Explaining the Education-Health Gradient in Preventing STIs in Andean Peru: Cognitive Executive Functioning, Awareness and Health Knowledge

CONTEXT: *Little is known about the pathways mediating the relationship between education and health. It is widely assumed that formal schooling leads to awareness of health risks (e.g., STIs) and, in turn, to adoption of preventive behavior (e.g., condom use); however, evidence supporting this mechanism has been limited.*

METHODS: *Survey data were collected in 2010 from a sample of 247 adults aged 30–62 living in an isolated Andean district of Peru; these individuals had widely varying exposure to schooling, and their community had recently experienced elevated risks of STIs. Structural equation modeling was used to estimate the degree to which schooling is associated with cognitive resources, STI awareness and sexual health knowledge, and how these jointly are associated with ever-use of condoms.*

RESULTS: *Thirty-two percent of respondents reported ever-use of condoms. One additional year of schooling was associated with a 2.7-percentage-point increase in the probability of condom use, after adjustment for covariates. The pathway between education and condom use was mediated by cognitive executive functioning (CEF) skills (0.26 standard deviations), STI awareness (0.09) and sexual health knowledge (0.10); CEF skills were associated with condom use both directly and indirectly, through STI awareness and sexual health knowledge, and accounted for two-thirds of the education–condom use gradient.*

CONCLUSIONS: *The relationship between education and STI prevention may be more complex than is often assumed and is mediated by CEF skills, STI awareness and sexual health knowledge. Studies should examine whether STI prevention interventions are more effective if they enhance cognitive skills used to translate information into protective behaviors.*

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Formal educational attainment has so frequently been shown to be independently and positively associated with health and longevity that researchers often refer to it simply as the "education-health gradient."[1–6] Moreover, education plays a major role in a person's health and is now considered a central social determinant of health disparities, in line with the epidemiologic "fundamental cause of disease theory."[7,8] This theory posits that social characteristics act to put individuals at increased or reduced risk of proximate biological causes of many diseases and are thus responsible for health disparities within populations. This is also true for social disparities in sexual and reproductive health: Greater educational attainment is associated with a reduced risk of contracting STIs, as well as more effective contraceptive practices, and better maternal and child health outcomes.[9–12]

Evidence about the education-health gradient in general, and about its relationship with sexual health specifically, comes chiefly from analyses of large probability samples responding to demographic and epidemiologic surveys.[13] While this suggests that the education-health gradient can be generalized to health outcomes across many nations, cultures and subpopulations, such surveys at best include only partial measurement of possible intervening factors. As a result, little is known about the mechanisms that underlie the education-health gradient.[2,4,5,14,15] Given this gap in the literature, an important next step is to identify the resources that education provides and how those resources lead to preventive behavior.

The main pathway from formal education to health is often assumed to be through awareness of health risks and disease prevention, with individuals attaining such awareness through basic literacy and numeracy skills, along with information learned from health curricula.[16,17] While schooling does promote gains in literacy and numeracy, emerging findings indicate that it also enhances generalizable cognitive functioning, known as cognitive executive functioning (CEF) skills—that is, mental resources for planning, organization, working memory, integration of experience, spatial reasoning, unique problem solving, decision making and goal-directed behavior.[18,19] At the same time, considerable psychological research has shown that awareness of health risks is necessary but not sufficient for prevention: Adequate underlying cognitive functioning is required if people are to turn awareness into deeper understanding—actual health knowledge—about a risk or disease, and make good decisions and adopt effective behavior.[20–23]

Taken together, these findings lead to a hypothesis that the pathway from education to improved health includes not only information resources about the risks associated with unsafe practices, but also improved cognitive skills that can yield health knowledge and effective preventive behavior. A supporting hypothesis is that educationally enhanced cognitive functioning is the central factor in this pathway, as it is also needed to acquire both awareness and accurate health knowledge. While this hypothesis of a broader, more complex pathway involving education and general cognitive functioning has received some empirical support,[15,24] it has never been applied to the gradient of education in STI prevention, nor has it been supported by data on awareness and health knowledge.

To test this hypothesis, we analyzed survey data gathered from adults living in Carhuaz, an isolated Andean district of Peru. This sample is unique in that the individuals live in an environment in which the risk of STIs is relatively new and increasing, and where public health workers have made some attempts to increase awareness of risks in local communities; in addition, educational attainment varies extensively, yet postschooling employment does not. These characteristics offer a rare opportunity to study an increasing health risk and its possible prevention, ensuring enough variation for these indicators, as well as reducing potential sources of endogeneity associated with educational attainment. Because study subjects participated in lengthy in-field interviews and cognitive testing, we were able to collect information on a number of factors along the hypothesized pathway behind the education–STI prevention gradient. In addition, our use of a series of structural equation models enabled us to examine the direct and indirect associations between education and condom use, through the mediation of three resources: cognitive functioning, STI awareness and sexual health knowledge. Finally, we were able to assess four possible sources of endogeneity and, thus, test the robustness of our results.

