to harm children's health, safety or morals. Article 4 of Convention No. 182 provides that the specific types of hazardous work are to be determined through national legislation. Accordingly, our operational definition draws primarily on Uganda's Employment (Employment of Children) Regulations, 2012 (S.I. No. 17), including Section 2, which provides the general definition of hazardous work, the national list of hazardous occupations and activities under Section 6, as well as the provisions on working hours and night work under Sections 10 and 12.

As the Ugandan legislation does not provide a list of hazardous activities specifically for coffee production, we developed a coffee-specific classification based on two complementary elements of the legislation. First, we considered the general criteria for hazardous work applicable across sectors. Second, we considered the specific hazardous activities listed under Section 6 for other agricultural activities, including tea and tobacco, and mapped these to the coffee-production activities captured in our survey.

The study includes indicators capturing children's involvement in hazardous child labour in agricultural activities in the last 12 months. Hazardous child labour was first defined as a categorical variable 1 = engaged in hazardous child labour and zero otherwise. Thereafter hazardous child labour was then categorized into three categories including children having participated in 1) Physical & Mechanical, 2)

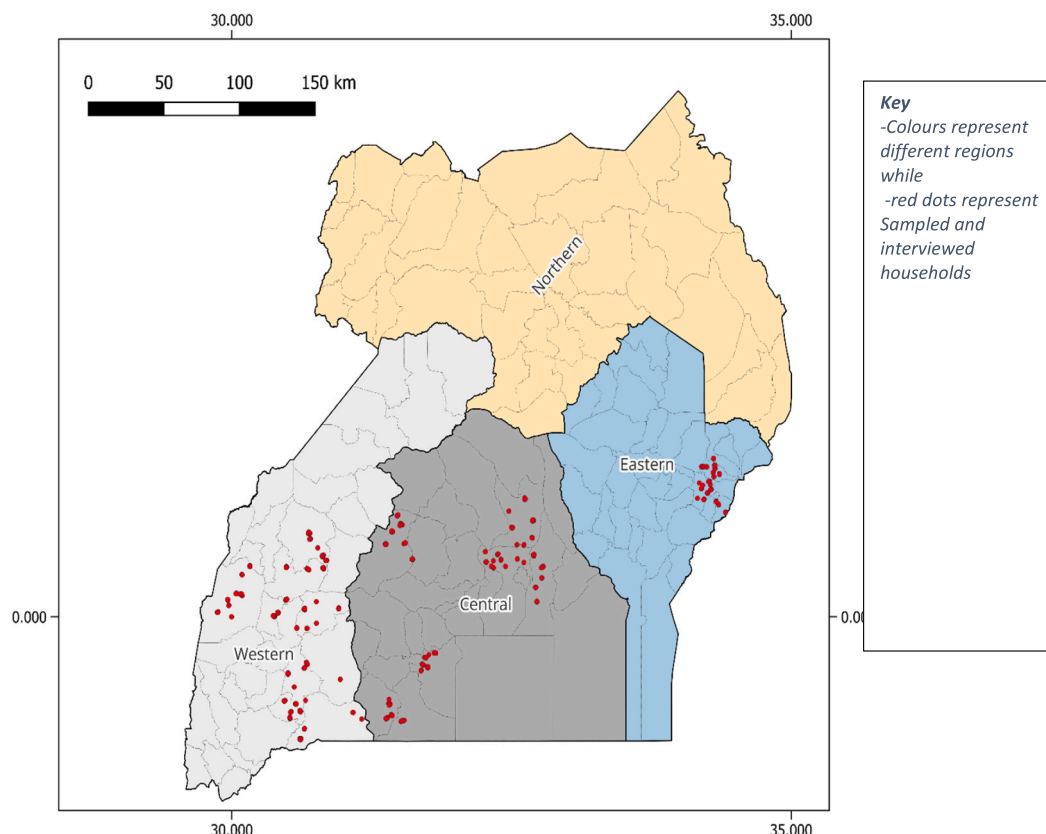


Fig. 1. Location of sample households.

Environmental & Chemical Exposure hazards and 3) Working Conditions & Time-related Risks/hazards. Table 1 provides an overview of the indicators used, their respective legal or methodological basis, and their classification into the three distinct hazard groups used in this study. Table 2 presents a summary of the measurement of key variables used in

Table 1
Operationalization of hazardous child labour in coffee and its sources.

Activity related to coffee	Source/methodological basis	Hazardous work grouping
Land clearing, or felling and chopping, or burning	Employment (Employment of Children) Regulations, 2012 (S.I. No. 17), Section 2a “a child is exposed to dangerous machinery, equipment and tools”	1 Physical and mechanical hazards
Using sharp tools		
Using big or heavy machines, or driving vehicles		
Working with fire, ovens or very hot machines or tools, or unsafe electric wires/cables		
Harvesting overhead coffee with a harvesting hook	Section 2b “a child carries heavy loads beyond their capacity”	2 Environmental and chemical exposure hazards
Carrying or pushing or pulling heavy loads		
Working indoors or outdoors where dust, sand, smoke or fumes make it hard to breathe or see clearly		
Working in very a noisy place, so that you had to shout to speak		
Working with or around agricultural chemicals? Or helping someone else to do this. e.g., spraying or spreading fertilizers to help crops/plants grow, spraying or spreading pesticides/herbicides to kill bugs or weeds, cleaning pesticide containers	Section 2c “a child works in unhealthy environments that expose them to hazardous substances, infectious diseases, excessive noise, temperature or vibrations”	3 Working conditions and time-related risks/hazards
Being present or working in the vicinity of farm during pesticide spraying		
Re-entering a sprayed farm within less than 12 h of spraying		
Working long hours in the hot sun without a break		
Working during the nighttime or very early in the morning, when it is dark? Including going to or from work when it is dark	Section 12 “A child shall not be employed at night between the hours of 7.00 p.m. and 7.00 a.m.” – slightly stricter study-specific threshold chosen by the authors.	
Worked on farm between 6.00 p.m. and 6.00 a.m.		
Worked on the farm for more than 3 h per day or more than 18 h per week		
Worked more than 2 h/day on a school day (for children in school)		
	Study-specific thresholds informed by Section 2 on light work and school attendance, but more conservative than the >14 and > 43 h/week thresholds used under Section 6 for a more conservative identification of potential school interferences.	

Table 2
Summary of Key variable definitions.

