Childhood Illness and the Gender Gap in Adolescent Education in Low- and Middle-Income Countries

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abstract

BACKGROUND: Achieving gender equality in education is an important development goal. We tested the hypothesis that the gender gap in adolescent education is accentuated by illnesses among young children in the household.

METHODS: Using Demographic and Health Surveys on 41 821 households in 38 low- and middle-income countries, we used linear regression to estimate the difference in the probability adolescent girls and boys were in school, and how this gap responded to illness episodes among children <5 years old. To test the hypothesis that investments in child health are related to the gender gap in education, we assessed the relationship between the gender gap and national immunization coverage.

RESULTS: In our sample of 120 708 adolescent boys and girls residing in 38 countries, girls were 5.08% less likely to attend school than boys in the absence of a recent illness among young children within the same household (95% confidence interval [CI], 5.50%–4.65%). This gap increased to 7.77% (95% CI, 8.24%–7.30%) and 8.53% (95% CI, 9.32%–7.74%) if the household reported 1 and 2 or more illness episodes, respectively. The gender gap in schooling in response to illness was larger in households with a working mother. Increases in child vaccination rates were associated with a closing of the gender gap in schooling (correlation coefficient = 0.34, $P = .02$).

CONCLUSIONS: Illnesses among children strongly predict a widening of the gender gap in education. Investments in early childhood health may have important effects on schooling attainment for adolescent girls.

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Drs Alsan and Bendavid conceived the work and conducted the analysis along with Ms Xing; Dr Darmstadt contributed to the conceptualization of factors impacting gender gaps and contributed to the manuscript preparation; Dr Wise helped with manuscript preparation and improved the clarity of the presentation; and all authors approved the final manuscript as submitted.

DOI: https://doi.org/10.1542/peds.2016-3175

Accepted for publication Apr 19, 2017

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

WHAT'S KNOWN ON THIS SUBJECT: In most developing countries, girls are less likely to complete secondary school. Much attention is given to the importance of gender inequalities, yet there is a lack of insight into mechanisms to close the gender gap while improving child health.

WHAT THIS STUDY ADDS: We illuminated the pathways connecting child health and gender inequalities. The gender gap in adolescent education is accentuated by illnesses among young children in the household, because adolescent girls in developing countries are often tasked with child care and chores.

To cite: Alsan M, Xing A, Wise P, et al. Childhood Illness and the Gender Gap in Adolescent Education in Low- and Middle-Income Countries. *Pediatrics.* 2017;140(1):e20163175

Gender equity in education is fundamental for achieving the sustainable development goals (SDGs), which are shared goals agreed on by member states of the United Nations.[1,2] SDGs 3, 4, and 5 call for healthy lives at all ages, inclusive and quality education, and gender equality and the empowerment of women, respectively. These SDGs recognize the intersecting roles of child health, education, and gender equity in promoting a better furture.[3] Although disparities in primary education have decreased substantially over the last 2 decades, the gender gap in completion of secondary education persists. In Sub-Saharan Africa and South Asia, boys are 1.55 times more likely to complete secondary education than girls.[4,5] Thus, many girls will miss out on the benefits of a secondary school education, including the reduced risk of HIV acquisition, delayed sexual debut, fewer pregnancies during the teen years, higher wages and employment later in life, and improved educational attainment for their children.[4,6–8] The potential gains from increased participation of women in the labor force (mostly in low- and middle-income countries [LMIC]) to global economic output over the next 10 years are estimated at $12 trillion.[9,10] Identifying actionable contributors to gender disparities in secondary education is therefore of broad relevance to health and development.

Despite its importance, causes for the gap in school attendance between adolescent girls and boys residing in LMIC are poorly characterized. In this article, we examine the role of child illness in explaining the gap in adolescent schooling. Our conceptual framework suggests that the gender differences in household responsibilities result in the substitution of older girl children for maternal care of a younger sibling who is ill. If older girls are preferentially tasked with household chores from an early age, then the illness of a younger child in the household will raise the likelihood that adolescent girls will stay out of school to care for the sick child (and not raise the likelihood for adolescent boys).[11,12] The deprivation of educational opportunities contributes to less-educated women and poorer outcomes for their children, which presents a vicious cycle of gender inequality (Fig 1).

