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Multiple Impacts of Ethiopia's Health Extension Program on Adolescent Health and Well-Being: A Quasi-Experimental Study 2002–2013

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A B S T R A C T

Purpose: Ethiopia has registered remarkable achievements in reaching global development goals, including reducing child marriage. Policymakers are keen to understand which investments have contributed to this. We evaluated the association between Ethiopia's Health Extension Program (HEP) and 12 adolescent health and wellbeing outcomes.
Methods: We used Young Lives Ethiopia cohort data between 2002 and 2013. We evaluated associations between household support from HEP at age 15 and 12 adolescent outcomes spread across health, gender-based violence, education, and employment at age 19 using the inverse probability of treatment weighting propensity score approach, stratifying by sex. Adjusted probability differences (APDs) and adjusted mean differences (AMDs) were used to contrast exposure to HEP versus no exposure.
Results: Of 775 adolescents with complete follow-up, 46% were female. Sixty-six percent of adolescents reported support from HEP, with higher rates of support in poorer, less educated, and rural households, particularly in Tigray Province. In boys, HEP was positively associated with education enrolment (APD: +20 percentage points [ppts], 95% confidence interval [CI]: +9 ppts, +31 ppts) and literacy (AMD: +6 ppts, 95% CI: +0.2, +11), and negatively associated with >4 hours in income-generating activities per day (APD: −19 ppts, 95% CI: −30 ppts, −9 ppts). In girls, HEP was positively associated with no child marriage (APD: +16 ppts, 95% CI: +4 ppts, +27 ppts), no adolescent pregnancy (APD: +17 ppts, 95% CI: +6 ppts, +28 ppts),

IMPLICATIONS AND CONTRIBUTION

This study evaluated the impact of the Ethiopian Health Extension Program on multiple adolescent health and wellbeing outcomes simultaneously. Findings support the effectiveness of salaried female community health workers for improving multiple dimensions of adolescent wellbeing, including reducing adolescent pregnancy, child marriage, and increasing education enrolment.

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education enrolment (APD: +27 ppts, 95% CI: +15 ppts, +39 ppts), literacy (AMD: +5 ppts, 95% CI: +0.2, +11), and numeracy (AMD: +8 ppts, 95% CI: +3; +13).
Discussion: Policies promoting HEP are likely to have supported improvements in multiple areas of adolescents' lives in Ethiopia.

Over the last decade, countries in Africa have experienced a "youth bulge," and adolescents (i.e., persons aged 10–19 years) now represent 20% of the total population in more than 40 countries across the continent [1,2]. Recently, governmental social and health policies have primarily focused on maternal health and early childhood development. Although effective, this has left some adolescent health needs unmet, particularly in the areas of sexual and reproductive health and rights (SRHR), mental health, and substance use [3]. The consequences are more severe for adolescent girls compared to boys, due to increased risk of gender violence, sexual coercion, and harmful practices like child marriage and female genital mutilation/cutting (FGM/C).

Adolescence is a critical period for growth and development when interventions can be especially beneficial [4]. Currently, knowledge around scalable interventions during this period of life is lacking [5]. In Ethiopia, a series of multisectoral policy initiatives have been attributed to significant progress in achieving global development goals particularly in primary education and addressing child marriage [6]. One such initiative was the community Health Extension Program (HEP). Rolled out in 2003, HEP aimed to improve access to essential promotive, preventive, and curative health care across family health, disease prevention and control, and hygiene and environmental sanitation (Figure A1) [7]. By 2010, HEP implementation had led to the deployment of 34,000 community Health Extension Workers (HEWs) (1 per 2,400 population), and the construction of 6,000 health posts [7].

Based on the principles of primary health care, HEP has a strong focus on community health promotion. HEWs are tasked with spending 75% of their time conducting outreach activities to educate families about health topics including immunization, family planning, malaria, HIV and TB prevention, preparation of nutritional foods, youth reproductive health and premarital HIV testing, FGM/C, and child marriage [7]. Evaluations have found HEP to be associated with earlier antenatal care use and child vaccination, but lower diarrheal disease management in children, and no change in knowledge or use of contraceptives [8]. More intense program implementation, measured by HEW household visits, has also been found to correlate with improved postnatal care and breastfeeding [8–10]. Households' graduation as HEP "model families," which is measured by their application of improved family health practices, is associated with improved healthcare seeking behaviors [11,12].

