

More than just a home: the impact of household conditions on early childhood development in Jordan

Health Education

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Received 4 September 2025
Revised 6 November 2025
Accepted 9 December 2025

Abstract

Purpose – This paper examines the impact of household environment and assets on early childhood development (ECD) in Jordan.

Design/methodology/approach – We develop a composite household environment and assets (HEA) index that captures key aspects of living conditions, including access to information, durable goods, water and sanitation, housing quality, cooking and cooling facilities, and financial inclusion. Based on nationally representative microdata from the 2023 Jordan Demographic and Health Survey, the first wave to provide detailed measures of developmental milestones for children aged 24–59 months, we examine the association between the HEA index and child development outcomes across health, learning, and psychosocial domains, using linear probability models, double machine learning, and Probit estimators.

Findings – Our findings indicate that higher HEA scores are associated with better developmental outcomes, even after controlling for parental education and regional characteristics. The results highlight that fostering early human capital formation requires not only poverty reduction but also targeted improvements in household living conditions.

Originality/value – These insights carry important implications for policies aimed at strengthening education, labour market participation, and long-term well-being in Jordan.

Keywords Household environment and assets (HEA) index, Early childhood development (ECD), Socioeconomic, Demographic and health surveys, Jordan

Paper type Research article

1. Introduction

It has been widely acknowledged in both the literature and policy debates that child health and development are closely linked to the physical and socioeconomic characteristics of the household environment (Ormandy, 2014; Weitzman *et al.*, 2013). In many developing countries, factors such as inadequate water and sanitation, overcrowding, and fragile housing structures have been shown to impact child health negatively (Brown *et al.*, 2023; Tusting *et al.*, 2020). Since children typically do not choose their home environment and spend a substantial proportion of their time within it, the quality of this environment is particularly critical (Fortson and Sanbonmatsu, 2010; Cattaneo *et al.*, 2009). Beyond physical health, the housing and asset environment plays an important role in shaping children's motor, psychosocial, and cognitive development (de Souza Morais *et al.*, 2021; Black *et al.*, 2017; Johnson *et al.*, 2016; Duncan *et al.*, 2011).

Building on Brown *et al.*'s (2023) study, our paper proposes a composite measure of household conditions that are widely recognised in the literature as influencing child health and development. We refer to this as the household environment and assets (HEA). There are many attributes of a home that can affect children's development. However, here we focus on a

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Funding: No specific funding was received for this research.

Conflict of interest: The authors declare that they have no conflict of interest relevant to the content of this research.



Health Education
Vol. 126 No. 4, 2026
pp. 499-516
Emerald Publishing Limited
e-ISSN: 1758-714X
p-ISSN: 0965-4283
DOI 10.1108/HE-09-2025-0168

set of conditions that are measurable within the DHS and are likely to be relevant in the Jordanian context. Our goal is to develop an operational index that encompasses both material living standards and broader socioeconomic factors influencing early childhood development.

The HEA index incorporates thirteen conditions, including access to information (television, mobile phone, internet), ownership of durable assets (housing, land, car), improved sanitation and drinking water, housing quality, cooking and cooling facilities, and financial inclusion (mobile money use, bank accounts). These attributes are selected because they plausibly reflect a household's ability to provide children with a healthier, safer, and more stimulating environment.

Of course, it is one thing to propose such an index, and another to be confident of its relevance. For validation, we examine the relationship between the HEA index and measures of early childhood development, encompassing health, learning, and psychosocial domains. We are not attempting to model child outcomes causally, but rather to demonstrate that our index has empirical salience: if it is meaningful, higher HEA should be systematically associated with stronger developmental outcomes among children.

We draw on insights from the multidisciplinary literature on ECD in constructing the HEA index. A central theme is that the early environment plays a decisive role in shaping lifelong outcomes in health, learning, and psychosocial development ([Rahman et al., 2023](#); [Luby et al., 2022](#); [United Nations, 2019](#); [McCoy et al., 2017](#); [Chetty et al., 2011](#); [Campbell et al., 2001](#); [Barnett, 1995](#)). This highlights that a nurturing early environment supports school readiness, strengthens human capital accumulation, and enhances productivity in adulthood ([Biglan et al., 2012](#)). Inadequate early environments may expose children to multiple risks, ranging from malnutrition and illness to cognitive delays that constrain their long-term development ([Black et al., 2017](#)).

From a policy perspective, this raises questions about whether households, when their incomes rise, allocate resources in ways that are consistent with promoting their children's development. While it is often assumed that poverty is the main barrier to healthy child development, research shows that poor outcomes can also occur in households that are not income-poor ([Egger et al., 2022](#)). Families may prioritise immediate consumption or durable goods over investments in aspects of the home environment, such as sanitation, safe water, or cognitive stimulation, that matter for children's development. Housing and assets typically exhibit a positive income elasticity of demand; however, evidence suggests that this elasticity is relatively low among poorer households, particularly in low- and middle-income countries ([Hansen et al., 1996](#); [Malpezzi and Mayo, 1987](#)).

Parental choices may reflect trade-offs that are rational from their perspective but suboptimal from the standpoint of child welfare ([Lawson and Mace, 2009](#)). Information gaps also play a role; many parents may not fully perceive the developmental consequences of, for example, indoor air pollution, inadequate nutrition, or limited access to learning resources ([Bush et al., 2020](#)). At the same time, governments, donors, and policymakers often place higher weight on child health and education, viewing them as public goods with long-term benefits for society. This creates a rationale for policy efforts that directly target the HEA index, rather than relying solely on income transfers ([Brown et al., 2023](#)).