Variable	Definition	Measurement
Hazardous child labour (Was defined in several ways)	1.Dummy 2.Categorical variable	1 = Child was engaged in hazardous child labour and zero otherwise Children having participated in 1 = Physical & Mechanical Hazards (tasks involving bodily strain or injury risk from tools, equipment, e.g., heavy lifting, climbing/falls, sharp tools, machinery/vehicles, harvesting with tools, and land clearing/burning. 2 = Environmental & Chemical Exposure hazards (if child was involved in activities such as risks from harmful surroundings or substances, e.g., heat/sun exposure, dust/smoke/fumes, noise, fire/heat/electric hazards, and working with or around agricultural chemicals (including pesticide exposure and re-entry into sprayed gardens). 3 = Working Conditions & Time-related Risks/hazards (if the child was involved in activities related to when and how long work is done, e.g., long hours, night/early morning work, working during school days, and overall workload intensity).
Educational outcome	Educational gap	Difference between expected and actual years of schooling
Own child	Dummy	1 = If the child is a biological child of household head
Age of child	Continuous	Children between 5 and 17 years
Housing quality	Dummy	1 = If the house was rated highest quality
Coffee plot size	Continuous	Plot where coffee is grown measured in acres
Household expenditure	Continuous	USD per capita per year

the models.

Educational outcome is captured using an educational gap, defined as the difference between expected and actual years of schooling. Expected years of schooling are calculated as the child's age minus six, while actual schooling is measured by the grade the child is currently attending. The education gap is computed as expected minus actual years of schooling, where higher values indicate that children are further behind their expected schooling level.

To analyse the drivers of hazardous child labour, the survey captured a set of explanatory variables grounded in theory and prior literature. These variables can be grouped into child characteristics and household characteristics, including demographics, financial status, agricultural practices, and infrastructure.

Based on the variables above, Fig. 2 depicts the links considered in this study's analysis between hazardous child labour and education trade-off. The paper does stepwise modelling considering entire sample of children in the household to those who did child labour but also did hazardous activities. Other confounding factors are also shown.

3.3. Estimation strategy

The empirical analysis relies on cross-sectional regressions estimated at the child level. Three sets of econometric specifications are employed.

The first set of regressions examines hazardous child labour outcomes as a function of child- and household-level characteristics. The specification is given by:

$$HCL_{ij} = \alpha + \beta X_{ij} + \gamma H_j + \delta C_j + \varepsilon_{ij} \quad (1)$$

, where HCL_{ij} denotes the binary hazardous child labour indicator of child i in household j , X_{ij} is a vector of child characteristics, H_j is a vector

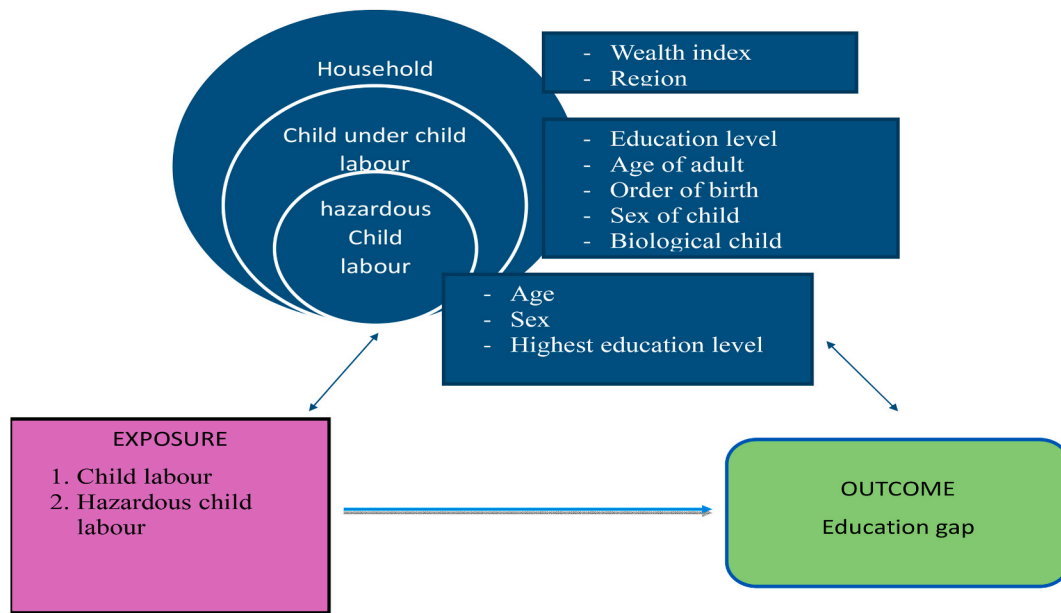


Fig. 2. Associations between hazardous child labour and education outcome.

of household controls, C_j is agricultural related activities such as involvement in coffee related activities (the share of the plot cultivated with coffee, a dummy for the coffee system (Arabica vs. Robusta) and a binary indicator for membership in a farmer's organization) and ε_{ij} is an error term.

Child-level controls include age and gender, school attendance, birth order and whether the child is a biological child or grandchild of the household head. Household characteristics include the age, gender, marital status and education of the household head, household size, gender and marital status of the household head. Household financial conditions are proxied by log per capita daily expenditure, complemented by indicators for remittances, non-farm income, and access to credit. Housing quality is included as a proxy for household wealth, while land ownership captures both wealth and labour demand. Further controls include regional dummies and distances to the nearest market. Since the outcome variable is measured as binary in equation (1) for entire sample as well as sub-sample of only children undertaking hazardous child labour, the models are estimated using probit estimation.

The second set of analysis focuses on hazardous child labour outcomes related to three categorizations of different hazardous activities in agricultural production. These models use the multivariate probit analysis (MVP) as this MVP estimates multiple, simultaneous binary outcomes where the error terms are correlated. It is widely used to analyse interdependent choices and is typically specified mathematically using latent variables, threshold limits, and a correlated error structure. It can be specified as:

$$y_{ij}^* = x_{ij}\beta_{ij} + u_{ij} \quad (2)$$

$$y_{ij} = 1(y_{ij}^* > 0) \quad (3)$$

$$u_i = [u_{i1}, \dots, u_{iM}] \sim \text{MVN}(\mathbf{0}, \mathbf{R}) \text{ or } y_i^* = [y_{i1}, \dots, y_{iM}] \sim \text{MVN}(x_i\mathbf{B}, \mathbf{R}) \quad (4)$$

, where y_{ij}^* is the latent (unobserved) propensity for outcome j , x_{ij} is a vector of explanatory variables (covariates), β_{ij} is the vector of coefficients to be estimated and u_{ij} is the error term. The actual observed binary outcomes y_{ij}^* determined by whether the latent propensity crosses a zero threshold of zero. $i = 1, \dots, N$ indexes observations, $j = 1, \dots, M$ indexes outcomes, the u_i are assumed to be iid independent across i but correlated across j for any i , and "MVN" denotes the multivariate

normal distribution. The error terms are assumed to follow a Multivariate Normal (MVN) distribution. The M-outcome models are then estimated using multivariate probit models estimation [53].

The third set of regressions inquired into the trade-offs between hazardous child labour and child education outcomes. The child education outcome indicator selected was the education gap (expected years of educational attainment (born age) less the actual years of education attained). This was the dependant variable. The study applied the ordinary least squares regression model using a step wise approach.

Model 1: The entire sample of 1252 was used and child engagement in hazardous child labour was modelled as a binary variable meaning 1 = if child was involved in any form of hazardous child labour as earlier defined.

Model 2: Only relied on the sub sample of 528 children who were actually engaged in child labour (both hazardous and non-hazardous).