Conceptual and Empirical Considerations

• *Education and CEF.* Substantial evidence exists that exposure to formal schooling enhances generalizable cognitive functioning, which is widely hypothesized to be the foundation for reasoning ability applied in novel contexts and for effective decision making.[25–27] A review of approximately 30 empirical cognitive and neurodevelopmental studies indicates that exposure to routine schooling activities significantly enhances metacognitive skills and their supporting neurological infrastructure.[19] A study employing neuroimaging and a field study found that regional brain activation of the substrate responsible for CEF skills can be shaped by common learning activities in school and that variable exposure to schooling is associated with differences in these skills in adulthood.[18]

Previous research has found substantial effect sizes between various educationally enhanced cognitive skills and overall health. For example, in a comprehensive analysis of health behavior and safety measures (e.g., smoking, drinking, overeating, and automobile and household safety) in the United States and the United Kingdom, Cutler and Lleras-Muney[28] estimated that cognitive ability and knowledge account for 30% of the education–health behavior gradient, while material status and psychological resources account for 20% and 12%, respectively. Furthermore, analyses of data from the British Cohort Study showed that education accounts for as much as 50% of the variance in self-reported poor health and that the education gradient may be steeper among individuals with higher cognitive abilities.[29,30] In another cohort study, after childhood cognitive abilities were taken into account, those in the top quartile of academic performance experienced a slightly higher mean score on a measure of general health and developed fewer chronic conditions (e.g., asthma, emphysema, cancer) on average than did those in the lowest quartile.[15] Lastly, an experimental intervention to improve numeracy had a positive effect on future healthy behaviors among college students, and higher objective numeracy (i.e., the ability to understand and use mathematical concepts) and other CEF skills were positively associated with STI prevention.[31–34]

• *Education, awareness and health knowledge.* It is well-established that gaining an accurate awareness of health risks is the first step in forming effective strategies to prevent risk-taking and avoid negative consequences; formal schooling increases one's ability to do this.[35–37] Furthermore, as a new health risk becomes more prevalent in everyday environments, people need to move beyond awareness to a deeper understanding of the risk if they are to initiate effective prevention.[24,31] For example, in Sub-Saharan African populations, when AIDS was widely evident and feared, young women who were aware of HIV but did not accurately understand its transmission mechanism continued participating in high-risk sexual behaviors.[38]

In addition to awareness, by enhancing CEF skills, formal education may affect an individual's ability to interpret basic information that they have received and, thus, help them develop more accurate and complex knowledge about the physical causes of and prevention methods for new risks and diseases.[39–41] When a new health risk appears and awareness of it grows, a mix of incomplete, inconsistent and inaccurate information often circulates; enhanced CEF skills may help people better evaluate information and then draw conclusions about the implications for their specific circumstances. More educated individuals (even those with only a few more years of schooling) are the first to comprehend and benefit from new and even incomplete information about health risks emerging from behavior once assumed to be safe.[10] For instance, among adolescents in the United States[42] and Kenya,[43] those holding more advanced (as opposed to more naive) knowledge about the biology of HIV transmission tended to reject myths and misunderstandings about the disease. Other research has shown that individuals without schooling

and with less enhanced CEF skills are less able to integrate otherwise correct partial information into an accurate understanding to guide their behavior: For example, one study conducted in Ghana found that uneducated adults stated that HIV could be transmitted through blood transfusion and separately understood that condom use could prevent transmission; however, they then indicated that the risk from transfusion was mitigated if a condom was used.[24] Lastly, without estimation of an antecedent education effect, a study of U.S. youth found an association between higher CEF skills and superior reasoning about such prevention information as antismoking messages.[44]

Examining STIs and Education in Andean Peru

We selected Carhuaz—located in the highlands of the Peruvian Andes, about 34 kilometers from the city of Huaraz, the capital of the Ancash region—as the setting for this study, because data from a sample of adults from this district were well-suited to examine the hypothesized pathway from education to health preventive behavior, through CEF skills, STI awareness and sexual health knowledge. First, the risk of HIV and other STIs (e.g., gonorrhea, syphilis, genital herpes) has grown in the local adult population since the late 1990s,[45] due to a mixture of traditional sexual practices (e.g., unprotected sex and men's having multiple female sex partners[46]) and the temporary in-migration of young male miners from urban areas with greater STI prevalence rates. Among the population of the Ancash region, STI prevalence increased from eight per 1,000 in 2002 to 12 per 1,000 in 2011.[47] Also, before the data used in this study were collected, initiatives conducted by the government and by international organizations had already raised public awareness about STIs and their possible prevention in this region, and had provided funds to strengthen school-based interventions and AIDS programs in the general population.[16,17,48] A prominent example was the 2004 National Antiretroviral Treatment Program, which promoted information campaigns to raise awareness about HIV transmission mechanisms and reduce stigma associated with HIV (along with providing free access to antiretroviral therapy).[49] These conditions ensured considerable variation among participants in preventive behavior and accurate understandings of STI prevention.