Time-use survey data support the hypothesis that adolescent girls often participate in time-consuming household chores at the expense of their education.[13] Moreover, multiple epidemiologic surveys also demonstrate that young children are ill frequently in LMIC.[3,14–16] We provide in our analysis an empirical linkage between childhood illness and girls' education. Our primary goal is to assess the magnitude of the pathway leading from childhood illness to a widening in the gap in schooling between adolescent boys and girls.

Characterizing such linkages could revise estimates of the returns to investments in child health in developing countries and aid in the design of complementary policies that capitalize on improvements in child health to retain adolescent girls in school, thus creating a virtuous cycle of improved health and development.[3,16]

METHODS

Overview

We employed individual-level data from the Demographic and Health Surveys (DHS) to examine the gap in the likelihood that adolescent boys and adolescent girls will be in school in relationship to illnesses among younger siblings. The DHS are nationally representative household surveys that provide information on the health of populations. In a second analysis, we examined whether the gap in school attendance would increase when the mother works outside the home because of the enhanced need for child care in the home. In a third analysis, we examined national data on the gender gap in adolescent education in association with national vaccination rates. We hypothesized that countries with high rates of childhood vaccination will experience lower rates of young child illness, thereby decreasing the need for adolescent girls to devote time to caring for sick children.

Data Sources

The primary data source of this analysis is the DHS.[15] In this analysis, we used 44 surveys conducted in 38 countries between 1999 and 2013. DHS typically include between 4 and 10 000 households in which the educational status of all household members is enumerated. For our primary analysis, which is the analysis of differential school attendance by gender to child illness episodes, we used information from all households with (1) at least 1 child <5 years of age, (2) at least 1 adolescent girl, (3) at least 1 adolescent boy, (4) information about current school attendance for all adolescent boys and girls, and (5) information about illnesses among the household's children <5 years old within 2 weeks preceding the survey. All households also had information on whether the mother works outside the home. Maternal work outside the home was identified by asking the following 2 questions: "Aside from your own housework, are you currently working?" and "Do you usually work at home or away from home?" The response rate for all the critical data elements (household census, child illness, and education status) was over 95% in the surveys used. We defined "adolescent" in this study as ages between 11 and 17 years old because

TABLE 1 Child and Household Characteristics by Gender and Illness Episodes

	Illness Episodes			Full Sample	
	0	1	2	Boys	Girls
N	59 624	47 239	13 845	61 201	59 507
Has electricity (% of households)	43.8	36.8	23.6	38.1	39.3
Has car (% of households)	7.1	6.7	5.2	6.5	6.9
Has telephone (% of households)	11.1	9.6	6.1	9.7	10.3
Urban city (% urban)	38.1	35.4	25.3	35.0	36.1
Mothers' literacy levels (% illiterate)	34.3	49.4	65.6	44.9	43.0
Highest education levels (% of teens)					
No education	14.7	21.0	34.9	17.1	21.9
Primary	61.3	59.9	53.8	62.3	57.5
Secondary or higher	23.9	19.0	11.3	20.6	20.6

The table illustrates frequencies in the full analytic sample of 120 708 adolescent boys and girls of household and education characteristics by number of illness episodes and gender. All differences across the number of illnesses are significant at $P < .001$ (χ^2). Household characteristics are different among households with 0, 1, or 2 illness episodes. These observed (and unobserved, fixed) differences are controlled for with household fixed effects.

this age group has been shown to be old enough to care for a young child but young enough to attend school in the 7 to 12 grade range.[17] In the sensitivity analyses presented in Supplemental Fig 5, we varied the youngest age range from 10 to 12 and the oldest from 16 to 18. Our figures illustrate that the findings are stable within this range of ages. For each adolescent, we used the DHS question "Is the household member still in school?" as the principal indicator of school attendance.