In this light, our HEA index seeks to capture the extent to which households are equipped to provide environments that foster ECD. While some conditions, such as housing quality or durable assets, reflect long-term wealth accumulation and may be slow to change, others, such as access to clean water, improved sanitation, or basic financial services, are more adaptable to policy interventions. We therefore view the HEA not only as an analytical tool for measuring disparities in child development but also as a framework for identifying which household-level attributes could be targeted to enhance early childhood outcomes.

Considering the context, this study examines the influence of the HEA index on ECD outcomes, using nationally representative microdata from the 2023 Jordan Demographic and Health Survey (JDHS). Notably, this is the first time the JDHS has collected detailed information on developmental milestones for children aged 24–59 months.

This study makes several contributions to the literature on household environment, assets, and children's early development, addressing important gaps at both the regional and global levels. First, to our knowledge, it is the first study to investigate the association between the household environment and ECD outcomes in Jordan using DHS data. While earlier research has explored these links in other contexts (e.g. [Qi et al., 2022](#), in China; [Rahman et al., 2023](#), in Bangladesh), evidence from the Middle East and North Africa (MENA) remains limited. This study, therefore, fills an important regional gap.

Second, while related work in Jordan and Türkiye ([Al-Masaeid and Almomani, 2025a, b, c](#); [Karaoglan et al., 2024](#)) has focused on maternal education as the key determinant of ECD, our study highlights the broader HEA as the primary channel. By moving beyond parental education, we offer a more comprehensive understanding of the material and infrastructural conditions that influence child development.

Third, we build upon the work of [Brown et al. \(2023\)](#), who examined child health outcomes, including infant mortality, stunting, and child illness, in 41 developing countries by building an index of the housing environment using indicators (e.g. access to media, crowding, sanitation, and water). Their aim was not to model child health outcomes or infer causal relationships, but rather to establish robust correlations across countries. In contrast, our study focuses specifically on ECD outcomes in Jordan and employs a more rigorous methodological approach. This allows us to move beyond descriptive associations and provide stronger evidence on the links between the household environment and early development.

In the empirical analysis, we examine the ECD index and its three domains using linear probability models (LPM), double machine learning (DML), and Probit estimators. Results show that about 76% of children in Jordan are on track, with 73% of boys and 79% of girls meeting milestones. Among children aged 36–47 months, over 88% reach developmental benchmarks, and on average, children aged 2–5 achieve 13.8 of 20 milestones. A higher HEA index—reflecting access to clean water, improved sanitation, durable goods, financial inclusion, and information access—is strongly associated with greater likelihood of being on track. Each additional positive household condition increases both the probability of meeting ECD benchmarks, and the number of milestones achieved, especially in health and learning. These findings highlight the role of the home environment in early human capital formation.

The following section describes our data and methods for addressing the study question. [Section 3](#) presents the empirical methodology, while [Section 4](#) provides results. [Section 5](#) concludes.

2. Data

The data for this study come from the 2023 round of the Jordan Population and Family Health Survey (JPFHS), which is conducted regularly every five years by the Department of Statistics. This survey is part of the broader Demographic and Health Surveys (DHS) series. Financed mainly by the United States Agency for International Development and implemented by Macro International in collaboration with national statistical agencies (see <https://dhsprogram.com/> for further information). The JPFHS is nationally representative, employing a two-stage stratified cluster sampling design. In the first stage, enumeration areas were selected from the national census frame with probability proportional to size. In the second stage, households within each cluster were systematically selected. Data were collected through face-to-face interviews with eligible women aged 15–49. Using standardised DHS questionnaires that were translated into Arabic and pretested prior to fieldwork (for more details, please see [DoS and ICF, 2023a](#)). For the first time in 2023, the JPFHS included a set of questions to assess the ECD of children aged 24–59 months. We use these questions to create the ECD index, focusing on the effects of the housing environment and assets. Our sample consists of 3,346 children who can be linked to their mothers and for whom complete data exist on ECD questions.

2.1 Early child development (ECD)

Early childhood development is a multidimensional process that involves the progression of motor, cognitive, language, socioemotional and regulatory skills during the early years of life ([United Nations Children's Fund, 2016](#)). These domains, while distinct, are closely interconnected, and nurturing them in an integrated manner is essential for enabling children to reach their full developmental potential. Early gains in physical growth, literacy, numeracy, socioemotional capacity, and learning readiness have a significant impact on long-term outcomes related to health, education, and overall well-being ([Shonkoff and Phillips, 2000](#)).

To support global monitoring of child development and ensure comparability across countries, UNICEF developed the Early Childhood Development Index 2030 (ECDI2030) as part of the Multiple Indicator Cluster Survey (MICS) program. The ECDI2030 comprises 20 items that assess developmental progress in three overarching domains: health, learning and psychosocial well-being. Each domain encompasses multiple subdomains. Health encompasses both gross and fine motor development, as well as self-care. Learning covers expressive language, literacy, numeracy, pre-writing and executive functioning. Psychosocial well-being includes emotional and social skills, as well as internalising and externalising behaviour. Unlike previous versions, ECDI2030 is designed to measure these domains separately as well as produce a unified summary score that aligns with Sustainable Development Goal (SDG) indicator 4.2.1 ([DoS and ICF, 2023b](#)).