In Ethiopia, there is an urgent need to identify initiatives to support adolescents reach their full potential. The aim of this study was to investigate the association between household support from HEP and 12 indicators of adolescent health and wellbeing. We hypothesize that health education provided by HEWs could have beneficial effects on adolescent health outcomes, in turn leading to effects on education and work-related indicators.

Methods

Study design

We used a quasi-experimental design based on the target trial framework and propensity score analysis to study the association between HEP and adolescent outcomes using Young Lives Ethiopia cohort data [13,14]. The study exploits variation in households' exposure to HEP between 2005 and 2009 to assess the programs' effects. The study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology checklist (Table A1) [15].

The Ethiopian Health Extension Program

HEP was implemented in rural regions in 2003 and later expanded to pastoralist and urban regions in 2006 and 2009, respectively [7]. Like the program today, two HEWs were assigned per kebele (ward), the lowest administrative unit in Ethiopia with 3,000–5,000 individuals and an average size of 33 km^2 [7]. HEWs were recruited from the kebele in which they would work according to specific criteria: capacity to speak the local language, >17 years of age, and completion of general secondary education (equivalent to 8 years of primary, and 2 years of secondary education) [7]. They were predominantly female to enable their role in improving maternal and newborn health, and because communities considered it more acceptable for home visits [16]. Before deployment, HEWs received 1-year pre-service theoretical and practical training [7]. HEWs often report the opportunity of a job as their motivation for joining HEP, but simultaneously report dissatisfaction with the salary they receive [16].

Upon deployment to their respective communities, pairs of HEWs divide their time between the health post (25%) and community health promotion through household visits, community meetings, and school health services (75%) [7]. Among households with exposure to the program, adult women are the most commonly contacted household members by HEWs, and the three most common health promotion services delivered by HEWs are cross-cutting health education, child vaccination, and family planning [17]. The HEP was designed to be universal and there were no selection criteria used to target households in rural and agrarian areas. Implemented in 2009, the urban HEP employed a categorization of households by wealth status to ensure equitable access to services [17]. Starting in 2005, HEWs focused on training successive groups of 30–60 families to become model families [18]. Families would receive 96 hours of health education and training over a period of 3 to 4 months,

after which they would be awarded a certificate and graduate as model families [18]. By 2010, approximately 6% of households were undertaking model family training and 4% had graduated as model families [18].

Study data

This study used the first four rounds of data obtained from the older cohort of children in Ethiopia in 2002, 2006, 2009, and 2013. Children were aged 7.5–8.5 years at round 1, and 18.5–19.5 years at round 4. We focused on the four regions of Ethiopia used by Young Lives Ethiopia for sampling, which account for 93% of Ethiopia's population: Amhara; Oromia; Southern Nations, Nationalities, and Peoples'; and Tigray. Participants sampled from Addis Ababa were excluded as HEP was not implemented in the capital city over the study period.

Sampling

A multistage process was used by Young Lives Ethiopia to select the cohort sample [19]. First, the regions where the study would take place were selected, then between three and five woredas (districts) were selected in each region, and at least one kebele was chosen in each woreda. Poor kebeles were oversampled because of Young Lives Ethiopia's focus on studying child poverty. Once selected, larger kebele were considered as a sentinel site on their own, and smaller kebele were merged with adjacent kebele to form sentinel sites. Fifty children were randomly sampled from sentinel sites.

Study variables

Outcome measures. Twelve outcomes were investigated at round 4 following a comprehensive review of the Young Lives data for indicators plausibly related to HEP. They included 10 binary indicators: (1) not underweight, measured as a weight-for-age z-score no lower than −2 standard deviations below the mean on the World Health Organization Child Growth Standards for adolescents younger than 18 years, and body mass index >18.5 for adolescents older than 18 years [20]; (2) very good health, measured as scoring five on a five-point scale ranging from very poor to very good; (3) fertility knowledge, measured as correct responses to both true/false statements "a woman/girl cannot get pregnant the first time she has sex" and "If a girl washes herself after sex she will not get pregnant"; (4) sexually transmitted infection (STI) knowledge, measured as correct responses to the true/false statements "Using a condom can prevent getting a disease through sex," "A person who looks very healthy cannot pass on a disease through sex," and "A person can get HIV or AIDS by having sex"; (5) no child marriage, measured as no self-reported marriage before the international and national legal age of 18; (6) no adolescent pregnancy, measured as no self-reported pregnancy or birth before age 20; (7) low/no alcohol use, measured as consuming alcohol no more than once per week; (8) education enrolment, measured as enrolment in formal education during the survey year; (9) <3 hours of domestic activities per day, which included household chores and caring for others. This threshold was previously associated with worse education outcomes in Ethiopia [21]; (10) >4 hours of income-generating activities per day, which included work inside the household that generated income (e.g., farming) or paid work outside of the household. We also studied two continuous scores: (1) literacy score measured using items from the Organisation for Economic Co-operation and Development program for International Student Assessment and the UNESCO Literacy Assessment and Monitoring Programme; (2) numeracy score measured using existing items from Trends in International Mathematics and Science Study 2003 [22]. Literacy and numeracy tests were answered in participants' preferred language. All outcomes were studied in both boys and girls except for child marriage and adolescent pregnancy, which were not measured in boys, and alcohol use in girls, which was too rare. Although the Young Lives data collected information on smoking at round 4, its prevalence was too low to be included as an outcome (<1%).