In each DHS, mothers were asked about signs of recent illnesses of young children. We used queries about the presence of diarrhea, fever, or cough in the 2 weeks preceding the survey to indicate illness (see Supplemental Information for variable definitions and for wording of survey questions). The presence of any of these signs indicated an episode of illness, but we counted no more than 1 episode for any single child even if their mother reported multiple signs. More than 1 episode of illness in the household may occur, however, if >1 child had one or more signs of illness in the 2 weeks preceding the survey. Household records with missing information for the included variables were excluded from the analysis (see Supplemental Table 4 for details).

Finally, to assess the relationship between the gender gap and vaccination coverage, we used the DHS-prepared statistics platform (STATCompiler; DHS, Rockville, MD) for the vaccination rates obtained during each survey.[16] We present the findings by using the proportion of children who were fully immunized (ie, children who received all 8 basic vaccines, including polio, diphtheria, pertussis, tetanus, and measles).

Analyses

Relationship Between School Attendance and Young Sibling Illness

Households that frequently experience episodes of illness for children <5 years old may be different from other households in many ways that we can and cannot observe. The observed differences are readily apparent in the data (Table 1): households with a young child who was ill in the 2 weeks preceding the survey (~50% of our sample) tend to have fewer assets and lower levels of maternal literacy. Hence, comparing how illness of young children affects the schooling opportunities for older girls across households will be confounded by unobserved factors that may affect both child illnesses and education of adolescent girls (eg, residence in remote areas may make securing clean water a challenge and may also make it difficult to reach school, accentuating a gender gap).

To circumvent such biases, we instead looked within households and measured the differential probability of attending school for adolescent girls versus boys in relationship to the same illness episodes.[17] This allowed us to isolate the role of factors that affect the schooling of boys and girls differentially within households and that interact with illness such as gender preferences for who should care for the sick child. Thus, we at least partially controlled for variables that persist over time within households, such as maternal education, household wealth, and cultural attitudes. Specifically, we regressed educational outcomes on gender; childhood illness episodes interacted with gender and indicator variables for each household in the sample (household fixed effects). For example, consider 2 households, each with 1 adolescent boy who is in school and 1 adolescent girl who is not in school. In the first household, no young children are ill, and in the second household 1 child is ill. Our models test the hypotheses that, within these households, the probability that the girl is out of school is greater than the probability that the boy is out of school, and additionally whether this probability is higher in households with a sick young child. The marginal effect of interest is then the interaction of childhood illness episodes with (older) girl gender. Please see Supplemental Information for the exact econometric specification.

Influence of Maternal Work on School Attendance

We next examine the influence of maternal work outside the home on the gender gap in school attendance associated with younger sibling illness. To do so, we estimated the same specification described immediately above and written

out formally in Supplemental Information in 2 samples: 1 in which the mother works outside the home and 1 in which she does not.

In Supplemental Fig 7 and Supplemental Fig 8, we included 2 important extensions of the baseline specification. First, we separated the sample by rural and urban locations. Second, we used alternative DHS outcome variables, including years of schooling and whether the child has attended school in the current year. In Supplemental Fig 9, we included only households with older boy children as a "placebo test." In Supplemental Table 3, we confirmed that the effects of birth order and gender are separate by including interactions in both with childhood illness.

National Vaccination Rates and Gender Gap in Schooling

We examined national estimates of the schooling gender gap and their association with national vaccination coverage rates in the 38 countries. The schooling gap for each survey was defined as the weighted mean of the schooling gap in each survey for 0, 1, and >1 illness. We then obtained vaccination rates for the same country-year survey, defined as receipt of the complete series of polio vaccinations; diphtheria, tetanus, and pertussis vaccinations; and measles-containing vaccinations, for a total of 8 vaccinations.[16] We also conducted subanalyses of the relationship between vaccination coverage and the schooling gender gap disaggregated by income group and by vaccine type. These findings are presented in Supplemental Fig 6.

Role of Sponsor and Permissions

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication. The study was determined as exempt by the Stanford Institutional Review Board.