The JPFHS 2023 administered the ECDI2030 module as part of its women's questionnaire. Mothers have been asked 20 questions about one of their randomly selected biological children under the age of 5 living with their mother. These questions assessed children's behaviour in daily contexts and their ability to perform age-appropriate tasks, reflecting a developmental progression of skills. The index captures whether children are developmentally on track based on the number of milestones achieved relative to their age group. Precisely, a child is considered on track if he/she meets the following minimum thresholds: at least 7 milestones for ages 24–29 months, 9 for 30–35 months, 11 for 36–41 months, 13 for 42–47 months and 15 for 48–59 months ([DoS and ICF, 2023a, b](#)).

A child's developmental status is assessed based on mothers' responses to a set of 20 questions covering three domains: health (4 questions), learning (11 questions), and psychosocial well-being (5 items). While the ECD index, derived from the MICS program, is a valuable tool for researchers and policymakers, it has certain limitations. Particularly, the data are based on caregiver reports rather than direct assessments, making the results somewhat subjective. As a result, caregiver responses may be affected by recall errors or reporting bias ([UNICEF, 2023](#)).

In the health domain, a child is considered developmentally on track if he/she can perform gross motor, fine motor development and self-care (e.g. walking on uneven surfaces; jumping with both feet; dressing themselves; fastening buttons without help). The learning domain covers several subskills, such as expressive language (e.g. saying 10 or more words, like mama or ball; speaking in sentences of three or more words that go together; speaking sentences of five or more words that go together), literacy (e.g. correctly use any of pronouns like "I", "you", "she", or "he"; can consistently name an object well known, if shown; can recognise at least 5 letters of the alphabet; can child write (his/her) name), numeracy (e.g. can recognise all numbers from 1 to 5), pre-writing and executive functioning skills (e.g. if asked to give you 3 objects, does child give the correct amount; can child count 10 objects without mistakes; can colour or play with building blocks without asking for help or giving up). The psychosocial well-being domain evaluates emotional and social behaviours (e.g. does child ask about familiar people other than parents when not there; does child offer to help someone who seems to need help; does child get along well with other children). It also includes assessments of internalising behaviours (e.g. how often does child seem to be very sad or depressed) and externalising behaviours (e.g. compared with other children, how much does child kick, bite, or hit other child) [1].

We set a binary variable to represent the overall ECD index, where a value of 1 indicates that the child is developmentally on track for their age group, and a value of 0 indicates otherwise.

2.2 Household environment and assets (HEA) index

Our analysis predominantly emphasises capturing living standards, access to infrastructure, financial inclusion, and other socioeconomic determinants that influence child development. House environment and assets have a plausible role in the Jordanian context, as expected to positively influence ECD through improved health, cognitive stimulation, and resource availability. We identified thirteen conditions generally observable in the DHS to assess the capacity for HEA to improve children's development, namely:

- (1) Information access: Having a TV, a mobile phone, or the internet expands parents' access to health, nutrition, and educational information. This enhanced knowledge base supports improved caregiving practices and creates more opportunities for cognitive stimulation in children.
- (2) Durable assets: When households own a car, a house, or land, they achieve greater stability and security. This reduces economic stress and strengthens the family's capacity to act on the information they access. For example, investing in children's nutrition, healthcare, or early learning resources.
- (3) Sanitation: the dwelling has its own "improved toilet" [2]. We take this to be a basic pre-condition for good personal hygiene and adequate sanitation reduces exposure to fecal pathogens, lowering risks of diarrheal disease and malnutrition, which directly safeguard children's physical and cognitive development.
- (4) Water: there is a water drinking source in the dwelling or its own yard area [3]. Easy and secure access to clean water supports hydration, reduces the risk of waterborne diseases, and enables critical hygiene practices like handwashing, all of which help protect child health and development.
- (5) Housing quality: the dwelling structure uses finished construction materials for at least two of the floors, walls and ceiling. This ensures a hygienic and protective living environment, reduces risks of illness, and provides children with a secure space for rest, play, and early learning.
- (6) Cooking and cooling facilities: Cooking is either done with gas or electricity. As well as the household has refrigerator, thereby reducing indoor air pollution and the risk of respiratory illness. The presence of a refrigerator ensures food safety and nutrition, protecting children from malnutrition and foodborne disease.
- (7) Financial inclusion: used mobile money for transactions (last 12 months); has an account at a bank/financial institution. Increases household resilience and helps families sustain their investments in children's health, nutrition, and education, even during times of crisis.

We define the HEA index in several forms. First, we created a binary HEA index (1/0), which takes the value of 1 if the household meets a defined threshold of conditions reflecting adequate living standards and 0 otherwise. This provides a straightforward measure of whether a household environment is broadly supportive of child development. As a robustness check, we used a count index (HEA 1–13), which sums the number of conditions satisfied. Finally, to account for differences in scale and facilitate comparability, we constructed a normalised index (HEA 0–1) by dividing the number of conditions satisfied by 13.

2.3 Controls

In addition to the house environment and assets index, we included a range of demographic, economic, and cultural characteristics that may influence ECD. Maternal age and its squared term were included to capture both linear and nonlinear effects on the ECD. Parental education was measured as the total years of schooling of both parents, reflecting its role in fostering child

development. We further controlled for maternal employment status, household wealth, birth order, number of children under five, household size, and rural residence. To account for unobserved heterogeneity, we also included fixed effects for governorate and child age in months.