Exposure to Health Extension Program. Recall by children's caregiver at round 4 of their household being a "beneficiary/member of HEP" (No/Yes) before or during 2009/2010 when they turned 15 years. We interpret this to refer to engagement with HEP via visits to the health post, household visits from HEW, or undertaking model family training. Considering the low uptake of model family training between 2005 and 2010, we expect this type of engagement to have been minimal. Exposure to HEP would indicate that caregivers and their children were exposed to health communication and education in family health, disease prevention and control, and hygiene and environmental sanitation, including in the areas of youth reproductive health and premarital HIV testing, female genital mutilation, and child marriage [7]. Our study exploits variation in households' exposure to the program that occurred during the early years of implementation related to multiple factors including delays in deploying HEWs, geographically large catchment areas, and competing demands for family members time [23]. Our specification of an age cut-off of 15 years for exposure to HEP aimed to ensure that exposure would precede the study outcomes of child marriage and adolescent pregnancy, which were also reported retrospectively. In national statistics, 90% of young women of a similar age to this cohort marry after age 15 [24].

Covariates. Covariates included 11 characteristics at round 1: child age, sex, stunting, health relative to other children of the same age, presence of long-term health problem, place of residence (rural/urban), region of residence, household wealth and size, caregiver age, and education. The Young Lives household wealth index ranges between 0 and 100 with higher values reflecting higher household wealth. Additional covariates over follow-up included school starting age, and indicators of household receipt of the national Productive Safety Net Programme (PSNP) and experience of drought [25].

Statistical analyses

We described round 1 characteristics of participants with loss to follow-up (LTFU), as well as those followed up at round 4 using count (%) and mean (standard deviation (SD)). Further cross-tabulations were used to investigate determinants of support from HEP, and correlations between study outcomes.

We controlled for measured covariates using the inverse probability of treatment weighting (IPTW) propensity score approach [14]. This is a robust approach (broadly equivalent to propensity score matching and stratification), particularly when estimating population average treatment effects [26]. First, propensity scores were estimated separately for boys and girls

Table 1
Summary of participant characteristics at round 1 overall, and disaggregated by sex

Characteristic	Overall (N = 775)	Boys (n = 420)	Girls (n = 355)	*p* value
Adolescent				
Age (in years)				.87
Mean (SD)	7.87 (.29)	7.87 (0.29)	7.87 (0.30)	
Stunting (short height-for-age)[a]				.17
None	482 (62)	269 (64)	213 (60)	
Moderate	160 (21)	77 (18)	83 (23)	
Severe	105 (14)	61 (15)	44 (12)	
Long-term health problem				.42
Yes	76 (10)	38 (9)	38 (11)	
Health relative to others				.9
Same	376 (49)	205 (49)	171 (48)	
Better	282 (36)	150 (36)	132 (37)	
Worse	117 (15)	65 (15)	52 (15)	
School enrolment				.65
Yes	473 (61)	249 (59)	224 (63)	
No: School fees too expensive	58 (7)	30 (7)	28 (8)	
No: School too far	74 (10)	41 (10)	33 (9)	
No: Help needed at home	96 (12)	56 (13)	40 (11)	
No: Other	71 (9)	43 (10)	28 (8)	
Location of residence				.41
Rural	587 (76)	323 (77)	264 (74)	
Region of residence				.77
Tigray	191 (25)	99 (24)	92 (26)	
Amhara	185 (24)	99 (24)	86 (24)	
Oromia	185 (24)	100 (24)	85 (24)	
SNNP	214 (28)	122 (29)	92 (26)	
Household				
Size				.27
Mean (SD)	6.52 (2.11)	6.60 (2.07)	6.43 (2.16)	
Wealth index				.39
Mean (SD)	19.22 (15.60)	18.78 (15.41)	19.75 (15.83)	
Caregiver				
Age				.84
Mean (SD)	35.07 (8.97)	35.01 (8.79)	35.14 (9.19)	
Education				.31
Grade 1–4/illiterate	645 (83)	349 (83)	296 (83)	
Grade 5–8	81 (10)	49 (12)	32 (9)	
Grade 9+	45 (6)	21 (5)	24 (7)	