RESULTS

Our data consisted of 120 708 adolescents residing in 41 821 households in 38 countries. Data were obtained from 47 surveys conducted between 1999 and 2013. The sample included all households, women, adolescents, and children that met our inclusion criteria. By using the criteria that the household have at least 1 child <5 years old and at least 2 older children (at least 1 boy and 1 girl), we limited the sample among the universe of DHS to slightly over 116 000 households in 63 countries. Once we required that the survey include information on schooling and gender and illness episodes, the number of households available for analysis was ∼42 000 (or 36% of all potential households in the DHS). We provide in Table 2 an assessment of the number of households with incomplete information, conditional on the country being in our sample. By using this measure, excluded households generally account for <1% of the within-country sample. As shown in Supplemental Table 4, there are no differences in observable characteristics between country samples with and without these data fields. We present in Table 1 the distribution of illness episodes and selected social characteristics. Approximately 50% of the included households reported no episodes of illness, whereas 39% reported 1 episode and 11.5% reported 2 episodes during the 2-week period preceding the survey. There were also significant differences in social variables (including car and telephone ownership and indicators of maternal education) between the households reporting 0, 1, or 2 illness episodes. We present in Table 2 the adolescent school attendance data, illness episodes, and vaccination coverage for each country included in the analyses. During the study period, 67.1% of all adolescent boys and 61.2% of all adolescent girls were in school. By country income group, the gender gap in adolescent education was 8.4% in low-income countries, 3.6% in lower-middle–income countries, and 2.0% in upper-middle–income countries. Over time, the gap decreased from 6.7% between 1999 and 2005 to 4.2% between 2006 and 2013 (however, the set of countries analyzed differed between the early and later time periods).

We find a significant gender gap in education between adolescent boys and girls when there are sick children at home (Fig 2). When no young children are ill, adolescent girls are on average 5.08% less likely to attend school than adolescent boys within the same household (95% confidence interval [CI], 5.50%–4.65%). This gap increases in magnitude to 7.77% (95% CI, 7.30%–8.24%) if the household reports 1 illness episode among children <5 years old and 8.53% (95% CI, 9.32%–7.74%) if there are ≥2 illness episodes.

In households where mothers are working, girls are 6.1% less likely to attend school than older boys within the same household (95% CI, 6.69%–5.60%); Fig 3). This gap increases in magnitude to 8.7% (95% CI, 9.27%–8.08%) if the household reports 1 illness episode and 10.06% (95% CI, 11.06%–9.05%) if there are ≥2 illness episodes. Comparable estimates for households in which the mother does not work outside the home are 3.13% (95% CI, 3.84%–2.42%), 6.21% (95% CI, 6.98%–5.44%), and 6.03% (95% CI, 7.30%–4.76%), respectively.

In our analysis of vaccination rates relative to the education gap, we found a statistically significant and strong negative correlation between the vaccination rates of children <5 years old and the gender gap in education (eg, the higher the vaccination rate, the smaller the