Second, adults from Andean communities such as Carhuaz vary substantially in their exposure to formal schooling. While access to formal schooling has increased in the region in recent generations, it is not universal: In 2007, the primary school enrollment rate was about 85%.[45] Also, as the study subjects were mostly subsistence farmers, there was relatively little variance in early childhood family environments, postschooling work experiences, economic status and access to health care, which all help to reduce potential sources of endogeneity. Both the spreading STI risk and the uneven educational attainment among residents make this a prime region for the study of the pathways underlying the education–condom use gradient.

Furthermore, although STIs are a major health challenge in Peru as a whole, studies on their prevention have mostly been conducted in urban areas. Despite the prevalence of risky practices, such as unprotected sex, and a recent trend of growing risk of STIs in rural communities, particularly in the Andean region, research in rural settings has been limited.[45,50,51] Thus, there is significant need to understand sexual risk practices and prevention strategies in these communities.

METHODS

Sample

We used a two-stage stratified sampling procedure to select a sample from among the adult population of Carhuaz. First, to construct a community-level sampling frame, Peru's 2007 national census was used to identify all small, traditional agrarian communities in the district; out of these, we selected 14 communities that had both the highest within-community variation in exposure to schooling (measured as the standard deviation of years of educational attainment among residents), and at least 50% of residents living and working on subsistence-level farms. Second, we conducted a door-to-door survey stratified by educational attainment in each household to recruit one or more participants per household who were aged 30–65, had no mental or physical disorder requiring regular or frequent medication and had no indications of past neurological trauma. We targeted participants of this age to increase the variance in educational attainment. Data collection was conducted after institutional review board protocol approval (IRB#24840), and informed written consent was obtained before each interview. All participants received a modest amount of household items and groceries in compensation for their time; in addition, the study organizers purchased new curricular materials for primary schools in each selected community.

Acceptance of invitations to participate was nearly universal, which resulted in a sample of 247 adults with a wide range of school attainment, including unschooled individuals, from communities of mostly farmers.

Data Collection

Participants completed questionnaires that asked about their individual, household and community characteristics; they also completed a panel of CEF tests. To ensure that the language used in the survey questions was accurate and relevant, two months before data collection, we conducted a pilot study consisting of a focus group discussion among residents of communities similar to the study communities, and another among knowledgeable bilingual (Spanish and Quechua) school teachers from Carhuaz. Through a process of discussion and consensus, all terms about STIs, health knowledge and condoms in the local vernacular language were adjusted for both accuracy and sensitivity to local cultural attitudes and values. Our research partners in Carhuaz—who had extensive prior field experience in the area—then back-translated these

local terms to confirm accuracy. For adaptation and validation, all CEF instruments were similarly translated from English to Spanish and then to the local Quechuan dialect. The instruments were then independently back-translated to confirm accuracy and pretested on individuals similar to the subjects of the main study to assess the clarity of the instructions. For validation, test scores obtained from the pilot study were analyzed to compare them with distributions and intercorrelations from reported U.S. samples, and were found to be consistent.

For the main study, we selected six local schoolteachers proficient in Spanish and Quechua, and who had previous experience in fieldwork, to be trained to conduct interviews and administer the CEF tests. Over the course of a week, they received an in-depth explanation of the study and demonstrations of interviewing, followed by practice and debriefings; they also had the opportunity to assist in the formulation of the final questions and instrument instructions.

All interviews were conducted in January and February 2010 as one-on-one sessions at the subjects' homes or at a local school. Except for a section of the Tower Test (see below) that required participants to organize wooden blocks, instruments were provided in paper form and read to subjects; once a questionnaire had been completed, a unique identification number was assigned to each participant to ensure confidentiality and anonymity. Given the rhythms of subsistence-level farming and comparatively relaxed daily demands on subjects' time, the questionnaires were completed over the course of two 2–3-hour sessions on separate days. Scoring of the CEF instruments was completed by the interviewers under supervision of study staff who had prior training on each instrument.