In models 3, 4, 5, the education gap was modelled as the dependent variable but hazardous child labour was disaggregated into the three categories of physical/mechanical hazards, environmental/chemical exposure risks, and bad working conditions or time-related risks as earlier elaborated. Just like in steps 1 and 2, the three categories were treated as binary variables. The relationship is modelled as:

$$\text{Edu} - \text{gap}_{ij} = \alpha + \theta \text{CL}_{ij} + \beta X_{ij} + \gamma H_j + \delta C_j + \varepsilon_{ij} \quad (3)$$

, where $\text{Edu}_{gap_{ij}}$ denotes the educational outcome of child i in household j , measured as (i) the education gap, defined as the difference between expected and actual years of schooling.

Across all specifications, standard errors are clustered at the household level to account for intra-household correlation in unobserved factors. Given the cross-sectional nature of the data, the estimated coefficients are interpreted as associations rather than causal effects.

4. Results and discussions

4.1. Socio-demographic characteristics of the sample

The summary statistics show that the mean age of children aged 5–17 years was 11 years, with girls accounting for 49% of the sample. On average, children had completed three years of schooling, while 5% had already dropped out of school. The mean household size was approximately seven members, and annual per capita household expenditure

was USD 1.813. Coffee was grown on an average of 1.3 acres, and 19.7% of farmers belonged to a farmer group (Table 3).

4.2. General engagement in coffee production

Overall, 42% of children participated in at least one coffee-related activity during the last two agricultural seasons. Participation was slightly higher among boys (44%) than among girls (40%). Disaggregating by coffee system, 40.3% of children in Robusta-producing households and 44.5% in Arabica-producing households were engaged in coffee-related activities.

To examine children's participation in coffee production in more detail, Table 4 presents the specific activities performed across the two agricultural seasons. Harvesting was the most common coffee-related activity, involving 77.5% of children in season 1 and 86.2% in season 2. This was followed by weeding, including herbicide application, at 54.7% and 53.9%, respectively. Drying involved about one-third of children in both seasons. Among children engaged in coffee production over the two seasons, 35% performed one activity, 27% performed two, and 21% performed three activities. Overall, these results indicate that children's involvement in coffee production is concentrated in a few labour-intensive activities, particularly harvesting and weeding, with many children participating in multiple tasks across seasons.

On average, children who were engaged in coffee-related activities performed them for 3.7 days (standard deviation: 8.5 days).

4.3. Prevalence of hazardous child labour

The hazardous activities module was administered to a sub-sample of children that were engaged in labour activities in the seven days prior to the survey (42%, $n = 528$). Out of this subsample, 23% of children were exposed to hazardous activities in coffee production in the past 12 months - 20% of girls versus 25% of boys. The most common hazardous activities reported among children included the use of sharp tools (69 children, 13%), land clearing activities such as felling, chopping, or burning vegetation (31 children, 6%), working more than 2 h on a school day (26 children, 5%), and working on the farm for more than 3 h

Table 3
Socio-demographic characteristics of the surveyed children and households.

	N	Mean	SD	Min	Max
Child characteristics					
Age (years)	1252	11.07	3.566	5	17
Girl (dummy = 1)	1252	0.490	0.500	0	1
Education (years)	1252	3.073	2.699	0	12
Left school (dummy = 1)	1252	0.0503	0.219	0	1
Own child (dummy = 1)	1252	0.958	0.201	0	1
Firstborn (dummy = 1)	1252	0.128	0.334	0	1
Household characteristics					
Household head: age (years)	417	52.81	14.45	22	103
Household head: female (dummy = 1)	417	0.249	0.433	0	1
Household head: education (years)	416	6.228	4.371	0	20
Household head: married (dummy = 1)	417	0.767	0.423	0	1
Household size	417	6.588	2.521	2	18
Household expenditure (USD per capita per year)	417	1.813	1.296	0.280	8.326
Distance to nearest market (km)	417	3.698	4.342	0	50
Coffee-related characteristics					
Arabica (dummy = 1)	415	0.373	0.484	0	1
Coffee plot size (acres)	417	1.296	1.347	0.125	11.75
Share of plot coffee is grown	417	0.281	0.183	0.012	1
Member of a farmer group (dummy = 1)	417	0.197	0.398	0	1

Table 4

Coffee-related activities performed by children in 1st Season 2024 (January to June 2024) and 2nd Season 2023 (July to December 2023).

Activity	First season (n = 593)		Second season (n = 505)	
	Frequency	Percent	Frequency	Percent
Harvesting	421	77.53	400	86.21
Weeding including herbicide application	297	54.70	250	53.88
Drying	175	32.23	157	33.84
Second ploughing/Harrowing	21	3.87	12	2.58
Land preparation/Tillage	70	12.89	63	13.58
Fertilizer/manure application	79	14.55	44	14.55
Please specify other labour activity	23	4.24	19	4.09
Packing into sacks	38	7.00	34	7.33
Planting including field marking and digging holes	59	10.87	22	4.74
Carrying water for spraying	26	4.79	12	2.59
Stalking/pruning	53	9.76	44	9.48
Weighing and packing	26	4.79	22	4.74
Thinning	14	2.58	11	2.37
Pesticides/fungicide application	43	7.90	24	5.17
Transport, storage and shipment	9	1.66	10	2.16
Bulking	5	0.92	4	0.86

per day or more than 18 h per week (24 children, 5%). After disaggregation of the hazardous activities as shown above, Physical/mechanical hazards had the highest proportion of children involved followed by bad working conditions and time-related risks while participation in environmental or being exposed to chemicals lagged behind the two categories.

Table 5 shows the results after disaggregating the children by age categories. The older children (15-17 years) tend to be deployed the most in all three hazardous categories, but more children (70.8%) are facing environmental, or chemicals hazards compared to physical/mechanical hazards (55.4%) and bad working conditions and time related risks (44.6%).

4.3.1. Health related injuries experienced by children due to hazardous work they do

Children experienced several health-related injuries because of participating in hazardous activities in coffee production. The highest proportion of the children involved in hazardous child labour experienced skin itches and scratches. The same proportion of the children (7.95%) encountered muscle pain and being hit by something very heavy falling on or being crushed by heavy machines while the rest experienced either eye or ear injury, and other body injuries (see Table 6).

Table 5

Hazardous activities exposed to over the last 12 months ($n = 528$) and categorized by child age in %.

Hazard disaggregation ^a	Overall	5-11	12-14	15-17
Participated in physical and mechanical hazards	15.7	19.3	25.3	55.4
Participated in environmental hazards or being exposed to chemicals	4.6	8.3	20.8	70.8
Participated in bad working conditions and time related risks	10.6	19.6	35.7	44.6

^a The aggregation of heterogeneous risks into broad hazard categories e.g. environmental and chemical hazards is due to nature and kind of activities in the work environment which is impacted by all these factors. The preference would be to undertake a non-disaggregated analyses but the sample sizes as noted in Table 4 are limiting. A future study with much larger sample could consider respective subcategories analyses.