TABLE 2 Survey Characteristics

Country	Year	Girls		Boys		Households				Vaccinated	Completeness
		N	In School (%)	*N*	In School (%)	*N*	Ill <5 Yr Old Children			(%)	(%)
							0 (%)	1 (%)	2+ (%)		
Armenia	2000	69	0.87	65	0.846	55	0.709	0.291	0	71.4	100
Benin	2006	1830	0.544	2003	0.699	1322	0.577	0.351	0.072	47.1	99.4
Bolivia	2003	1367	0.5	1375	0.517	1077	0.521	0.391	0.088	50.4	99.7
Bolivia	2008	1019	0.839	1061	0.88	829	0.559	0.375	0.066	76.7	100
Burkina Faso	2003	2155	0.227	2431	0.3	1441	0.42	0.477	0.103	43.9	99.7
Cambodia	2000	1306	0.501	1287	0.656	1010	0.598	0.353	0.049	39.9	99.7
Cameroon	2004	1394	0.742	1435	0.842	938	0.452	0.431	0.117	48.2	99.5
Chad	2004	774	0.469	851	0.644	554	0.433	0.457	0.11	11.3	98.7
Colombia	2000	1683	0.769	1717	0.738	1319	0.556	0.377	0.067	62.4	99.9
Colombia	2004	407	0.73	411	0.723	322	0.584	0.376	0.04	63.9	99.8
Colombia	2009	1924	0.836	1899	0.83	1511	0.541	0.396	0.062	67.7	99
Congo	2005	820	0.843	858	0.88	593	0.558	0.39	0.052	52.1	99.7
Dominican Republic	2002	1081	0.907	1119	0.884	869	0.631	0.299	0.07	34.9	99.3
Dominican Republic	2007	1060	0.885	1079	0.87	863	0.672	0.294	0.034	58	97.5
Egypt	2000	1906	0.633	1921	0.79	1389	0.665	0.289	0.047	92.2	100
Ethiopia	2000	1367	0.342	1404	0.501	1094	0.536	0.374	0.09	14.3	100
Ghana	2003	485	0.647	532	0.714	384	0.625	0.336	0.039	69.4	99.9
Guinea	2005	981	0.499	1076	0.667	697	0.534	0.396	0.07	37.2	99.5
Haiti	2000	916	0.728	951	0.766	706	0.367	0.459	0.174	33.5	97
Honduras	2011	1906	0.491	1965	0.43	1438	0.531	0.392	0.076	84.5	99.8
Kenya	2003	738	0.767	785	0.857	570	0.43	0.446	0.125	51.8	99.5
Lesotho	2004	750	0.829	742	0.686	599	0.646	0.326	0.028	67.8	99.7
Liberia	2013	886	0.885	929	0.919	701	0.494	0.427	0.08	54.8	93.8
Madagascar	2003	607	0.601	641	0.647	468	0.675	0.278	0.047	52.9	99.6
Malawi	2000	1486	0.812	1536	0.838	1174	0.386	0.51	0.104	70.1	99.7
Malawi	2004	833	0.794	843	0.826	652	0.403	0.491	0.106	64.4	99.8
Mali	2001	4603	0.288	4683	0.403	986	0.124	0.489	0.387	28.7	99.5
Mali	2006	1485	0.415	1538	0.521	1045	0.654	0.271	0.076	48.2	99.3
Morocco	2003	1109	0.484	1125	0.636	841	0.653	0.303	0.044	89.1	99.9
Mozambique	2003	1364	0.718	1392	0.802	1017	0.559	0.383	0.057	63.3	99.7
Namibia	2000	710	0.872	709	0.869	498	0.592	0.355	0.052	64.8	99
Nepal	2001	848	0.459	798	0.709	646	0.455	0.454	0.091	65.6	100
Nicaragua	2001	1440	0.605	1455	0.553	1027	0.579	0.333	0.088	70.1	99.8
Niger	2006	1325	0.362	1393	0.462	922	0.47	0.407	0.124	29	98.7
Nigeria	2003	687	0.683	751	0.724	517	0.47	0.42	0.11	12.9	99.8
Peru	2000	1939	0.793	1974	0.849	1565	0.546	0.38	0.074	64	99.8
Peru	2003	2207	0.838	2260	0.86	1819	0.549	0.409	0.042	64.7	99.8
Philippines	2003	980	0.835	999	0.74	756	0.591	0.335	0.074	69.8	99.8
Rwanda	2000	1207	0.308	1189	0.304	907	0.526	0.385	0.089	76	99.7
Rwanda	2005	1015	0.718	1030	0.75	818	0.601	0.308	0.09	75.2	99.6
Senegal	2005	3052	0.48	3170	0.54	1799	0.403	0.473	0.124	58.7	99.4
Tanzania	2004	1282	0.708	1290	0.745	952	0.575	0.334	0.091	71.1	99.7
Tanzania	2009	1263	0.714	1240	0.76	933	0.663	0.284	0.053	75.2	99.3
Turkey	2003	557	0.442	545	0.772	396	0.389	0.46	0.152	45.7	99.9
Uganda	2000	978	0.849	998	0.88	689	0.447	0.389	0.164	36.7	99.6
Zambia	2001	951	0.685	1003	0.763	716	0.397	0.486	0.117	70	99.4
Zimbabwe	1999	755	0.783	743	0.816	535	0.609	0.338	0.052	64	99.9

gender gap in education; correlation coefficient = 0.34, $P = .02$; Fig 4). The adolescent gender gap in education approaches zero with coverage rates exceeding ~70% for all 8 vaccines. We performed several specification checks to ensure that our results are robust. These include varying the age of the included older children, using alternative educational outcomes, and splitting the sample by rural and urban location. We describe these supplementary changes in detail. In Supplemental Fig 5, we varied the age thresholds for older children in the following different ways: 10 to 16, 10 to 17, 10 to 18, 11 to 16, 12 to 16, 12 to 17, and 12 to 18. Our results are not sensitive to varying the thresholds.