Measures

The outcome measure for this study was the preventive behavior of condom use. Participants were asked the yes-or-no question, "Have you ever used a condom during sexual relations?" Independent variables included those related to STI awareness, sexual health knowledge, education and CEF skills, as well as control measures.

• *STI awareness.* Participants were asked if they had heard of any of the following seven STIs: chlamydia, gonorrhea, herpes, HIV, hepatitis B, syphilis and HPV. STI awareness was a binary variable coded as 1 if participants were aware of at least one of the infections and 0 if not.

• *Sexual health knowledge.* To gauge participants' knowledge of sexual health, we presented them with 10 behavior items and asked whether each behavior protects against STIs. Examples include "Do not share food with people who have STIs," "Use a condom whenever you have sex" and "Avoid sexual relations with people that have many sexual partners." Sexual health knowledge was measured as the total number of correct answers.

• *Years of schooling.* We included a continuous variable measuring the number of years of formal schooling attained by participants.

• *CEF skills.* Participants were tested on seven widely used instruments to measure different CEF skills.[18,20,24] Verbal associative fluency was measured using the Controlled Oral Word Association Test (COWAT), in which participants are tasked to name as many words as possible belonging to a common category; the score is the total number of words produced.[52] Working memory was measured with the Backward Digit Span task, in which participants repeated back progressively longer strings of digits in the reverse order of presentation; the score is the number of correct responses, and the range is 0 to 10.[53] The Tower Test from the Delis-Kaplan Executive Function System measured abstract thinking, problem solving, planning, impulse control and concept formation, by tasking the participant to move wooden disks that vary in size across three pegs to match a displayed tower in the fewest possible valid moves; the score is the number of correct towers formed, and the range is 0–9.[54] Raven's Colored Progressive Matrices test, which measures both visual perception and reasoning ability, asks the participant to select the appropriate choice to match the missing part of an incomplete figure; the total score is the average of four subtests with 12 items each, resulting in a score range of 0–12.[55] Numeracy (i.e., math calculations such as addition, subtraction, multiplication and division) was measured using the first 18 items of the Woodcock–Johnson III Calculation test; the score is the total number of correct responses and ranges from 0 to 18.[56] The Peabody Picture Vocabulary Test (PPVT) measured receptive vocabulary by asking participants to point to the picture that best corresponds to a given word. The score is determined by adding the number of correct responses between the base (i.e., the lowest set of items administered containing one or no errors) and ceiling (i.e., the highest set of items administered containing eight or more errors) to the base score; the range is 0–125. Finally, decision-making ability was assessed with the Stickman test, in which participants are shown illustrations of various hypothetical scenarios and asked to indicate the one in which it would be most likely that the first person they met would be HIV-positive. For example, in a relatively simple scenario that presented two villages of equal size, the number of red stickmen (representing HIV-positive individuals) and black stickmen (HIV-negative individuals) differed; in six noncongruent scenarios, the villages were of different sizes, and the larger village had a larger number but a smaller proportion of red stickmen, thus corresponding to a lower risk. The score is determined by the number of correct responses to noncongruent scenarios; the range is 0–6.[24]

• *Control variables.* As is standard in research on disease awareness, health knowledge and health protective behavior,[46,57] control variables at the individual and family levels included sex, age (continuous) and area of residence (village or town, or other). In addition, we included a wealth index (standardized composite score with a mean of 1 and a standard deviation of 0) constructed on the basis of materials used for housing construction; types of

water access and sanitation facilities; and ownership of 11 assets, including a refrigerator, computer, television and bicycle. Correlations between variables included in the models are presented in Appendix Table 1.

Analysis

We conducted four structural equation models using logistic regression analysis for binary outcomes to estimate the direct and indirect associations between schooling and condom use, as mediated by CEF skills, STI awareness and sexual health knowledge. A combination of factor analysis and path analysis, structural equation modeling is appropriate for testing the proposed models because it can simultaneously estimate a measurement model of the multiple CEF skills, and a structural model to evaluate how CEF skills, STI awareness and sexual health knowledge mediate the hypothesized pathway from years of schooling to condom use.[58,59]

In our first specification (Model A), we estimated the direct association between years of schooling and condom use controlling for demographic and socioeconomic variables. Next, we estimated the degree to which multiple indicators of a participant's CEF skills mediate the relationship between education and condom use (Model B). We then examined the degree to which CEF skills, STI awareness and sexual health knowledge simultaneously mediate the education–condom use gradient (Model C). Finally, we estimated the association between educationally enhanced CEF skills and condom use through STI awareness and sexual health knowledge (Model D).