3. Empirical methodology

The relationship between ECD and HEA is estimated using the following specification:

$$ECD_i = \beta_0 + \beta_1 HEA_i + \beta_2 X_i + \mu_i \tag{1}$$

where ECD is the early childhood development status of child i , HEA is house environment and assets index, X is a vector of control variables that include the variables listed above, and μ is the random error term. The coefficients of interest are β_1 , which shows the improvement in the ECD index when the house environment and assets index increase, and β_2 , which shows how control variables impact the ECD. We include governorates and child age in months fixed effects by adding dummy variables for each province and child age in months (with one omitted category to avoid perfect multicollinearity), these province and child age dummies are included in X_i . We use sampling weights throughout the analysis.

4. Results

4.1 Descriptive statistics

Table 1 presents the descriptive statistics of the variables for children aged 24–59 months in our sample. The sample comprises girls, who represent half of the total, and the average age of all children is 42.6 months. Overall, 76% of children were found to be on track in terms of the overall ECD index. By gender, data show that 79% of girls are developmentally on track compared to 73% of boys, suggesting a slight advantage for girls. By age group, 77% of children aged 24–35 months are on track, followed by 88% among those aged 36–47 months, and 73% for children aged 48–59 months. Children in Jordan achieved an average of 13.8 out of 20 milestones. Disaggregated by domain, the mean number of milestones achieved is 2.87 out of 4 for the health domain, 8.09 out of 11 for learning, and 3.63 out of 5 for psychosocial well-being. Across all domains, girls slightly outperform boys. For instance, girls achieved 14.11 milestones on average, compared to 13.51 for boys, with similar patterns observed across the health, learning, and psychosocial sub-domains.

Table 1 also shows the descriptive statistics of HEA for our sample. Household living conditions are generally high, with 98% of households owning a TV, 94% owning a mobile phone, 81% using the internet, and 97% having a refrigerator. Access to modern utilities is also common, as 95% of households cook with gas or electricity, and 59% use an improved flush toilet connected to a piped sewer. More than half have access to drinking water within the dwelling or yard, and 83% live in houses with at least two finished construction materials. However, ownership of higher-value assets is less common: only 44% own a car, 11% have a bank account, 9% use mobile phones for financial transactions, and very few households report owning a house 5% or land 4%. The HEA index, our primary independent variable, was constructed using information on 13 indicators of household living conditions and asset ownership. Each item was coded as a binary variable (1/0) and then aggregated to form two measures: a simple count ranging from 0 to 13, with a mean of 7.48, and a normalised index ranging from 0 to 1, with a mean of 0.57. A binary classification was created to indicate whether households meet a minimum threshold of adequate living standards, with 79% of households scoring above this cut-off. These indicators collectively capture the material environment in which children grow up and serve as a proxy for household socio-economic status.

Mothers of the children in the sample have an average age of 31.9 years and possess an average of 11.2 years of education, while the fathers have an average of 10.5 years of education. The distribution of household wealth reveals that a significant proportion of

Table 1. Descriptive statistics

	Whole	Male	Female
ECD index (1/0)	0.76	0.73	0.79
ECD index 24–35 (1/0)*	0.77	0.75	0.79
ECD index 36–47 (1/0)**	0.88	0.76	0.81
ECD index 48–59 (1/0)***	0.73	0.69	0.77
Number of ECD milestones achieved (0/20)	13.80	13.51	14.11
Number of health ECD milestones achieved (0/4)	2.87	2.81	2.93
Number of learning ECD milestones achieved (0/11)	8.09	7.93	8.25
Number of psychosocial ECD milestones achieved (0/5)	3.63	3.59	3.68
ECD index (0–1)****	0.69	0.67	0.70
ECD health index (0–1)****	0.71	0.70	0.73
ECD learning index (0–1)****	0.73	0.72	0.75
ECD psychosocial index (0–1)****	0.72	0.72	0.74
Has tv (1/0)	0.98	0.97	0.98
Has mobile phone (1/0)	0.94	0.94	0.93
Use of internet (1/0)	0.81	0.81	0.81
Use mobile telephone for financial transactions (1/0)	0.09	0.10	0.08
Has an account in a bank or other financial institution (1/0)	0.11	0.12	0.11
Has refrigerator (1/0)	0.97	0.97	0.97
Cooks with gas or electric (1/0)	0.95	0.95	0.95
Has car (1/0)	0.44	0.43	0.45
Has house (1/0)	0.05	0.06	0.05
Has land (1/0)	0.04	0.05	0.03
Has improved toilet flush to piped sewer (1/0)	0.59	0.60	0.57
Water drinking source in dwelling or yard (1/0)	0.52	0.53	0.52
At least two finished construction materials (1/0)	0.83	0.83	0.83
House environment and assets (HEA) index binary (1/0)*****	0.79	0.79	0.79
House environment and assets (HEA) (1–13)	7.48	7.51	7.44
House environment and assets (HEA) index (0–1) *****	0.57	0.57	0.57
Female	0.50	–	–
Age in months	42.67	42.74	42.58
Mother's years of education	11.18	11.17	11.19
Father's years of education	10.53	10.60	10.46
Mother's age	31.89	32.00	31.78
Household wealth quantile	2.27	2.27	2.27
Bottom 20%	0.38	0.38	0.38
2nd 20%	0.24	0.24	0.23
3rd 20%	0.18	0.17	0.19
4th 20%	0.14	0.15	0.14
Top 20%	0.06	0.06	0.06
Birth order	1.51	1.49	1.54
Number of children under five	1.85	1.82	1.87
Household size	6.00	6.01	5.99
Rural Residence	0.18	0.17	0.19
Mother's work	0.10	0.10	0.10
# of Observations	3,346	1,682	1,664