Table 6

Health related injuries experienced by children involved in hazardous work.

Variables	Proportion
Injuries from falls (falling from ladders, trees)	5.87
Hit by something very heavy falling on or being crushed by heavy machines	4.92
Deep or long cut	7.95
Bad bruises, bumps or swelling (e.g., a strained muscle, dislocation)	7.2
Animal or snake bite	5.68
Head, back or neck injury	5.68
Broken Bone	5.3
Eye or ear injury/damage	5.87
Skin Itches and scratches	8.9
Muscle pain	7.95

4.4. Drivers of hazardous child labour

4.4.1. All and sub-sample regression results

Table 7 presents the regression results for hazardous child labour: (1) a binary indicator capturing whether a child was involved in hazardous activities but drawn from the entire sample ($n = 1252$); (2) a binary indicator when a child is involved in hazardous activities but for the sub-sample of children engaged in any work over the 7 days preceding the survey ($n = 528$).

Across both model specifications 1 and 2, older children are significantly more engaged in labour activities compared to younger children. Children aged 12–14 are 9.1 percentage points more likely to be engaged in hazardous labour activities than children aged 5–11, while children aged 15–17 show an even larger increase of 15.5 percentage points (model 1). However, for model 2, only children aged 15–17 are significantly more engaged in hazardous child labour with 17.8 percentage points (model 2). Hence, age emerges as an important determinant, with older children more likely to participate in hazardous child

Table 7

Drivers of hazardous child labour: all and sub-sample regression results.

Variable	(1) -All sample		(2) – Sub-sample	
	dy/dx	std. err.	dy/dx	std. err.
12-14 years	0.091***	0.030	0.081	0.060
15-17 years	0.155***	0.041	0.178**	0.081
Girl (dummy)	–0.015	0.015	–0.030	0.031
Firstborn (dummy)	0.009	0.023	0.071	0.049
Left school (dummy)	0.002	0.005	0.005	0.011
Own child/grandchild (dummy)	–0.083**	0.039	–0.193**	0.084
Per capita expenditure (ln)	–0.037**	0.018	–0.137***	0.040
Age of household head	–0.000	0.001	–0.000	0.002
Highest grade: household head	–0.004	0.004	–0.007	0.007
Household size	–0.003	0.004	0.001	0.008
Female-headed household (dummy)	–0.019	0.040	0.007	0.086
Married household head (dummy)	–0.002	0.038	0.007	0.085
Highest housing quality (dummy)	–0.013	0.013	–0.003	0.023
Land owned (acres)	0.003	0.003	0.013**	0.005
Received remittances (dummy)	0.009	0.025	0.043	0.049
Received non-farm income (dummy)	–0.001	0.020	0.036	0.039
Share of plot cultivated with coffee	0.014	0.054	0.120	0.111
Arabica (dummy)	–0.014	0.034	0.033	0.067
Member of farmer's organisation (dummy)	0.017	0.024	0.078	0.050
Distance to nearest health facility	–0.001	0.003	0.005	0.005
Distance to nearest tarmac road	0.003	0.004	–0.006	0.013
Distance to nearest market (km)	–0.002	0.003	–0.009	0.006
Access to credit (dummy)	–0.022	0.026	–0.025	0.053
Eastern region	0.083**	0.041	0.190**	0.076
Western region	–0.026	0.028	–0.070	0.051
Number of observations	1247		524	

labour. This is probably because they are more energetic and tend to endure much more than younger children. This result agrees with results by Spencer et al. [54].

Children who are the biological children or grandchildren of the household head are less likely to be engaged in hazardous child labour than other children residing in the household. Model 1 indicates an 8.3 percentage point lower probability of engagement in labour activities for own children or grandchildren, while in model 2, this number more than doubles to an increase of 19.3 percentage points. Both coefficients are significant at five percent level of significance. This is probably because children who are not biological children of the parents have weaker bargaining power within households, besides that the caregivers may have lower investment incentives on them and or the caregiver sees it fit to use the fostered children as substitute labour. This finding is in line with findings by DeGraff et al. [17] and Kamei [23] who find that children engaged in hazardous activities were more likely not be living without both parents.

Higher per capita expenditure is strongly associated with lower likelihood of child engagement in hazardous child labour. For example, as per capita expenditure increases, the probability of a child engaging in hazardous work decreases by 3.7 percentage points in model 1 and 13.7 percentage points in model 2. Both are statistically significant at five percent level and at one percent level of significance, respectively. This strong association is probably because ability to hire labour from outside as well as purchase machinery that reduces drudgery in the agricultural activities.

Further, children living in households with larger landholdings are significantly more likely to engage in hazardous child labour, although this association is observed only in model 2. Specifically, each additional acre of land owned is associated with a 1.3 percentage point increase in the probability of a child engaging in hazardous work, and the coefficient is statistically significant at the five percent level. This finding is consistent with the argument that land ownership may increase household demand for family labour in agricultural production, particularly during labour-intensive activities such as coffee harvesting. In this context, land may operate not only as a wealth indicator but also as a source of increased labour demand, echoing the “wealth paradox” identified by Bhalotra and Heady [9].

On the other hand, children from household in eastern region where arabica coffee is grown have the highest likelihood of being involved in hazardous child labour in both specifications compared to children in the central region where most Robusta coffee is grown. This evidence shows that coffee production system matter, with children in Arabica-producing households showing slightly higher participation in hazardous child labour. This is because Arabica coffee is more labour-intensive overall due to the several factors related to the plant's delicate nature and specific growing requirements. For instance, Arabica coffee grows best on difficult to access mountain slopes that makes it more challenging; arabica coffee is also more susceptible to pests, diseases and weather extremes that requires more mulching, shade trees provision and regular pesticide use; moreover, its harvesting is more selective due to uneven ripening of the cherries [55,56].

4.4.2. Multivariate probit results for three categories of hazardous labour

The disaggregated hazardous child labour results using a multivariate probit model are presented in Table 8. The results show that compared to children aged 5–11, children aged 12–14 have a significantly higher likelihood of participating in environmentally/chemically hazardous child labour and in bad working conditions/time related risks but not in physically/mechanically hazardous child labour.

However, compared to children aged 5–11 years, children aged 15–17 have a significantly higher likelihood of participating in all categories of hazardous child labour (physical/mechanical hazards; environmental/chemical risks; and in bad working conditions or time related risks).

Girls are significantly less likely than boys to participate in physically/mechanically hazardous child labour and less likely to suffer

Table 8

Multivariate probit results for hazardous child labour.