The association between maternal work location and the gender gap related to illness episodes is driven by the low-income countries in our sample (correlation coefficient = 0.48, $P = .02$), which are far below middle-income countries in average vaccination coverage; in middle-income countries, the gender gap is narrow irrespective of the

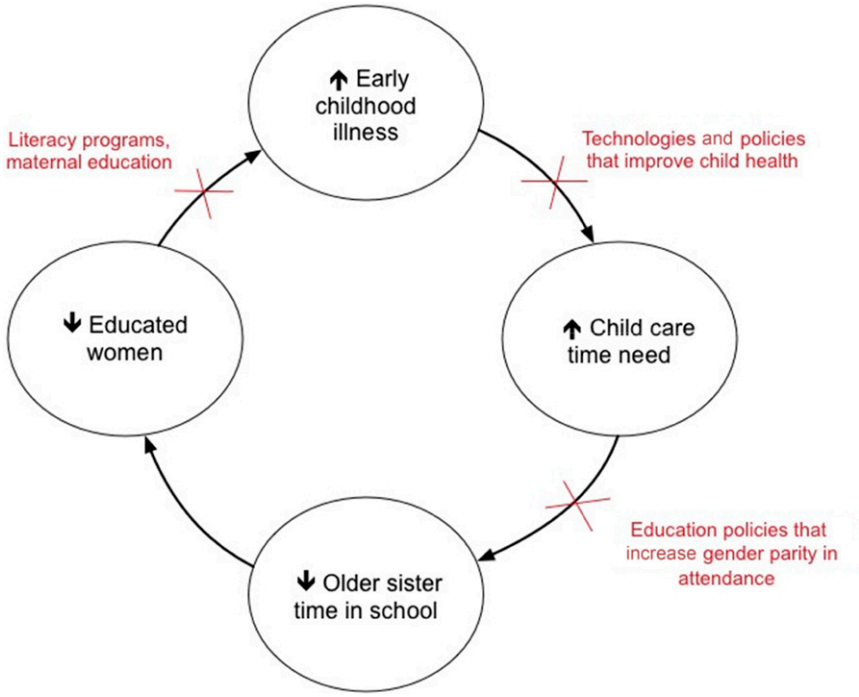

FIGURE 1
Proposed mechanism linking childhood illness to gender gap in secondary education. The figure depicts the conceptual relationship between early childhood illness, the adolescent gender gap in schooling, and long-run health and socioeconomic outcomes. The diagram depicts a vicious cycle of gender inequality that can be broken at various points by interventions.

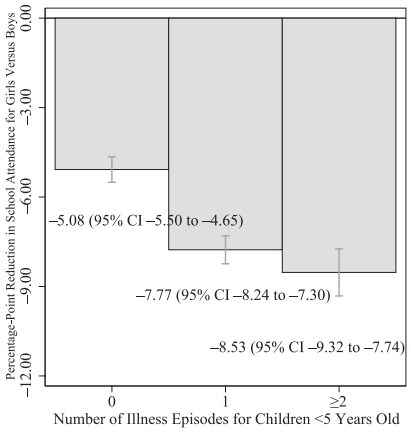

FIGURE 2
The gender gap in education of older siblings as a function of illness episodes of children <5 years old in the household. The average marginal effect (eg, percentage point reduction in school attendance for girls versus boys) and a 95% CI are shown on the graph. The leftmost column depicts and reports the effect of a gender gap in education if there were no children <5 years old with illness episodes in the last 2 weeks reported by the household. The middle column depicts the same for households that have 1 illness episode in the preceding 2 weeks, and the rightmost column presents the estimate for those households with ≥2 illness episodes.