Data are expressed as mean (SD) for continuous variables and n (%) for categorical variables.
SD = standard deviation; SNNP = Southern Nations, Nationalities, and Peoples'.
[a] Moderate stunting corresponds to a height-for-age z-score below minus two; and severe stunting corresponds to a height-for-age z-score below minus three standard deviations lower than the mean on the World Health Organization child growth standards.

using logistic regression, in which HEP exposure was regressed on all 11 round 1 covariates. We assessed balance of covariates between exposure groups using standardized mean differences. Associations between HEP and study outcomes were then estimated by regression, weighting unexposed participants as 1/(1−propensity score) and exposed participants as 1/propensity score, and adjusting models for a binary indicator of experiencing drought over follow-up, which remained unbalanced across HEP exposure groups after weighting. Logistic regression was used for binary outcomes and linear regression for continuous outcomes. Adjusted probability differences and adjusted mean differences were used to compare the scenarios: "No HEP" and "HEP" for HEP outcome associations with $p < .05$. Finally, we investigated the influence of dose-wise exposure to HEP and study outcomes according to frequency and duration of HEP support. For this we used IPTW based on the generalized propensity score proposed by Imbens [27]. Missing values were handled by pairwise deletion. Analyses were stratified by sex because of the gendered nature of our outcomes, and performed using Stata 15.

Ethics

Research data used in this analysis were accessed under safeguarded conditions of use from the UK Data Archive website [28]. Details of ethical approvals, and informed consent obtained in the primary research are available online at https://www.younglives.org.uk/content/research-ethics.

Results

Study size

Out of 850 participants, 9% (n = 75) were LTFU by round 4. Participants LTFU were similar to those with complete follow-up data except they were more likely to be female, older, live in the Southern Nations, Nationalities, and Peoples' region, and have caregivers with no education (Table A2). The final analysis included 775 participants with a mean time to follow-up of 11.15 years (SD 0.13). Missing values for all variables were ≤5% (Table A3).

Descriptive analysis

Characteristics of study participants are summarized overall and disaggregated by sex in Table 1. At round 1, the mean age was 7.87 years (SD 0.29), and 355 (46%) participants were female. Participants were spread equally across the study regions, and the majority resided in rural areas. The prevalence of moderate and severe stunting was high (35%), and over one third were not enrolled in education (38%). Mean household wealth was 19.22 (range: 0.0–87.78) and mean household size, including the participant was 6.52 (SD 2.11). Participant caregivers had a mean age of 35.07 years (SD 8.97), and most were either illiterate or had less than grade 4 education (83%). Over follow-up, participants' mean age at the start of school was 8.27 (SD 2.11), and the majority experienced drought (57%). Forty-seven percent of households received support from PSNP. On average, boys started school half a year later than girls ($p = .004$).

Study outcomes and their correlations at round 4 are summarized disaggregated by sex in Table 2. Compared to boys, girls were more likely to have a healthy weight, and be enrolled in education; but they were less likely to have very good health, good knowledge about fertility or STIs, spend <3 hours on domestic chores per day, spend >4 hours in income-generating activities per day, or achieve high numeracy scores. In boys and girls, literacy and numeracy scores showed a strong positive correlation. In boys, spending >4 hours in income-generating activities per day, and education enrolment showed a strong negative correlation. In girls, no child marriage and no adolescent pregnancy showed a strong positive correlation. Univariable associations between HEP and study outcomes are reported in Table A4.

In line with HEP's gradual roll-out, household support for boys and girls at age 12 was 32% and 34%, respectively; and at age 15 it was 68% and 63%, respectively. Among caregivers recalling

Table 2
Summary of study outcomes and their correlations disaggregated by sex (N = 775)