The root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis index (TLI) were used to assess the fit of the models to the observed data. RMSEA represents closeness of fit; values of less than 0.05 indicate very good fit, while values between 0.05 and 0.08 indicate reasonably good fit. CFI and TLI provide a measure of incremental fit compared with a null model. For both indices, a value of 0.90 is minimally acceptable, and values closer to 1.00 are indicative of excellent fit.

All analyses were performed with Mplus version 6.1. Standard errors were adjusted to account for possible clustering of observations at the community level, which was the primary sampling unit in the study. It was not feasible to implement a community fixed-effects specification because of the small number of observations.

Although all models controlled for several noneducational variables (i.e., gender, age, area of residence, wealth and community clusters), education was not randomly assigned to subjects, and other unobserved factors may have simultaneously affected the variables of interest. Thus, we performed robustness tests to address four particularly important endogeneity concerns that could bias estimates. First, individuals with greater CEF skills may be more likely to attain greater levels of education. This is particularly important in agrarian communities, since parents may balance decisions about educational investments with needs for their children to contribute to farming and household work. To assess this source of bias, we evaluated whether including participants' reasons for attending or not attending school significantly changed our results. Second, the type and content of jobs may affect skills related to cognitive functioning.[60] Therefore, we included participants' occupation as a control in our analysis. Third, since other family characteristics—such as parental education—may also simultaneously affect participants' educational attainment, CEF skills and health knowledge,[61] we tested whether including parental education in the analysis changed our main results. Finally, condom use may depend on marital status, as married participants may be systematically less likely to use condoms during sexual intercourse with their partner;[62] therefore, we evaluated whether results differed after married participants were excluded from the analysis.

RESULTS

Descriptive Statistics

Forty-nine percent of the sample was male, and 60% lived in a village or town (Table 1). On average, respondents were 46 years old and had seven years of schooling; 16% had never attended school (not shown). Nearly one-third (31%; Table 1) reported ever having used a condom during sexual relations. Sixty-one percent of respondents were aware of at least one of the seven STIs; however, on average, sexual health knowledge was low (mean score, 3.6).

TABLE 1. Selected characteristics of adult survey participants, Carhuaz District, Peru, 2010

Characteristic	%/mean (SD) (n=247)
PERCENTAGES	
Male	49
Resident of village/town	59
Ever used a condom	31
Aware of ≥1 STI	61
MEANS	
Age (range, 30.6–61.8)	45.62 (8.73)
Years of education (range, 0–18)	7.30 (5.03)
Standardized wealth index score (range, –2.41 to 2.87)	1.00 (0.00)
Sexual health knowledge score (range, 0–10)	3.62 (3.17)
Cognitive executive functioning scores	
COWAT (range, 6–31)	16.58 (4.79)
Backwards Digit Span (range, 0–10)	3.36 (2.08)
Tower Test (range, 1–9)	3.60 (1.91)
Raven's Matrices (range, 0–12)	7.33 (2.93)
Woodcock–Johnson III Calculation (range, 0–18)	13.35 (4.74)
PPVT (range, 11–125)	87.77 (23.00)
Stickman (range, 0–18)	2.37 (1.58)

Notes: SD=standard deviation. The standardized wealth index score is a composite score constructed on the basis of materials used for housing construction; types of water access and sanitation facilities; and assets ownership. Controlled Oral Word Association Test (COWAT) measures verbal associative fluency. Backwards Digit Span task measures working memory. Tower Test measures abstract thinking, problem solving, planning, impulse control and concept formation. Raven's Colored Progressive Matrices test measures both visual perception and reasoning ability. Woodcock–Johnson III Calculation test measures numeracy. Peabody Picture Vocabulary Test (PPVT) measures receptive vocabulary. Stickman test measures decision-making ability.

Structural Equation Models

In Model A, which estimated the pathway between education and ever-use of condoms without hypothesized mediating factors, an additional year of schooling was associated with an increase in the likelihood of condom use by a coefficient of 0.38—interpretable as an effect size of 0.38 of the standard deviation in condom use (Figure 1). Put another way, each additional year of education was associated with a 2.7-percentage-point increase in the probability of condom use.

Model B incorporates CEF skills' partial mediation of the association between years of schooling and condom use (Figure 2). Although still significant, the coefficient for the direct pathway from years of education to condom use decreased by 68%, to 0.12. In addition, the indirect pathway between education and condom use via CEF skills was significant (coefficient, 0.26).*

In Model C, which includes STI awareness and sexual health knowledge as additional potential mediators, the estimated direct pathway between education and condom use was nonsignificant, indicating that CEF skills, STI awareness and sexual health knowledge mediated this association (Figure 3). The strongest mediation ran through CEF skills, with a coefficient of 0.26; in comparison, the pathways via STI awareness and sexual health knowledge had coefficients of 0.09 and 0.10, respectively. Unlike those for the previous model, the goodness-of-fit statistics for Model C reflect a rather poor fit to the data. Although RMSEA was within accepted limits for reasonably good fit, the CFI and TLI values were below 0.90, which indicate a poor-fitting model.