vaccination rate, with vaccination rates unrelated to the gender gap in education (correlation coefficient = 0.10, $P = .66$; see Supplemental Fig 6 for detailed presentation of this analysis). In addition, the gradients in illness episodes and educational gender gaps were comparable in urban and rural settings (see Supplemental Fig 7 for detailed presentation of this analysis). We also found that in households that had only older boy children (11–17 years old), there was no educational gap between older and younger boy children (Supplemental Fig 9). Finally, we explored the role of birth order in influencing the gender gap findings. By interacting the gender of the child, the number of illnesses, and an indicator for being the oldest sibling, we found that the oldest sibling is less likely to be in school when compared with younger siblings, and this gap is greater if the older siblings are girls. There is no gradient with increasing illnesses

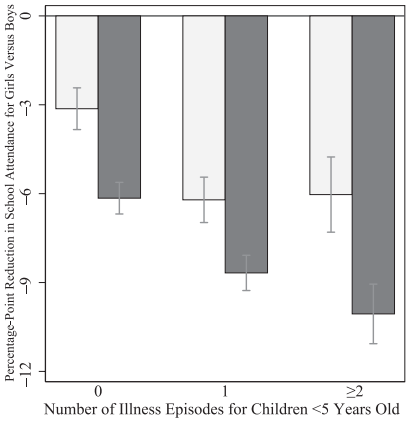

FIGURE 3
The gender gap in education of older siblings as a function of illness episodes of children <5 years old in the household by maternal labor force participation. The figure depicts the gender gap in education as a function of children <5 years old with illness. The dark bars represent the results of the average marginal effect for households whose mothers work outside the home, and the lighter bars represent the effect for mothers who do not work outside the home. The leftmost column depicts and reports the effect of a gender gap in education if there were no children <5 years old with illness episodes in the last 2 weeks reported by the household. The middle column depicts the same for households that have 1 illness episode in the preceding 2 weeks, and the rightmost column presents the estimate for those households with ≥2 illness episodes.

for boys irrespective of birth order (Supplemental Table 3). Our analyses that used alternative educational variables, such as whether the child attended any school in the past year or the number of years of education, did not alter the findings (see Supplemental Fig 8 for detailed presentation of this analysis).

DISCUSSION

Our findings in this study suggest that adolescent girls' schooling is sensitive to the health of younger children in the household. Adolescent girls were found to be less likely to attend school than adolescent boys in the same household, and that this gender gap was exacerbated by the domestic demands associated with illness among young children in the household. However, the impact of young child illness on school

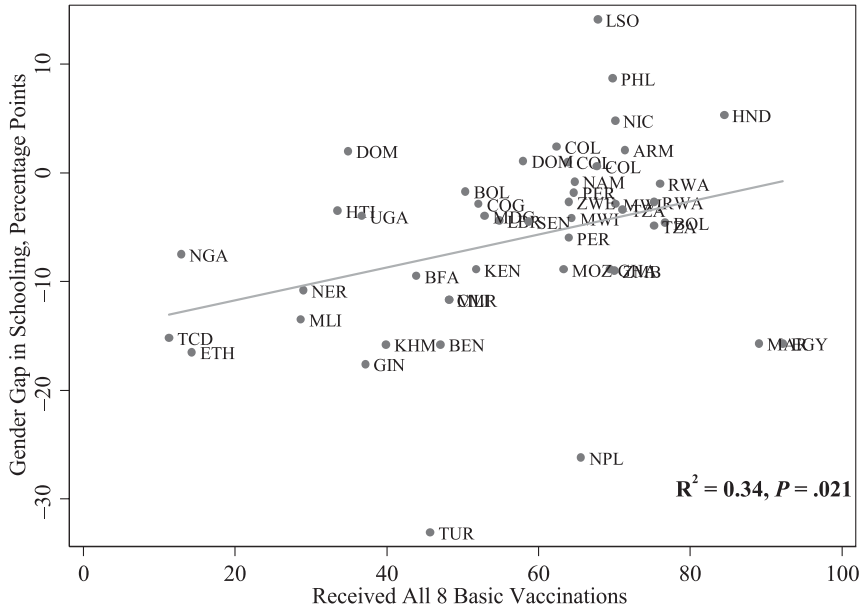

FIGURE 4

Country-level gender gap and vaccination rates. The figure demonstrates the correlation between the gender gap in adolescent schooling in response to households with children <5 years old with illness at the country-level and the receipt of all 8 basic vaccinations. The adolescent education gender gap is derived by using a fixed-effects estimator as described in the text.