Outcome	n (%)	Correlations											
		1	2	3	4	5	6	7	8	9	10	11	12
Boys (n = 420)													
1. Not underweight	305 (73)	1.000											
2. Very good health	214 (51)	0.060	1.000										
3. Fertility knowledge[a]	211 (50)	0.069	0.064	1.000									
4. STI knowledge[a]	214 (51)	0.024	0.021	0.270	1.000								
5. No child marriage	420 (100)	-	-	-	-	1.000							
6. No adolescent pregnancy	420 (100)	-	-	-	-	-	1.000						
7. Low/no alcohol use[b]	327 (81)	0.049	−0.027	0.018	0.048			1.000					
8. Education enrolment	239 (57)	−0.017	−0.036	0.001	−0.054	-	-	0.212	1.000				
9. <3 hours domestic activities	309 (74)	0.056	−0.037	−0.055	0.062	-	-	−0.103	−0.140	1.000			
10. >4 hours income generating activities	199 (47)	−0.027	−0.004	0.022	0.056	-	-	−0.124	−0.599	0.255	1.000		
11. Literacy score[c,d]	55.47 (22.32)	0.059	−0.104	0.052	0.185	-	-	−0.004	0.364	0.079	−0.275	1.000	
12. Numeracy score[c,e]	49.62 (21.36)	0.043	−0.056	0.084	0.196	-	-	0.042	0.281	0.020	−0.224	0.758	1.000
Girls (n = 355)													
1. Not underweight	306 (86)	1.000											
2. Very good health	125 (35)	0.056	1.000										
3. Fertility knowledge[a]	135 (38)	0.028	0.053	1.000									
4. STI knowledge[a]	142 (40)	0.078	0.010	0.069	1.000								
5. No child marriage	318 (90)	0.024	0.078	0.040	−0.003	1.000							
6. No adolescent pregnancy	311 (88)	0.056	0.041	0.043	0.045	0.721	1.000						
7. Low/no alcohol use[f]	321 (95)	−0.023	0.063	0.045	0.085	0.089	0.134	1.000					
8. Education enrolment	228 (64)	−0.043	0.046	0.005	−0.013	0.399	0.381	0.031	1.000				
9. <3 hours domestic activities	97 (27)	−0.030	−0.055	−0.060	−0.046	0.147	0.180	0.007	0.088	1.000			
10. >4 hours income generating activities	74 (21)	0.045	−0.044	0.026	0.019	−0.007	−0.012	−0.010	−0.384	0.214	1.000		
11. Literacy score[c,g]	54.69 (20.31)	0.072	−0.096	0.099	0.129	0.195	0.202	0.075	0.307	0.099	0.033	1.000	
12. Numeracy score[c,h]	42.39 (19.90)	0.202	0.065	0.146	0.136	0.216	0.191	0.067	0.267	0.060	−0.037	0.634	1.000

Coefficients are Pearson correlations.
STI = sexually transmitted infection.
[a] One missing observation.
[b] Seventeen missing observations.
[c] Outcomes are measured as continuous scores.
[d] Two missing observations.
[e] Twenty-one missing observations.
[f] Sixteen missing observations.
[g] Six missing observations.
[h] Eighteen missing observations.

support before their child turned 15, most reported monthly or bimonthly support (52%), and their satisfaction with HEP services was also high (fully satisfied: 68%) (Table A5). Compared to boys, girls received more regular household support ($p = .013$), and their caregivers had higher satisfaction with HEP ($p = .021$). Participants in households supported by HEP were younger, less likely to be enrolled in school, had caregivers with lower education, lower household wealth, and were more likely to live in a rural area and in the Tigray region (Table 3). Our propensity score models were assessed to have good discriminative ability in both boys and girls, with Hosmer-Lemeshow chi-square values of 6.98 ($p = .54$) and 9.47 ($p = .30$), and area under the receiver operating characteristic curve of 0.7 and 0.75, respectively (Table A6). After weighting, standardized differences for covariates across HEP exposure groups were all <0.1 (implying good balance) except for a binary indicator of experiencing drought between round 1 and round 4 (Table A7, Figure A2) [29].

Receipt of Health Extension Program and adolescent outcomes

Association between Health Extension Program and study outcomes. In boys, we found very strong evidence that HEP was associated with higher odds of education enrolment but lower odds of >4 hours in income-generating activities per day, and moderate evidence of an association with higher literacy (Table 4). In girls, we found very strong evidence that HEP was associated with higher odds of no adolescent pregnancy and education enrolment, strong evidence of an association with higher odds of no child marriage and higher numeracy, and moderate evidence of an association with higher literacy (Table 4). Adjusted probabilities of study outcomes conditional on exposure to HEP, together with adjusted probability differences and adjusted mean differences are summarized in Figure 1.

We found no evidence in either boys or girls that monthly/bimonthly support from HEP was associated with dose-wise higher probability of study outcomes compared to quarterly/annual support from HEP, or that commencement of support in 2003–2006 was associated with dose-wise higher probability of study outcomes compared to commencement of support in 2007–2010 (Tables A9 and A10).