	Physical and mechanical hazards		Environmental or being exposed to chemicals		Bad working conditions and time related risks	
	(dy/dx)	Std Error.	(dy/dx)	Std Error.	(dy/dx)	Std Error.
12-14 years	0.032	0.023	0.029*	0.016	0.062***	0.021
15-17 years	0.068**	0.030	0.060***	0.021	0.105***	0.027
Girl (dummy)	-0.033**	0.013	-0.002	0.008	0.020*	0.011
Firstborn (dummy)	0.012	0.019	-0.000	0.010	0.013	0.016
Left school (dummy)	0.009**	0.004	-0.002	0.002	-0.004	0.003
Own child/grandchild (dummy)	-0.068**	0.028	-0.011	0.016	-0.051**	0.022
Per capita expenditure (ln)	-0.024**	0.013	0.002	0.007	-0.022**	0.011
Age of household head	0.000	0.001	-0.000	0.000	-0.000	0.000
Highest grade: household head	-0.003	0.002	0.001	0.001	-0.007***	0.002
Household size	-0.001	0.003	-0.005**	0.002	0.001	0.002
Female-headed household (dummy)	-0.010	0.024	-0.004	0.013	-0.017	0.022
Married household head (dummy)	-0.012	0.026	-0.003	0.014	0.012	0.022
Highest housing quality (dummy)	-0.015*	0.008	-0.000	0.005	0.000	0.007
Land owned (acres)	0.000	0.002	-0.001	0.001	0.002*	0.001
Received remittances (dummy)	-0.012	0.016	0.013	0.009	0.015	0.014
Received non-farm income (dummy)	-0.011	0.013	0.002	0.008	0.007	0.011
Share of plot cultivated with coffee	0.003	0.038	-0.009	0.022	0.021	0.030
Arabica (dummy)	0.023	0.021	-0.016	0.015	-0.017	0.019
Member of farmer's organisation	0.018	0.015	0.014	0.009	0.004	0.014
Distance to nearest health facility	-0.007**	0.003	0.000	0.001	-0.002	0.002
Distance to nearest tarmac road	0.002	0.005	0.000	0.001	0.001	0.003
Distance to nearest market (km)	-0.003	0.002	0.001	0.001	0.000	0.002
Access to credit (dummy)	-0.004	0.019	0.003	0.011	-0.016	0.015
Eastern region	0.083**	0.026	0.010	0.018	-0.005	0.023
Western region	0.009	0.020	0.004	0.010	-0.036**	0.015
Number of observations	1247		1247		1247	

environmental/chemical exposure risks. However, girls were significantly more likely than boys to face bad working conditions and time related risks compared to other hazard categories. This could be due to gender segregation of agricultural tasks where girls tend to take on less tasking activities, or probably due to girls' greater involvement in unpaid household labour/chores and other domestic responsibilities before and after farm work. It may also be due to differences in reporting behaviour.

Children who are biological children or grandchildren of the household head are significantly less likely than other resident children to be exposed to physical/mechanical hazards and poor working conditions or time-related risks. This suggests that kinship ties may be associated with the allocation of hazardous tasks within the household, with non-biological children potentially facing greater exposure to more demanding or less protected forms of work. In contrast, children who have left school are significantly more likely than those still in school to be engaged in physical/mechanical hazards, pointing to a link between school disengagement and exposure to physically risky work.

Increase in per capita expenditure significantly reduces the likelihood of children participating in physical/mechanical hazards and the likelihood of them facing bad working conditions/time related risks but it does not significantly lower the likelihood of facing environmental/chemical risks.

Higher educational attainment of the household head is associated with a lower likelihood of children experiencing poor working conditions and time-related risks. However, this relationship is statistically significant only for the working-conditions/time-related risk category, suggesting that household head education may be more relevant for reducing excessive or poorly timed work than for preventing other forms of hazardous exposure. This finding is consistent with evidence that parental education is negatively associated with children's work. For example, Abaidoo [57] finds in Malawi that higher parental educational attainment generally reduces child labour, with the effects partly operating through educated parents' greater engagement in non-farm employment. Similarly, Webbink, Smits, and de Jong [46] show that across 18 developing countries, household resources, including parental education, are important determinants of child labour.

The higher the household size, the lower the likelihood of children being engaged in environmental or chemical exposure risky activities

since there would probably be more older adults over 17 years therefore, such activities would be undertaken by adults in the larger household sizes. Further, children living in households with the highest housing quality - a proxy for household wealth - are less likely to be engaged in physical/mechanical hazards, with negative and statistically significant associations observed in the model specification.

The higher the average land owned by the household, the higher the likelihood of children participating in bad working conditions/time related activities compared to other hazards. An increase in distance to the nearest health facility significantly lowers the likelihood of children participating in physical/mechanical hazards.

Region wise, compared to the central region, children in eastern region are significantly more likely to be engaged in physical/mechanical hazards since crops such as coffee from this area require more staking, and pruning compared to robusta coffee from the central or western regions. Further, children from households from western region are significantly less likely to be involved in bad working conditions or time related risks compared to those from central region. This pattern is repeated for other types of hazards and is probably due to reported lower poverty levels in the western region compared to other regions.

4.5. Education-hazardous child labour trade-off: regression results

As shown in Table 9, with the exception of model 3 on physical/mechanical hazardous child labour, child engagement in hazardous labor has a positive and significant association with child education gap (i.e. children lag further behind their expected years of schooling) at the 10% level of significance. The coefficient is highest for model 4 (environmental/chemical hazardous child labour) followed by model 5 (bad working conditions/time related hazards) then model 1 and 2 with hazardous child labour undifferentiated. The coefficient is small and insignificant for model 3 (physical/mechanical hazards). These results suggest that child engagement in hazardous child labour grossly affects child education as measured by education gap. Specifically, child education gap increases with an increase in engagement in different hazardous child activities. These results are in agreement with cross country synthesis results that show that children in hazardous forms of labour are more likely to drop out and perform poorly in school, and that school

Table 9
Regression results - education-labour trade-off.