Note(s): Author's calculations using data from the 2023 JPFHS. *The total number of observations for the ECD index among children aged 24–35 months is 935; **1,157 for children aged 36–47 months; and ***1,254 for children aged 48–59 months ****the index was normalised to a 0–1 scale using the min–max transformation $(x - \min) / (\max - \min)$ where 0 represents the lowest observed score and 1 represents the highest. ***** The HEA index represents our primary explanatory variable, which is set equal to one if the household meets all conditions, zero if it meets none

families with young children fall within the lower wealth quintiles: 38% are in the bottom 20%, and 24% are in the second quintile. Only 6% of households belong to the top 20%, highlighting the economic vulnerability faced by families with young children in Jordan. The average

household size consists of six members, and the average birth order of the child is 1.5, indicating that many of the children in the sample are either firstborn or secondborn. On average, there are 1.85 children under the age of five per household. Furthermore, 18% of the sample population resides in rural areas, and 10% of mothers have jobs.

4.2 Linear probability model results

Table 2 presents the LPM estimates of equation (1). The results show that an increase in the number of positive household conditions, such as access to information, clean water, improved toilets, durable assets, and financial inclusion, is strongly associated with a higher probability of a child being developmentally on track. Since the index is a count of these conditions, a higher score directly translates to a more stimulating, sanitary, and stable home environment. This association holds even after controlling for household characteristics, parental background, and geographic variables. This finding underscores the profound impact of a secure and resourceful household on a child’s health and cognitive development, a result that aligns with economic theories of human capital development, which emphasise the role of early life investments.

The finding in Panels 2 and 3 shows that the HEA index has a larger effect on girls’ development than on boys’ is particularly significant in the 24–59-month age range, a period of rapid physical and cognitive development. This difference suggests that an improved household environment may be particularly effective at narrowing existing gender gaps. Improved sanitation and access to water can reduce the time girls spend on household chores, freeing up more time for play and learning, which are crucial for their development (Bose et al., 2024; Choudhuri and Desai, 2021). An increase in durable and financial assets can help families invest in a wider range of toys and educational materials, which may have a greater impact on girls if they were previously given fewer of these resources (Duncan et al., 2011). Girls in this age group may be more susceptible to specific health issues or may be involved in tasks that increase their exposure to unhygienic conditions (Bloomfield et al., 2006). Thus, improvements in this area may benefit them more.

4.3 Overall results

Table 3 illustrates the impact of the HEA index on ECD as measured by these age-specific milestones. The findings indicate a positive relationship between the HEA index and the

Table 2. LPM results

Variables	ECD index		
	1	2	3
Panel	Whole	Male	Female
HEA index	0.075*** (0.024)	0.064* (0.033)	0.090*** (0.029)
Mother’s education	0.008*** (0.002)	0.006 (0.004)	0.010*** (0.003)
Father’s education	0.003 (0.002)	0.005 (0.003)	0.001 (0.003)
Mother’s age	−0.011 (0.012)	−0.011 (0.016)	−0.013 (0.015)
Mother’s age square	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Household wealth	0.018** (0.008)	0.019* (0.011)	0.019 (0.011)
Birth order	0.015 (0.018)	0.024 (0.025)	−0.006 (0.023)
Number of children under five	−0.009 (0.010)	−0.003 (0.015)	−0.008 (0.015)
Household size	0.002 (0.004)	0.002 (0.005)	0.001 (0.005)
Rural residence	0.040* (0.021)	0.031 (0.031)	0.051* (0.028)
Mother has work	−0.009 (0.024)	−0.039 (0.036)	0.021 (0.033)
# of obs	3,280	1,650	1,630
R ²	0.08	0.10	0.10

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All regressions include governorates and child age in months as fixed effects. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3. LPM results for ECD on track for different age group

Variables	ECD index 24–35	ECD index 36–47	ECD index 48–59
Panel	1	2	3
HEA index	0.152*** (0.041)	0.085** (0.035)	0.008 (0.040)
# of obs	918	1,135	1,227
R ²	0.10	0.06	0.09

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, mother's education, father's education, mother's age, mother's age square, household wealth, birth order, number of children under five, household size, rural residence, and mother works, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

likelihood of a child being developmentally on track for the younger age groups. For children aged 24–35 months (Panel 1), a strong relationship exists between a better household environment and achieving the milestones of 9 developmental achievements. This suggests that during the very early stages of development, when a child's environment is the primary source of stimulation and safety, a well-resourced household is paramount. For the 36–47-month age group (Panel 2), the effect of the HEA index is still significantly positive, but it has decreased. This may be because, as children grow older, other external factors, such as preschool attendance, peer interactions and community resources, begin to play a more important role in their development, potentially lessening the relative importance of the immediate household environment. Finally, for the oldest age group (48–59 months, Panel 3), the effect of the HEA index becomes insignificant. This suggests that by the time children are expected to have achieved 15 milestones, the HEA are no longer the primary determinant of whether they are developmentally on track. At this stage, a child's developmental trajectory is likely more influenced by factors outside the home, such as formal education and social experiences.