attendance was not observed in households with only adolescent boys. These effects were substantial and suggest that the gender gap in adolescent school attendance increased by >50% when young children in the household became ill. The estimates are even larger when mothers worked outside the home. These results were generally supported by our findings that education gender gaps were smaller in countries with relatively high vaccination rates, which may be associated with lower young child illness. This result was strongest in low-income countries and is consistent with the suggestion that in such settings, the opportunities associated with the education of girls are likely to compete with gender-specific, domestic roles of adolescent girls.

A strength of our analysis is that we examined within-household differences in education attendance in the presence of young child illness, which mitigates concerns associated with the nonrandom allocation of child illness across households. Any analysis relating childhood illnesses to education patterns must account for the likelihood that the household burden of childhood disease will be related to how the education of adolescent girls is valued or the material resources available to support it. The scale and comprehensive nature of the DHS permitted the analysis of gender gaps within households, an approach that diminishes the potential for confounding by unobservable household factors.

Our findings emphasize the complex determinants of the gender gap in adolescent school attendance.[8,13] That episodes of young child illness in the household can affect adolescent girl education participation suggest that policies directed at enhancing girl's education should address not only the availability of educational opportunities but also the prevalence of competing domestic tasks that fall more heavily on girls. Policies that strengthen family and community support for challenges such as sick child care will likely prove essential, particularly as women move increasingly into the work force outside the home.

There are several limitations to our analysis. The household-level analysis used only illnesses reported over the 2 weeks preceding the survey. This focus on this recent period reduces recall bias but may lead to an underestimate of the overall effect of illness on the adolescent gender gap in education. In addition, our sample necessarily includes households with at least 3 children, which may not fully reflect the experiences of households with fewer children, although fertility rates are generally >3 in low-income countries.[18] Although the models employed in this study remove many confounding factors, there may remain unobserved variables that are related to adverse child health events that interact with older sibling gender. However, similar results have been replicated by using natural experiments that impact child health, such as national immunization campaigns.[11] Researchers for future studies should attempt to disentangle when girls are the most vulnerable and what potential policies are most effective at assisting parents in educating their daughters. These policies may vary by local context depending, for example, on local labor markets and educational infrastructure. In addition, the country-level regressions associating the gender gap in education with vaccination rates should be interpreted cautiously because they cannot document causality; other social determinants across countries could be driving both higher vaccination rates and a lower children <5 years old illness-associated gender gap in education.

Our analysis suggests that gender-based household tasks represent an important and underrecognized driver of the gap in schooling between adolescent boys and girls. This finding was based on the analysis of comprehensive surveys conducted in a variety of low- and middle-income settings and is consistent with observational studies demonstrating that girls are preferentially tasked

to care for young children.[11,12] Given the long-term benefits of secondary schooling for women's health and economic outcomes, our study underscores the potential societal returns of policies that improve child health and support the ability of low-income families to meet the dual challenges of early child-rearing and sustained, high-quality adolescent education for girls in complex and highly dynamic societies.

ACKNOWLEDGMENTS

We thank Sarah Henry at Stanford University for her critical review of a draft of the manuscript.

ABBREVIATIONS

SDG: sustainable development goal
LMIC: low- and middle-income countries
DHS: Demographic and Health Surveys
CI: confidence interval

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: This work was supported in part by grant funding from the US National Institutes of Health Eunice Kennedy Shriver National Institute of Child Health and Human Development (1K01HD084709-01; PI Alsan) as well as from the Doris Duke Charitable Foundation (Bendavid) and Centre on the Demography and Economics of Health and Aging (Bendavid). Funded by the National Institutes of Health (NIH).

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

COMPANION PAPER: A companion to this article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2017-1322.

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Pediatrics 2017;140;
DOI: 10.1542/peds.2016-3175 originally published online June 26, 2017;

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