Variables	(1)	(2)	(3)	(4)	(5)
	All sample	Sub- sample	Physical/mechanical hazard	Environment/chemical hazards	Bad conditions/time related risks
Experienced hazard (all sample)	0.590*** (0.202)				
Experienced hazard (sub-sample)		0.495** (0.211)			
Physical/mechanical hazard			0.207 (0.235)		
Environment/chemical hazards				1.185*** (0.455)	
Bad working conditions/time related risks					1.017*** (0.295)
12-14 years	1.976*** (0.091)	1.997*** (0.179)	2.005*** (0.091)	2.004*** (0.090)	1.980*** (0.091)
15-17 years	2.932*** (0.142)	3.127*** (0.232)	2.998*** (0.142)	2.967*** (0.141)	2.942*** (0.140)
Girl (dummy)	-0.378*** (0.087)	-0.340** (0.140)	-0.383*** (0.087)	-0.377*** (0.087)	-0.395*** (0.087)
Firstborn (dummy)	-0.311*** (0.109)	-0.271 (0.177)	-0.311*** (0.110)	-0.326*** (0.110)	-0.323*** (0.109)
Own child/grandchild (dummy)	-0.882*** (0.306)	-1.543*** (0.524)	-0.923*** (0.316)	-0.878*** (0.309)	-0.838*** (0.299)
Per capita expenditure (ln)	-0.335*** (0.096)	-0.237 (0.180)	-0.350*** (0.097)	-0.359*** (0.096)	-0.327*** (0.095)
Age of household head	0.005 (0.005)	0.002 (0.008)	0.004 (0.005)	0.004 (0.005)	0.004 (0.005)
Highest grade: household head	-0.057*** (0.016)	-0.092*** (0.028)	-0.059*** (0.016)	-0.057*** (0.016)	-0.052*** (0.016)
Household size	0.009 (0.021)	0.014 (0.037)	0.007 (0.021)	0.012 (0.021)	0.007 (0.021)
Female-headed household (dummy)	-0.337 (0.208)	-0.366 (0.270)	-0.350* (0.208)	-0.345* (0.208)	-0.323 (0.210)
Married household head (dummy)	0.086 (0.231)	0.152 (0.298)	0.088 (0.232)	0.088 (0.233)	0.076 (0.231)
Highest housing quality (dummy)	-0.136* (0.071)	-0.152 (0.113)	-0.141* (0.072)	-0.144** (0.071)	-0.144** (0.070)
Land owned (acres)	-0.019 (0.012)	-0.033 (0.020)	-0.018 (0.012)	-0.017 (0.012)	-0.020 (0.012)
Received remittances (dummy)	0.123 (0.142)	-0.010 (0.226)	0.133 (0.143)	0.112 (0.137)	0.125 (0.140)
Received non-farm income (dummy)	-0.129 (0.109)	-0.020 (0.179)	-0.128 (0.109)	-0.136 (0.108)	-0.137 (0.107)
Share of plot cultivated with coffee	-0.301 (0.300)	-0.731 (0.445)	-0.295 (0.301)	-0.281 (0.299)	-0.316 (0.296)
Arabica (dummy)	-0.349*** (0.131)	-0.223 (0.178)	-0.360*** (0.133)	-0.344*** (0.132)	-0.342*** (0.129)
Member of farmer's organisation (dummy)	0.015 (0.124)	0.208 (0.200)	0.020 (0.123)	-0.000 (0.122)	0.017 (0.122)
Distance to nearest health facility	0.012 (0.013)	0.021 (0.019)	0.012 (0.014)	0.011 (0.013)	0.012 (0.013)
Distance to nearest tarmac road	0.040** (0.018)	0.034 (0.039)	0.040** (0.018)	0.040** (0.018)	0.042** (0.018)
Distance to nearest market (km)	-0.012 (0.016)	-0.005 (0.020)	-0.012 (0.016)	-0.013 (0.016)	-0.013 (0.016)
Access to credit (dummy)	0.081 (0.155)	-0.123 (0.206)	0.068 (0.158)	0.059 (0.158)	0.096 (0.151)
Eastern region	0.622*** (0.190)	0.174 (0.279)	0.651*** (0.192)	0.668*** (0.190)	0.692*** (0.189)
Western region	0.259* (0.149)	0.257 (0.224)	0.243 (0.152)	0.239 (0.149)	0.275* (0.147)
Constant	1.664*** (0.515)	2.841*** (0.804)	1.758*** (0.530)	1.698*** (0.526)	1.610*** (0.506)
Observations	1247	524	1247	1247	1247
R-squared	0.477	0.436	0.471	0.476	0.481

Standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

attendance is variably affected by child labour intensity (Thévenon & Edmonds, 2019).

The other factors that are positively associated with child educational attainment include children in the age bracket of 12 – 14 years, age category 15 – 17 years, distance to the main road (proxy for accessibility) and region. All these four covariates are positively and significantly (at 1% level of significance) associated with the education

gap of the child. The exception is model 3 i.e. the physical/mechanical hazard category.

For age categories 12-14 and 15-17, the magnitude of the coefficients ranges from 2 to 3 signifying the sensitivity of child education to the engagement of these age groups in child labour when compared to younger children (5-11), the base category. The coefficients on distance from the road and region are positively influencing variables.

Meanwhile, there are six covariates that are negatively associated with the child education gap meaning that they reduce the child education gap. These include child being a female, child being a first born, child being an own child, educational attainment of the household head, housing quality and arabica cropping system. These results speak to cultural norms and household wealth in as far as they are associated with child education outcomes. The results suggest that girls, first born children, and own children mitigate the deterioration in child education outcomes for children engaged in hazardous child labour. Household wealth proxy indicators of level of education, arabica cropping system, Eastern region (predominantly arabica growing area) also work to mitigate significant associations between child engagement in hazardous work and child educational outcomes as measured by the child education gap.

The results further suggest the critical importance of cultural norms and household wealth as safeguards of child educational attainment in an environment prone with hazardous child labour.

Finally, it's important to note that the estimated relationship between hazardous child labour and educational outcomes discussed above is conditional and associational and may reflect reverse causality and omitted-variable bias due to inability to identify a credible instrumental variable for undertaking instrumental variable estimations.

Revisiting our hypotheses, we find that hazardous child labour is increased by household poverty, as higher per capita expenditure is significantly associated with a lower probability of children engaging in hazardous work, suggesting that economically constrained households are more likely to rely on children's labour. Also, being a more distant relative or unrelated to the household head increases the selection of children for hazardous work, with biological children and grandchildren appearing relatively protected from hazardous tasks. Finally, hazardous child labour is associated with poorer schooling and educational outcomes, particularly wider education gaps among children exposed to hazardous work, although these relationships are interpreted as associations rather than causal effects because the data are cross-sectional.

5. Limitations and future research

While these findings align with existing literature, they should be interpreted with caution. The cross-sectional nature of our data limits the analysis to associations rather than causal relationships, and potential endogeneity - such as the simultaneous determination of schooling and hazardous child labour - cannot be fully addressed. Hence, the estimated relationship between hazardous child labour and educational outcomes discussed is conditional and associational and may reflect reverse causality and omitted-variable bias. Panel or follow-up surveys would strengthen causal inference and provide a more robust understanding of the drivers.

6. Conclusion

Despite global commitments and declining prevalence rates in some regions, hazardous child labour - particularly in agriculture - continues to represent a significant social cost of food systems in Sub-Saharan Africa. This study contributes to the evidence base by providing detailed, micro-level insights into hazardous child labour in smallholder coffee production in Uganda and their relationship with educational outcomes.

Our results show that hazardous child labour participation in coffee farming is still widespread among children aged 5-17 years in Uganda. The results suggest that both child characteristics and household characteristics are important drivers of hazardous child labour among Uganda coffee smallholder farmers. Results show that 22.5% of the children who participated in any form of child labour also participated in hazardous work. Children were more involved in physical/mechanical hazardous work while older child category participated the most in all hazardous work categories. Regression results show that hazardous

child labour is strongly associated with children's age, school attendance status, the relation to the household head, and the educational attainment of the household head. Within coffee production systems, older children and non-biological household members face significantly higher exposure to hazardous work.