Table 4 reveals a significant positive relationship between the HEA index (as a count of conditions ranging from 1 to 13) and the total number of ECD milestones a child achieves (ranging from 0 to 20). The coefficient indicates that for each additional positive household condition (e.g. having a refrigerator, an improved toilet, or a mobile phone), a child, on average, achieves roughly 0.29 more developmental milestones. This is a substantial effect, reinforcing the idea that a better-resourced home environment is directly linked to a child's overall developmental success.

The HEA index has a positive impact on learning milestones (Panel 3). An additional household asset or condition is associated with a nearly 0.10 increase in the number of learning milestones achieved. This is logical, as HEA components like information access (TV, internet), durable assets (financial stability for educational resources), and a stable living

Table 4. OLS results for milestones achieved of ECD with different domains

Variables	ECD milestone total	Health milestones	Learning milestones	Psychosocial milestones
Panel	1	2	3	4
House environment and assets (HEA) (1–13)	0.286*** (0.067)	0.031* (0.017)	0.099*** (0.036)	0.025 (0.020)
# of obs	3,117	3,083	2,651	3,117
R ²	0.30	0.22	0.25	0.08

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, controls variables as Table 2, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

environment directly support cognitive stimulation and early learning. The HEA index also shows a positive effect on health milestones (Panel 2) and suggests that improved sanitation, clean water, and food safety (refrigerator) directly contribute to a child’s physical well-being, which in turn helps them meet health-related milestones. The HEA index has no statistically significant effect on psychosocial well-being milestones (Panel 4). This suggests that while a supportive household environment is critical for learning and health, psychosocial development, which involves social interactions and emotional regulation, may be more influenced by factors not captured in the HEA index, such as the quality of parent-child interactions, peer relationships, and family dynamics.

Table 5 presents the same analysis using a normalised HEA index (0–1), which confirms the findings from Table 4. The positive effect on the overall ECD index, health index, and learning index corroborates that the HEA are key drivers of child development. The lack of a significant effect on the psychosocial index is also consistent across both tables. The use of OLS regression in both tables is appropriate because it treats the number of milestones achieved and the normalised indices as continuous variables. This contrasts with the previous LPM analysis, which modelled the binary outcome of being “on track.”

4.4 Heterogeneity analysis

The following sections outline a series of robustness checks designed to assess the stability and validity of our primary findings. Initially, we investigate variations in the effect of the HEA index across important subgroups, as shown in Table 6.

First, the HEA index is significant in urban areas because the benefits of household assets are amplified by urban infrastructure. Access to amenities like high-quality schools, clinics, and social networks in cities makes it easier for families to translate household resources, like a TV or an internet connection, into better developmental outcomes for their children (Sen and Gredebäck, 2025). In contrast, the effect is insignificant in rural areas because these regions often lack the supporting infrastructure to make a difference. Even with some household assets, children in rural areas may still face disadvantages due to limited access to healthcare, specialised services, and quality education (Gosse et al., 2025).

The HEA index is also significant for the poorest 40% because a better household environment represents a vital source of support. For these families, a simple asset, such as an improved toilet, access to clean water, or a mobile phone, can have a dramatic impact on health and provide crucial information, directly affecting a child’s development (Karlsson et al., 2020). The effect is insignificant for the wealthiest 60% because these families have already met these basic needs. Their children’s development is likely influenced by factors beyond the HEA index, such as private education or specialised enrichment programs (Gennetian et al., 2010).

Table 5. OLS results for milestones achieved of ECD with different domains (normalise)

Variables	ECD index (0–1)	ECD health index (0–1)	ECD learning index (0–1)	ECD psychosocial index (0–1)
Panel	1	2	3	4
House environment and assets (HEA) (0–1)	0.186*** (0.043)	0.102* (0.056)	0.117*** (0.043)	0.065 (0.052)
# of obs	3,117	3,083	2,651	3,117
R ²	0.30	0.22	0.25	0.08

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, controls variables as Table 2, **p* < 0.1, ***p* < 0.05, ****p* < 0.01

Table 6. LPM estimation, heterogeneity analysis

Variables	ECD index		Wealth		Mother's work status	
	Residence					
Panel	Urban	Rural	Poorest 40%	Richest 60%	Work	No work
HEA index	0.089*** (0.028)	0.013 (0.047)	0.080*** (0.027)	0.037 (0.054)	0.261*** (0.078)	0.067*** (0.020)
# of obs	2,684	596	2,006	1,274	330	2,950
R-squared	0.08	0.13	0.09	0.07	0.15	0.08

Panel	Region		Maternal age group			
	Central	North	South	<25	25–34	35+
HEA index	0.044 (0.036)	0.102*** (0.036)	0.063 (0.061)	0.001 (0.067)	0.070** (0.032)	0.121*** (0.044)
# of obs	1,413	1,140	727	393	1,795	1,092
R ²	0.09	0.11	0.12	0.18	0.10	0.11

Note(s): Control variable that corresponds to the main variable of interest in each regression are excluded to avoid multicollinearity. For example, when examining heterogeneity by place of residence or region, the rural residence variable is omitted from the set of controls. Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, controls variables as Table 2, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The mean of dependent variable is 0.76

In addition, the effect is larger for children of working mothers, highlighting a powerful synergistic effect. A working mother's income allows her to invest in household assets that create a more stimulating environment, offsetting potential time constraints and positively influencing her child's development. For children of non-working mothers, the effect is smaller, as the family's ability to acquire and use these assets may be more limited (Erola *et al.*, 2016).