Discussion

Two thirds of adolescents in this cohort reported household support from Ethiopia's HEP at age 15. Lower household socioeconomic status, rural location, and residence in Tigray were significant determinants of receiving support from HEP. Accounting for differences between exposure groups, in adolescent boys, HEP was associated with higher education attendance and better literacy, and lower probability of working more than 4

Table 3
Summary of participant characteristics at round 1 by exposure to HEP disaggregated by sex (N = 775)

Characteristic	Boys			Girls		
	No HEP (n = 130)	HEP (n = 271)	*p* value	No HEP (n = 130)	HEP (n = 224)	*p* value
Adolescent						
Child's age (in years)			.42			.005
Mean (SD)	7.89 (0.29)	7.87 (0.29)		7.92 (0.28)	7.83 (0.30)	
Stunting (short height-for-age)[a]			.31			.51
None	90 (69)	167 (62)		80 (62)	132 (59)	
Moderate	24 (18)	50 (18)		33 (25)	50 (22)	
Severe	14 (11)	43 (16)		13 (10)	31 (14)	
Long-term health problem			.32			.73
Yes	9 (7)	27 (10)		13 (10)	25 (11)	
Health relative to others			.21			.75
Same	67 (52)	131 (48)		59 (45)	111 (50)	
Better	50 (38)	95 (35)		51 (39)	81 (36)	
Worse	13 (10)	45 (17)		20 (15)	32 (14)	
School enrolment			.02			.005
Yes	89 (68)	150 (55)		98 (75)	126 (56)	
No: School fees too expensive	10 (8)	17 (6)		8 (6)	20 (9)	
No: School too far	7 (5)	33 (12)		7 (5)	25 (11)	
No: Help needed at home	10 (8)	44 (16)		7 (5)	33 (15)	
No: Other	13 (10)	27 (10)		10 (8)	18 (8)	
Location of residence			.001			<.001
Rural	86 (66)	219 (81)		77 (59)	186 (83)	
Region of residence			.002			<.001
Tigray	22 (17)	62 (23)		17 (13)	74 (33)	
Amhara	26 (20)	72 (27)		35 (27)	51 (23)	
Oromia	27 (21)	73 (27)		35 (27)	50 (22)	
SNNP	55 (42)	64 (24)		43 (33)	49 (22)	
Household						
Inhabitants			.11			.14
Mean (SD)	6.37 (2.21)	6.72 (2.03)		6.21 (2.13)	6.56 (2.18)	
Wealth index			<.001			<.001
Mean (SD)	23.28 (16.64)	16.70 (14.65)		25.27 (16.88)	16.58 (14.34)	
Caregiver						
Age			.65			.78
Mean (SD)	35.31 (8.93)	34.89 (8.77)		35.34 (9.46)	35.05 (9.07)	
Education			.03			.069
Grade 1–4/illiterate	100 (77)	230 (85)		101 (77.69)	194 (86.61)	
Grade 5–8	18 (14)	31 (11)		15 (11.54)	17 (7.59)	
Grade 9+	12 (9)	9 (3)		13 (10.00)	11 (4.91)	

Data are expressed as mean (SD) for continuous variables, and n (%) for categorical variables.
HEP = health extension program; SD = standard deviation; SNNP = Southern Nations, Nationalities, and Peoples'.
[a] Moderate stunting corresponds to a height-for-age z-score below minus two; and severe stunting corresponds to a height-for-age z-score below minus three standard deviations lower than the mean on the World Health Organization child growth standards.

hours/day at age 19. In adolescent girls, HEP was associated with lower risk of child marriage and adolescent pregnancy, higher education attendance, and better literacy and numeracy at age 19. We found no evidence of an association between HEP and self-reported health, nutrition, fertility knowledge, STI knowledge, or alcohol use in either boys or girls.

To our knowledge, this study is the first to examine the association between household support from HEP and a range of adolescent health and wellbeing, including health knowledge, child marriage, adolescent pregnancy, and access to education and income-generating activities [8–12]. The high satisfaction with HEP observed in our study matches previous research on community perspectives of the program [18,30]. Evidence of protective associations between HEP and child marriage, adolescent pregnancy, and educational outcomes is consistent with the inter-related nature of adolescent development, and adds to our understanding of the potential for community health programs to accelerate adolescent achievement [3].