The education attainment measured as education gap of children is negatively associated with engagement in hazardous labour activities as evidenced by the positive and significant coefficient of hazardous child labour on education attainment. Empirical results show that engagement in hazardous work during the previous seven days is strongly associated with children having a wider education gap falling more than a full year behind their expected grade level. This leads to lack of building potential human capital and can result in reduced life time income of affected children as well as reduced future national income. Its important to note that the education results may be interpreted as associational rather than causal. While hazardous child labour is positively associated with education gaps in the analysis, the study cannot rule out reverse causality or omitted-variable bias. Children's schooling outcomes and exposure to hazardous work may be jointly shaped by household constraints, school access, child characteristics, and local labour demand. Consequently, the findings support the need for policies that reduce children's exposure to hazardous work while supporting schooling, but they should not be read as establishing a causal effect of hazardous child labour on educational delays.

The findings of this study point to the need for targeted policy responses:

- Policymakers should strengthen policies and programmes that support children's continued participation in education, including interventions that address basic needs such as school fee subsidies, school feeding programmes, and infrastructural constraints.
- Greater awareness among parents and caregivers is needed to prevent children's exposure to hazardous work activities that can negatively affect their health and well-being.
- In addition, the specific needs of particularly vulnerable children, such as non-biological children, including orphans or those living with relatives, require careful consideration to ensure equal opportunities and adequate protection for all children.

CRedit authorship contribution statement

Rosemary Emegu Isoto: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Friederike Schilling:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Patrick Shortall:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Bernhard Bashaasha:** Writing – review & editing, Methodology, Conceptualization. **Joachim von Braun:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of AI-assisted technologies in the writing process

During the preparation of this work, No AI was used.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