Finally, Model D examined the degree to which educationally enhanced CEF skills facilitate the acquisition of STI awareness and sexual health knowledge, and lead to the use of condoms (Figure 4). In this model, the associations between education and both STI awareness and sexual health knowledge were partially mediated by CEF skills. Although still significant, the coefficient for the direct pathway from years of education to STI awareness decreased by 40% (to 0.31, from 0.51 in Model C), and the coefficient for the direct pathway from education and sexual health knowledge decreased by 60% (to 0.18, from 0.46). Furthermore, the direct association between educationally enhanced CEF skills and condom use was partially mediated by awareness (0.03) and health knowledge (0.04), although the difference between these two mediation paths was not statistically significant. In other words, educationally enhanced CEF skills were not only directly associated with more condom use, these skills also were associated with the prevention behavior through their association with both greater STI awareness and more accurate sexual health knowledge. Adding these paths also resulted in a better fitting model: RMSEA was less than 0.05, and the CFI and TLI values above or only slightly below 0.90.

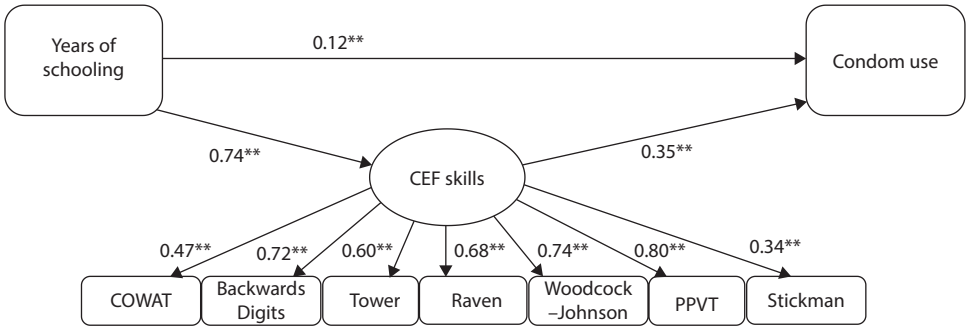
Robustness Tests

We analyzed four possible sources of endogeneity. First, individuals with greater cognitive talent may have been selected by families to receive more education. However, when participants in our sample were asked why they had

FIGURE 1. Results of structural equation model estimating the direct association between education and condom use, controlling for background factors (Model A)

**p<.01. *Notes:* Fit indexes: pseudo R^2=0.30. Analysis controls for gender, age, area of residence, wealth index score and community clusters. Coefficient is standardized.

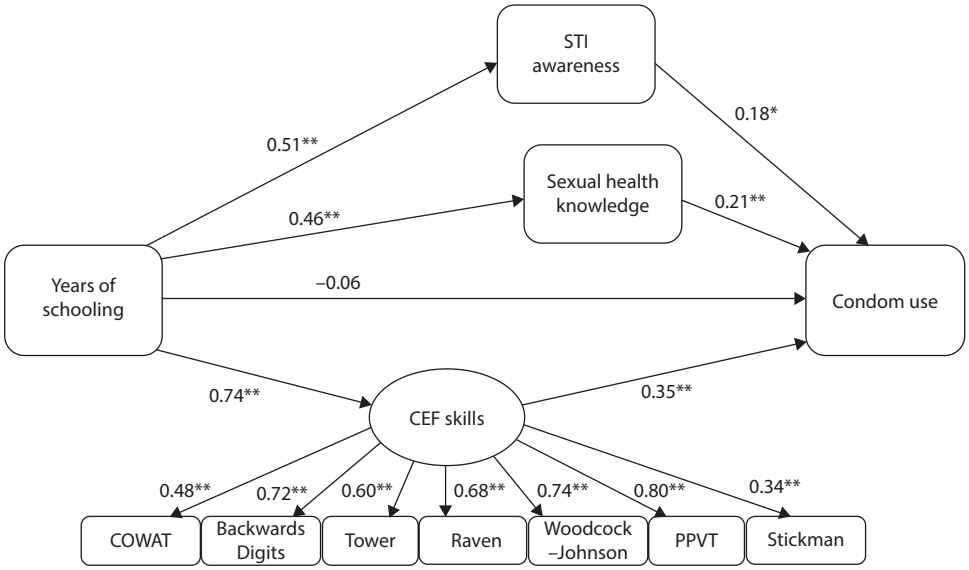
***FIGURE 2. Results of structural equation model estimating the direct association between education and condom use, and the indirect association through cognitive executive functioning skills* (Model B)**



*p<.05. **p<.01. *Notes:* Fit indexes: RMSEA=0.042; CFI=0.920; TLI=0.891. Analysis controls for gender, age, area of residence, wealth index score and community clusters. All coefficients are standardized. CEF=cognitive executive functioning. For purpose of individual CEF skills tests, see Table 1.