Findings around child marriage, adolescent pregnancy, and girls' educational attainment at age 19 are consistent with the well-established relationship among these three outcomes [31]. Furthermore, the overlapping reductions in child marriage and adolescent pregnancy we observe match the low tolerance for childbearing outside of marriage in Ethiopia [32]. Key informant interviews with HEWs have previously revealed the focus of HEP on helping parents to understand the health risks of child marriage and the benefits of girls' education [33,34]. However, mixed evidence for the effectiveness of community awareness programs for addressing child marriage and girls' education indicate that other mechanisms may also underlie the observed link between HEP and these outcomes [35]. Drawing on recent evidence around favorable job markets and community role models, HEP's employment of mostly female HEWs that have completed general secondary education, may also have acted as an incentive for girls to remain in school [35]. Positive associations between HEP and higher education enrolment and literacy could also be explained by positive effects of HEW visits on family and particularly caregiver health, as health shocks are a common cause for withdrawal of children from school [36].

Table 4
Summary of associations between HEP and adolescent outcomes using IPTW-based propensity score approach (N = 775)

Sex	Not underweight		Very good health		Fertility knowledge[a]		STI knowledge[a]		No child marriage		No early pregnancy	
	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value
Boys (n = 420)	0.84 (0.48–1.45)	.52	1.27 (0.79–2.05)	.32	1.04 (0.65–1.68)	.87	0.96 (0.59–1.54)	.85	[b]		[b]	
Girls (n = 355)	0.99 (0.47–2.08)	.98	0.83 (0.45–1.52)	.55	1.62 (0.93–2.83)	.09	1.17 (0.66–2.08)	.6	4.11 (1.64–10.31)	.003	4.96 (2.03–12.13)	<.001
	Low/no alcohol use[c]		Education enrolment		<3 hours domestic activities/day		>4 income-generating activities/day		Literacy[d]		Numeracy[e]	
	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	AOR (95% CI)	p value	ABeta (95% CI)	p value	ABeta (95% CI)	p value
Boys (n = 420)	1.64 (0.90–2.99)	.11	2.29 (1.43–3.67)	<.001	0.72 (0.43–1.21)	.21	0.45 (0.28–0.72)	<.001	5.62 (0.24–11.00)	.041	3.58 (−1.47, 8.63)	.165
Girls (n = 355)	[b]		3.08 (1.78–5.34)	<.001	0.68 (0.37–1.23)	.2	0.62 (0.31–1.24)	.17	5.49 (0.16–10.82)	.043	7.89 (2.68–13.11)	.003

Models are weighted by the inverse probability of participants' observed exposure status using the propensity score, and adjusted for exposure to drought between round one and round four.
ABeta = adjusted ordinary least squares regression coefficient; AOR = adjusted odds ratio; CI = confidence interval; IPTW = inverse probability of treatment weighting; STI = sexually transmitted infection.
[a] One missing observation in boys and girls.
[b] Outcome was either not measured or too rare to evaluate.
[c] Seventeen missing observations in boys.
[d] Two missing observations in boys and six missing observations in girls.
[e] Twenty-one missing observations in boys and 18 missing observations in girls.

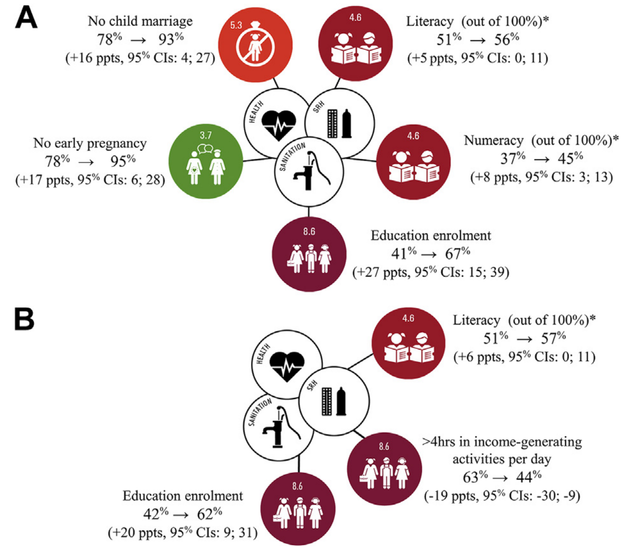

Figure 1. Adjusted probabilities and values of adolescent outcome by exposure to HEP in (A) girls and (B) boys. Percentages joined by an arrow are adjusted outcome probabilities for the scenarios (1) "No HEP" and (2) "HEP." Data in the brackets are the estimated probability difference between adjusted outcome probabilities and 95% confidence intervals. Green circles correspond to outcomes related to SDG 3: Good Health and Wellbeing. Red circles correspond to outcomes related to SDG 4: Quality Education. Orange circles correspond to outcomes related to SDG 5: Gender Equality. Maroon circles correspond to outcomes related to SDG 8: Decent Work and Economic Growth. The values used to build Figure 1 are provided in Table A8. *Percentages joined by an arrow are adjusted mean scores for the scenarios (1) "No HEP" and (2) "HEP." CI = confidence interval; ppts = percentage points; SDG = Sustainable Development Goal.