References

- [1] J. von Braun, S.L. Hendriks, Full-cost accounting and redefining the cost of food: implications for agricultural economics research, *Agric. Econ.* 54 (4) (2023) 451–454, <https://doi.org/10.1111/agec.12774>.
- [2] ILO, UNICEF, Child Labour: Global Estimates 2024, Trends and the Road Forward, International Labour Organization and United Nations Children's Fund, 2024.
- [3] Uganda Bureau of Statistics, Uganda National Household Survey 2019/2020, UBOS, 2021.
- [4] A. Bandara, R. Dehejia, S. Lavie-Rouse, The impact of income and non-income shocks on child labor: evidence from a panel survey of Tanzania, *World Dev.* 67 (2015) 218–237, <https://doi.org/10.1016/j.worlddev.2014.10.019>.
- [5] K. Basu, P.H. Van, The economics of child labor, *Am. Econ. Rev.* 88 (3) (1998) 412–427.
- [6] K. Beegle, R.H. Dehejia, R. Gatti, Child labor and agricultural shocks, *J. Dev. Econ.* 81 (1) (2006) 80–96, <https://doi.org/10.1016/j.jdeveco.2005.05.003>.
- [7] I.E. de Carvalho Filho, Household income as a determinant of child labor and school enrollment in Brazil: evidence from a social security reform, *Econ. Dev. Cult. Change* 60 (2) (2012) 399–435, <https://doi.org/10.1086/662576>.
- [8] E.V. Edmonds, Does child labor decline with improving economic status? *J. Hum. Resour.* 40 (1) (2005) 77–99.
- [9] S. Bhalotra, C. Heady, Child farm labor: the wealth paradox, *World Bank Econ. Rev.* 17 (2) (2003) 197–227.
- [10] J. Bai, Y. Wang, Returns to work, child labor and schooling: the income vs. price effects, *J. Dev. Econ.* 145 (2020) 102466, <https://doi.org/10.1016/j.jdeveco.2020.102466>.
- [11] C. Dumas, Market imperfections and child labor, *World Dev.* 42 (2013) 127–142.
- [12] D.I. Kruger, Coffee production effects on child labor and schooling in rural Brazil, *J. Dev. Econ.* 82 (2) (2007) 448–463.
- [13] T.G. Ango, L. Börjeson, P. Wisborg, F. Senbeta, H. Alem, Coffee, child labour, and education: examining a triple social-ecological trade-off in an afro-montane forest landscape, *Int. J. Educ. Dev.* 95 (2022) 102681, <https://doi.org/10.1016/j.ijeducdev.2022.102681>.
- [14] K. Beegle, R.H. Dehejia, R. Gatti, Why should we care about child labor? The education, labor market, and health consequences of child labor, *J. Hum. Resour.* 44 (4) (2009) 871–889.
- [15] D.L. Putnick, M.H. Bornstein, Is child labor a barrier to school enrollment in low- and middle-income countries? *Int. J. Educ. Dev.* 41 (2015) 112–120.
- [16] D.S. DeGraff, A.R. Ferro, D. Levison, Kids at risk: children's employment in hazardous occupations in Brazil, *Estud. Econ.* 44 (4) (2014) 685–721.
- [17] D.S. DeGraff, A.R. Ferro, D. Levison, In harm's way: children's work in risky occupations in Brazil, *J. Int. Dev.* 28 (4) (2016) 447–472, <https://doi.org/10.1002/jid.3111>.
- [18] E.V. Edmonds, M. Shrestha, You get what you pay for: schooling incentives and child labor, *J. Dev. Econ.* 111 (2014) 196–211.
- [19] K. Basu, Z. Tzannatos, The global child labor problem: what do we know and what can we do? *World Bank Econ. Rev.* 17 (2) (2003) 147–173.
- [20] I. Singh, L. Squire, J. Strauss (Eds.), *Agricultural Household Models: Extensions, Applications, and Policy*, Johns Hopkins University Press, 1986.
- [21] J. Morduch, Income smoothing and consumption smoothing, *J. Econ. Perspect.* 9 (3) (1995) 103–114.
- [22] K. Basu, S. Das, B. Dutta, Child labor and household wealth: theory and empirical evidence of an inverted-U, *J. Dev. Econ.* 91 (1) (2010) 8–14, <https://doi.org/10.1016/j.jdeveco.2009.01.006>.
- [23] A. Kamei, Parental absence and agency: the household characteristics of hazardous forms of child labour in Nepal, *J. Int. Dev.* 30 (7) (2018) 1116–1141, <https://doi.org/10.1002/jid.3371>.
- [24] E. Emerson, G. Llewellyn, Youth with disabilities are more likely than their peers to engage in hazardous child labour, *Child Care Health Dev.* 47 (1) (2021) 119–127, <https://doi.org/10.1111/cch.12820>.
- [25] A. Posso, The health consequences of hazardous and nonhazardous child labor, *Rev. Dev. Econ.* 23 (2) (2019) 619–639, <https://doi.org/10.1111/rode.12571>.
- [26] L. Pirkle, C. Zimmerman, S. Sadhu, K. Kysia, M. Ranganathan, Child labour in cocoa growing regions of Ghana and Côte d'Ivoire: an analysis of academic attainment in children engaged in hazardous labour, *Glob. Public Health* 19 (1) (2024), <https://doi.org/10.1080/17441692.2024.2320860>.
- [27] E.V. Edmonds, Selection into worst forms of child labor, *Res. Labor Econ.* 31 (2010) 1–31.
- [28] G.S. Becker, A theory of the allocation of time, *Econ. J.* 75 (299) (1965) 493–517.
- [29] J.-M. Baland, J.A. Robinson, Is child labor inefficient? *J. Polit. Econ.* 108 (4) (2000) 663–679, <https://doi.org/10.1086/316097>. JSTOR.
- [30] E.C. Eze, A.N. Amedu, M. Sampson, I.D. Okoro, C.P. Nwabudike, S.I. Ogar, Influence of environmental shocks and child labour on children's educational outcomes: a scoping review, *Child Indic. Res.* 17 (3) (2024) 1071–1095, <https://doi.org/10.1007/s12187-024-10109-6>.
- [31] T. Woldehanna, K. Endale, J. Hamory, S. Baird, Absenteeism, dropout, and on-time school completion of vulnerable primary school students in Ethiopia: exploring the role of adolescent decision-making power in the household, exposure to violence, and paid and unpaid work, *Eur. J. Dev. Res.* 33 (2021) 1349–1389, <https://doi.org/10.1057/s41287-021-00454-5>.
- [32] M. Björkman-Nyqvist, Income shocks and gender gaps in education: evidence from Uganda, *J. Dev. Econ.* 105 (2013) 237–253.
- [33] A.C. Dammert, Child labor and schooling response to changes in coca production in rural Peru, *J. Dev. Econ.* 86 (1) (2008) 164–180.
- [34] M. Buonomo Zabaleta, The impact of child labor on schooling outcomes in Nicaragua, *Econ. Educ. Rev.* 30 (6) (2011) 1527–1539.
- [35] A.R. Cardoso, D. Verner, School Drop-Out and Push-Out Factors in Brazil: the Role of Early Parenthood, Child Labor, and Poverty, 2515, IZA DP No, 2006.
- [36] K. Basu, Gender and say: a model of household behaviour with endogenously determined balance of power, *Econ. J.* 116 (511) (2006) 558–580, <https://doi.org/10.1111/j.1468-0297.2006.01092.x>.
- [37] K. Basu, R. Ray, The Collective Model of the Household and an Unexpected Implication for Child Labor: Hypothesis and an Empirical Test (Policy Research Working Paper No. 2813), World Bank, 2002, <https://doi.org/10.1596/1813-9450-2813>.
- [38] M. Browning, P.-A. Chiappori, Efficient intra-household allocations: a general characterization and empirical tests, *Econometrica* 66 (6) (1998) 1241–1278.
- [39] E. Dufo, Grandmothers and granddaughters: old-age pensions and intrahousehold allocation in South Africa, *World Bank Econ. Rev.* 17 (1) (2003) 1–25.
- [40] A.R. Quisumbing, J.A. Maluccio, Resources at marriage and intrahousehold allocation: evidence from Bangladesh, Ethiopia, Indonesia, and South Africa, *Oxf. Bull. Econ. Stat.* 65 (3) (2003) 283–327.
- [41] M. Manser, M. Brown, Marriage and household decision-making: a bargaining analysis, *Int. Econ. Rev.* 21 (1) (1980) 31–44.
- [42] E.V. Edmonds, Child labor, in: T.P. Schultz, J. Strauss (Eds.), *Handbook of Development Economics*, 4, Elsevier, 2007, pp. 3607–3709.
- [43] A.C. Dammert, J. de Hoop, E. Mvukiyehe, F.C. Rosati, Effects of public policy on child labor: current knowledge, gaps, and implications for program design, *World Dev.* 110 (2018) 104–123.
- [44] Food and Agriculture Organization of the United Nations, World day against child labour: the need for joint actions to end child labour in agrifood systems. <https://www.fao.org/partnerships/fao-un-system/spotlight/world-day-against-child-labour-the-need-for-joint-actions-to-end-child-labour-in-agrifood-systems/en>, 2025, June 12.
- [45] International Labour Organization, United Nations Children's Fund, Child Labour: Global Estimates 2024, Trends and the Road Forward, 2025, <https://doi.org/10.54394/HGQM8706>.
- [46] E. Webbink, J. Smits, E. de Jong, Hidden child labor: determinants of housework and family business work of children in 16 developing countries, *World Dev.* 40 (3) (2012) 631–642.
- [47] Food and Agriculture Organization of the United Nations, Preventing hazardous child labour in agriculture. <https://www.fao.org/gender/news/news-detail/preventing-hazardous-child-labour-in-agriculture-en>, 2011, June 13.
- [48] International Labour Organization, United Nations Children's Fund, Child Labour: Global Estimates 2020, Trends and the Road Forward, International Labour Office and UNICEF, 2021, <https://doi.org/10.54394/JIPE1898>.
- [49] A. Dillon, Child labour and schooling responses to production and health shocks in northern Mali, *J. Afr. Econ.* 22 (2) (2013) 276–299.
- [50] A. Case, I.-F. Lin, S. McLanahan, How hungry is the selfish gene? *Econ. J.* 110 (466) (2000) 781–804.
- [51] A. Case, C. Paxson, Mothers and others: who invests in children's health? *J. Health Econ.* 20 (3) (2001) 301–328.
- [52] ILO-IPEC, Interactive tools in sampling with household-based child labour surveys. <https://www.ilo.org/resource/training-material/interactive-tools-sampling-household-based-child-labour-surveys>, 2014.
- [53] L. Cappellari, S.P. Jenkins, Multivariate probit regression using simulated maximum likelihood, *STATA J.* 3 (3) (2003) 278–294.
- [54] N. Spencer, G. Gunnlaugsson, S. Raman, Prevalence and correlates of child labour in five low-income countries: a descriptive study based on UNICEF multiple indicator cluster surveys 6 (MICS6), *BMJ Paediatr. Open* 8 (1) (2024) e002871, <https://doi.org/10.1136/bmjpo-2024-002871>.
- [55] H.X. Sterling, Arabica coffee vs. Robusta: A deeper dive into environmental and farming realities. https://coffeeanalytica.com/blogs/coffee-origins/arabica-coffee-vs-robusta-a-deeper-dive-into-environmental-and-farming-realities?srsltid=AfmBOOrWs-a7PvHodQ5IcHKQ-r3V_AjmcQJa12htxElWq9tpDsd1MAA, 2024. (Accessed 12 June 2026).
- [56] F. Davies, Arabica VS. Robusta coffee. <https://www.coaltowncoffee.co.uk/blogs/news/arabica-vs-Robusta?srsltid=AfmBOOrJOLK3mkYobug9p3oXsA1os8-K72JZedFZB4dH7QLMfQ0f0>, 2022. (Accessed 4 January 2026).
- [57] R. Abaidoo, Parental educational attainment and child labor: evidence from Malawi, *J. Agric. Appl. Econ.* 56 (1) (2024) 155–183. <https://www.cambridge.org/core/journals/journal-of-agricultural-and-applied-economics/article/parental-educational-attainment-and-child-labor-evidence-from-malawi/7C072CD8032452573BC67FC9AE880515>.