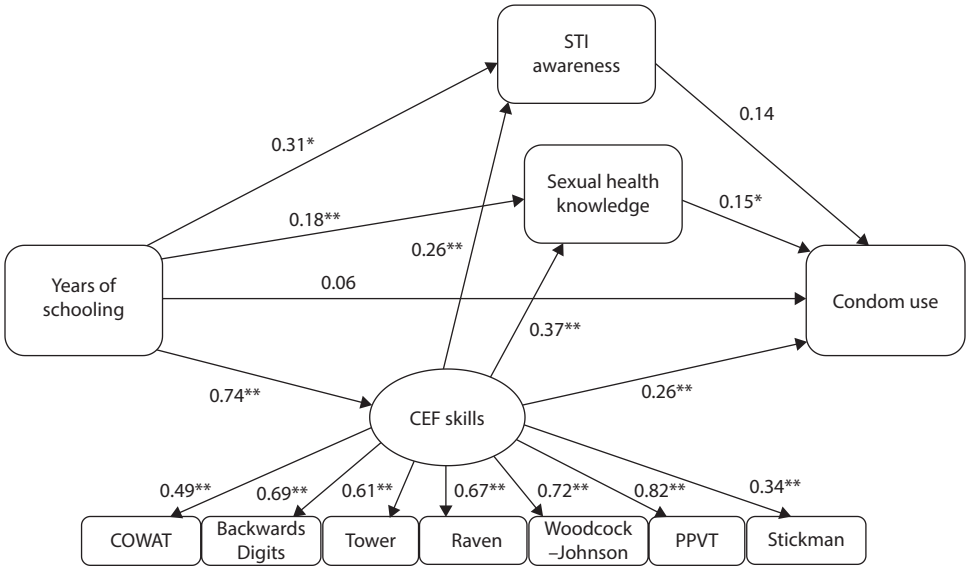
*The coefficient for an indirect pathway is calculated by multiplying the coefficients for its components.

FIGURE 3. Results of structural equation model estimating the direct association between education and condom use, and indirect associations through cognitive executive functioning skills, STI awareness and sexual health knowledge (Model C)



*p<.05. **p<.01. *Notes:* Fit indexes: RMSEA=0.071; CFI=0.752; TLI=0.638. Analysis controls for gender, age, area of residence, wealth index score and community clusters. All coefficients are standardized. CEF=cognitive executive functioning. For purpose of individual CEF skills tests, see Table 1.

FIGURE 4. Results of structural equation model estimating direct associations between education and condom use, STI awareness and sexual health knowledge, and the indirect associations through cognitive executive functioning skills (Model D)



*p<.05. **p<.01. *Notes:* Fit indexes: RMSEA=0.044; CFI=0.906; TLI=0.860. Analysis controls for gender, age, area of residence, wealth index score and community clusters. All coefficients are standardized. CEF=cognitive executive functioning. For purpose of individual CEF skills tests, see Table 1.

attended or not attended school, most reported reasons related to noncognitive factors, such as access to schooling, economic problems at home or parental health problems. To assess this source of bias, all of these reasons for not having attended school were coded and included as control variables. After we reestimated the model, our main results remained unchanged. (See Appendix Table 2 for coding and results.) Furthermore, when participants were young, school attendance was not mandatory in these communities, so social stigma for low attendance or nonattendance was unlikely.

Second, exposure to certain occupational activities after finishing school may have affected the development of CEF skills, so that exposure to schooling was not the necessary component. However, this explanation is unlikely in the present sample, because participants' jobs varied little in their cognitive demands (around 35% of the sample were farm workers, 25% small vendors, 20% administrative employees and 20% other occupations). When we reestimated the model to control for participants' occupation, the primary results remained, although the coefficient for the association between years of schooling and CEF skills was slightly larger.

Third, certain family characteristics—in particular, parental education—may have affected our variables of interest. However, most participants' parents did not receive formal schooling when they were of school age (unschooled fathers and mothers accounted for 45% and 70%, respectively, in our sample). Thus, it is unlikely that parental education played a major role in the results. Nonetheless, to assess this source of endogeneity, we coded participants' parental education level and included it as a control variable in the analysis. After reestimating the model, we found no significant change in the coefficients, except for a smaller coefficient for the association between years of schooling and CEF skills.