In this study, we found weak evidence linking HEP to improved fertility knowledge in adolescent girls, and no evidence linking the program to better STI knowledge in this group. These findings are similar to a previous evaluation of HEP, which found no evidence supporting improved knowledge or use of contraceptives among adolescent girls and women benefitting from the program. They also match with findings of the low priority attributed to adolescent SRH during household visits from HEWs [18]. These results indicate a possible need to revisit HEP's communication strategy around SRHR [8]. Such efforts should consider the desires and needs of adolescents and the difficulties they face in accessing knowledge or services, for example, caregiver concerns about promoting promiscuity [7,34].

Strengths of this study included the richness of the Young Lives Ethiopia data, which allowed us to evaluate 12 adolescent outcomes, including key public health challenges like child marriage and adolescent pregnancy. The study also has limitations. The study sample size prevented stratification of our analysis by region, self-reported variables may have been prone to recall bias, and the short scales used to measure general health, knowledge about fertility and STIs may limit the reliability of these outcomes. Social desirability bias may have led to underreporting of sensitive outcomes like child marriage. However, we are reassured by the observed prevalence of this outcome matching data from the Ethiopian Demographic and Health Survey [37]. Like all observational studies, LTFU is a concern for selection bias, and unmeasured or residual confounding is a threat to internal validity. Although these limitations mean that our study is unable to establish whether

estimated associations are causal, our use of the target trial framework and propensity score analysis helped to maximize internal validity [13,14]. We also aimed to address the risk of reverse causality by ensuring that support from HEP began before study outcomes. Lack of evidence for a dose relationship between the duration or frequency of household support from HEP and study outcomes may either be due to low statistical power, recall bias, or because such a relationship is dependent on both of these factors.

The generalizability of study findings is supported by the study's high internal validity, and diverse sample, albeit focused on poor households, and in rural areas [19]. Both the study exposures, represented by a community health program delivered by local salaried female HEWs and study outcomes, all common indicators of adolescent health and wellbeing, are focuses for social policies across contexts.

This study provides new knowledge around effective gender- and adolescent-responsive health programing in Ethiopia, and has important policy implications for the national focus on youth empowerment, and target to eliminate child marriage by 2025 [38]. Our findings suggest that continued investments in HEP may be effective for impacting multiple dimensions of adolescent wellbeing, including the priority areas of child marriage, adolescent pregnancy, and girls' education. They also suggest that the program could be strengthened in the areas of adolescent SRHR and nutrition, and that addressing a fuller spectrum of health needs may be necessary to improve self-rated health.

Building on this study, further analysis should aim to unpack the causal mechanisms underlying associations observed in this analysis. Clarifying the effects of HEP on community norms, favorable job markets, and girls' aspirations would facilitate efficiencies in the implementation of HEP and its translation to different contexts. Further research into culturally sensitive strategies for HEWs to communicate with families about adolescent SRHR could also accelerate progress on this outcome. In this study, we controlled for possible effects of Ethiopia's national PSNP on adolescent outcomes. However, evidence linking PSNP to lower risk of child marriage [39,40], increased time in paid work [41], and improved nutrition among adolescents [42] suggests that future work could valuably explore whether receipt of HEP and PSNP together is associated with additional benefits beyond receipt of just one of these interventions. Key features of PSNP such as its focus on food insecure households in rural areas [43], mean that this would require a different study design to the one used in this study, including an alternative weighting approach based on households' probability to receive neither program, only HEP, only PSNP, or both [14]. Future evaluations with larger sample sizes, or alternative study designs, should aim to evaluate further the influence of more frequent visits from HEWs, and model family training on adolescent outcomes [10], and also consider outcomes that we were unable to investigate, for example, FGM/C.

Conclusion

Policies promoting locally employed and predominantly female community health workers can improve multiple areas of adolescent lives including child marriage, adolescent pregnancy, and education simultaneously. Further research into the mechanisms underlying these observations would facilitate translation of HEP to different contexts.

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Supplementary Data

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