The HEA index has a significant positive effect on ECD in the North region of Jordan. This contrasts with the Central and South regions, where the effect is not statistically significant. This finding suggests that a better HEA are most impactful in the North, a region that includes governorates such as Irbid, Mafrqa, Jarash, and Ajloun, which collectively have a significant number of observations (1,140). The lack of a significant effect in the Central (including Amman and Zarqa) and South regions suggests that in these areas, other factors or a different set of unaccounted variables may be more influential on child development. The variation in significance across regions likely points to existing disparities in local infrastructure, access to services, or socioeconomic conditions that influence how household assets translate into developmental outcomes for children.

Lastly, the impact of the HEA index strengthens with the mother's age. It is insignificant for mothers under 25, suggesting that these younger mothers may lack the experience or financial stability to leverage their household assets for their child's development fully. As mothers mature (25–34, then 35+), they often gain more experience, financial security, and confidence, allowing them to use their household resources more effectively to support their child's growth (Duncan *et al.*, 2018).

4.5 Robustness analysis

Double Machine Learning (DML) is a crucial estimation technique in this study, as it strengthens the causal interpretation of our results by moving beyond simple correlation. Unlike standard regression models, such as the Least Squares, which can be prone to bias from complex or unobserved confounders, DML employs machine learning methods to

systematically “de-confound” the data. This process isolates the true causal effect of the HEA index by flexibly controlling for all other variables with potentially intricate, non-linear relationships. For instance, household wealth may be related in a complex way to maternal education and child age, which OLS may not adequately capture. By contrast, DML accounts for these complexities, providing more robust estimates. This strengthens our conclusion that a better home environment genuinely contributes to improved child development (Ahrens *et al.*, 2024a, b).

The results from the DML estimator reported in Table 7 are consistent with those obtained from the LPM and OLS models. For the overall ECD index (Panel 1), the estimated DML coefficient is similar in magnitude to the estimates from simpler models. Comparable consistency is observed across different age groups (Panels 2–4) and milestone counts (Panels 5–6). The close alignment of the DML results with those of the conventional models provides a powerful robustness check. It demonstrates that the positive association between the HEA index and child development is not driven by model-specific assumptions or unobserved complexities but reflects a stable and credible relationship.

Furthermore, using a Probit model is crucial for analysing data because the outcome variable, whether a child is “on track,” is binary (i.e. either yes or no). Unlike the Linear Probability Model (LPM), which uses a simple linear regression, the Probit model uses a non-linear S-shaped curve to ensure that the predicted probabilities of being on track always fall between 0 and 1. This prevents the illogical predictions (e.g. a child having a 120% chance of being on track) that can occur with LPM. The Probit model’s structure is also more consistent with the underlying assumption that a latent, unobserved variable (such as a child’s overall developmental potential) is being influenced by the variables in the model (Cameron and Trivedi, 2010).

The results in Table 8 are mainly consistent with our previous findings, providing a crucial robustness check. The Probit coefficients themselves are not directly interpretable as they are on a different scale. However, the marginal effects (ME), shown in the even-numbered panels, are directly comparable to your LPM results and confirm the findings.

For the overall sample (Panel 2), the marginal effect shows that a one-unit increase in the HEA index increases the probability of a child being on track by 6.6% points, which is very close to your LPM result of 7.5% points. This confirms the strong, positive effect of HEA on child development. The results across different age groups also align with our previous analysis. The effect of the HEA index is most pronounced for the youngest children (24–35 months) (Panel 4). The effect then decreases with age, becoming statistically insignificant for the 48–59-month age group (Panel 8). This consistency across different models strengthens the validity and reliability of our study’s results.

Table 7. Double machine learning estimator of partially linear model

Variables	ECD index	ECD index 24–35	ECD index 36–47	ECD index 48–59	ECD total milestone	ECD index (0–1)
Partially linear model						
Panel	1	2	3	4	5	6
HEA index	0.072*** (0.024)	0.154*** (0.042)	0.080** (0.034)	0.007 (0.040)		
HEA index (1–13)					0.284*** (0.067)	
HEA index (0–1)						0.186*** (0.043)
# of obs	3,346	918	1,135	1,227	3,346	3,346

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, controls variables as Table 2, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Probit model

Variables	ECD index		ECD index 24–35		ECD index 36–47		ECD index 48–59	
Panel	Probit	ME	Probit	ME	Probit	ME	Probit	ME
	1	2	3	4	5	6	7	8
HEA	0.234***	0.066***	0.496***	0.133***	0.282**	0.076**	0.030	0.009
index	(0.075)	(0.021)	(0.129)	(0.033)	(0.114)	(0.030)	(0.122)	(0.036)
# of obs	3,280		918		1,135		1,227	
R ²	0.07		0.10		0.06		0.08	

Note(s): Robust standard errors in parentheses clustered at the altitude in meters to sea level. All the regressions include governorates and child age in months dummies, controls variables as Table 2, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion

This paper examines the impact of the HEA index on ECD outcomes in Jordan, using individual-level data from the 2023 Jordan Demographic and Health Survey (JDHS). We employ a comprehensive econometric framework that includes Least Squares, Probit, and Double Machine Learning estimators for robust results. A key contribution of this study is the use of a newly developed instrument for measuring ECD outcomes that aligns with Sustainable Development Goal (SDG) indicator 4.2.1, combined with nationally representative microdata enriched with detailed household, maternal, and regional information. Building on prior research (e.g. Al-Masaied and Almomani, 2025a, 2025b, 2025c; Osiesi *et al.*, 2025; Sweileh, 2025; Almomani and Al-Masaied, 2025a, 2025b), our approach supports a different analysis by controlling for a wide set of covariates. This approach provides evidence that a well-resourced and nurturing home environment is a critical driver of children's developmental outcomes in Jordan.

This study contributes to the growing literature on the role of HEA in shaping child health and development by focusing on ECD outcomes in Jordan. These early outcomes are critical, as they shape an individual's future educational attainment, labour market opportunities, and overall life trajectory. Our results consistently demonstrate that a higher HEA index, capturing conditions such as access to clean water, improved sanitation, durable goods, financial inclusion, and information access, is strongly associated with a greater likelihood of children being developmentally on track. Each additional positive household condition increases both the probability of meeting ECD benchmarks, and the total number of developmental milestones achieved, particularly in health and learning domains. These findings highlight the important role of the home environment in shaping early human capital formation.

The impact of the HEA index is heterogeneous across subgroups. Girls, especially those aged 24–59 months, benefit more strongly than boys, suggesting that improvements in household conditions may help narrow existing gender gaps. The effects are also concentrated among children in urban areas and in the poorest households, where household assets provide the most transformative gains. Regional variation further highlights that the north of Jordan experiences the strongest effects, reflecting disparities in infrastructure and service provision across the country. Additionally, the positive influence of household environment strengthens with maternal age, indicating that older mothers may be better able to leverage household resources to support their children's development.

From a methodological perspective, the consistency of results across LPM, Probit, and DML estimators provides a powerful robustness check. The Probit model confirms that the HEA index raises the probability of being developmentally on track, closely mirroring LPM results. The Double Machine Learning, by flexibly controlling for complex non-linear confounders, reinforces the causal interpretation of our findings and shows that the observed effects are not artifacts of model specification. Our findings highlight the

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importance of a secure, resourceful, and nurturing home environment as a key factor influencing children’s developmental outcomes in Jordan. By improving access to essential infrastructure, resources, and information, families can foster conditions that promote children’s physical, cognitive, and learning growth, particularly during those critical early years.

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A key limitation is reliance on caregiver-reported data, which may be subject to recall bias. Future research could enhance these findings by incorporating longitudinal data and direct, objective assessments of children’s development. Additionally, exploring how specific types of assets, such as books or educational toys, affect developmental domains individually could provide more granular insights. Future studies could also investigate the interplay between the HEA index and the quality of parental interaction to better understand the mechanisms through which household assets influence child well-being.

5.1 Policy implications

Depending on the findings, we suggest several policy implications. Investments in basic household infrastructure, such as safe water, sanitation, durable assets, and financial inclusion, should be recognised not merely as welfare improvements but as strategic drivers of human capital development. The evidence shows that even small improvements in household conditions can substantially increase children’s likelihood of being developmentally on track, particularly in poorer households and among younger age groups. This suggests that targeted interventions, such as support projects that improve access to clean water and sanitation, conditional cash transfers to support asset acquisition, and microfinance programs that promote financial stability, can have transformative effects on child health and cognitive outcomes. Importantly, these investments yield long-term payoffs in education, labour market outcomes, and overall life trajectories, making them a cornerstone of inclusive growth strategies in lower-middle-income settings.

At the same time, the results reveal important heterogeneities by gender, region, maternal employment, and socioeconomic status that demand tailored policy responses. Suggesting better infrastructure and access to durable goods can help narrow gender gaps in early development. Region-specific interventions are also crucial. Similarly, policies that empower working mothers, through childcare support, employment-linked asset subsidies, or community-based parenting programs, can amplify the positive effects of household improvements. Finally, raising parental awareness about the importance of a stimulating home environment, combined with investments in early learning and nutrition programs, would ensure that improvements in household conditions translate effectively into developmental gains. Taken together, these interventions align with the Sustainable Development Goals on health and well-being (SDG 3) and quality education (SDG 4), and position household-level investments as an integral component of national strategies to build human capital and reduce intergenerational inequalities.

Data

As the data used in this study are secondary and publicly available from DHS data <https://dhsprogram.com/>, informed consent was obtained by the original data collectors.

Notes

1. To simplify analysis, categorical variables related to emotional well-being and behavioural indicators were recoded into binary variables. Positive developmental outcomes are coded as 1, while negative outcomes are coded as 0. For example, a child not showing signs of sadness or aggression is classified as 1 (on track), whereas any signs of these emotions are scored as 0 (not on track). Aggressive behaviour was recoded; children indicating “not at all” were coded as 1 (not aggressive/on track), while all other responses were coded as 0 (aggressive/not on track).

2. Following DHS standards, we define an improved toilet as (1) Flush to piped sewer system, (0) Other/ Unsafe compostable toilets (flush to pit latrine, ventilated improved pit latrine (vip), pit latrine with slab, pit latrine without slab/open pit and no facility/bush/field).
3. A water source here refers to water that is piped either into the household's dwelling or yard, or if the household reports that their water source is from their own dwelling or yard.

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