Finally, marital status might have been correlated with the likelihood of condom use. However, that was not the case in this sample, as condom use during sexual intercourse was reported only slightly less often among married participants than among unmarried participants (30% vs. 32%). To examine whether marital status might have biased the results, we excluded married participants, who accounted for 55% of the sample; following reestimation of the model, the main results remained.

DISCUSSION

Our results show that attainment of formal education is associated with condom use in the context of a rising risk of STIs in rural Andean communities with many subsistence-level farmers, net of individual demographic, socioeconomic and geographic factors. A 2.7-percentage-point increase in the probability of condom use for each additional year of schooling is consistent with prior findings about the education-STI gradient and gradients with other health risks in different settings.[5,39,41] Our findings also demonstrate that along with awareness, the pathway from education to the prevention of STIs through condom use included cognition and accurate knowledge about risks and prevention. This is particularly the case for educationally enhanced CEF skills, which accounted for (mediated) more than two-thirds of the education-STI gradient in these data. Furthermore, the findings indicate that education's association with CEF skills centrally underlay the gradient, as these skills not only were directly associated with prevention behavior, but also with increased awareness and knowledge, which are themselves associated with condom use.

Additionally, our results about specific parts of the hypothesized pathway are consistent with prior research, and the unique data set adds new findings to this literature. Various past experiments support the hypothesis that the learning process in school enhances underlying general cognitive functioning. Although it has a substantial genetic component, general intelligence is significantly influenced by such environmental factors as schooling, even beyond early ages.[19] It is likely that as a result of exposure to schooling, more-educated individuals are able to apply cognition to new risks and prevention behaviors over the course of their lives. Similarly, the finding that educationally enhanced CEF helps individuals become aware of recent elevation in their STI risk, and become more knowledgeable about risks and prevention, is in line with results from studies of decision-making and problem-solving behavior, as well as with accumulating research on the dynamic relationship among education, cognitive functioning and health knowledge.[3,23,35]

These new results are timely in several ways. First, there is mounting evidence of an education gradient in sexual and reproductive health that is in line with the increasing reporting of education gradients for many health risks and disease.[63–65] Second, relatively unfamiliar STIs were rapidly introduced into this region, in part from an expanding mining industry's employment of young males from the capital, where STIs are more prevalent, and sexual practices did not usually include the use of condoms, particularly for the prevention of vaguely understood STIs.[46,66] Therefore, the increased risk of STIs in this region and its substantial variation in exposure to formal schooling would make education a major contributor to health disparities in sexual and reproductive health, similar to earlier cases of HIV infection in some nations of Sub-Saharan Africa.[67,68]

Limitations

Certain limitations must be considered when evaluating these results. First, the data are taken from one point in time; thus, conclusions about causal direction may not be warranted. Despite the robustness tests and the evidence supporting the mechanism proposed to explain how years of schooling affect condom use, other preexisting differences among participants that were not considered might have affected both education and STI prevention behavior. Second, our outcome variable was ever-use of a condom during sexual relations, as this was the only STI prevention behavior measure available in the data. Thus, it is possible, although unlikely, that participants had used condoms before they completed their schooling or before they learned about the new rising risk of STIs in their communities. It is also possible that some use of condoms was for birth control, although the survey did not inquire about birth control methods. Third, the participants' age-range was wide, from 30 to 62 years, and while our analyses controlled for age, the modest sample size does not permit separate analysis by birth cohorts.

CONCLUSIONS

While several community interventions, school-based programs and efforts to include health risk information in the Peruvian school curriculum may have successfully increased the ability of individuals to remember basic facts and prevention strategies about STIs, our results support the importance of policies that improve school access and attendance. Although providing a primary education and at least some secondary schooling—taught by professionally trained teachers with suitable curricular materials—to all children is an expensive undertaking, particularly among relatively isolated Peruvian Andeans, its potential

lasting impact on cognitive functioning—and thus the ability to understand and prevent STIs and other health risks—is a major benefit.

Finally, although the pattern of associations among education, CEF skills, STI awareness, sexual health knowledge and condom use is encouraging, additional investigation of specific causal mechanisms underlying schooling and cognitive processes will enrich this line of research on the education-health gradient.[69,70]

Future work should explore what it is about education-enhanced CEF skills that enables individuals to translate health knowledge into protective behaviors. In addition, research should examine pathways across different stages of a population's exposure to new risks of STIs. Finally, previous research in Peru and in similar contexts suggests that the association between education and health is not homogenous across regions and communities.[71,72] Future research should consider how geographic, environmental and contextual differences may affect individual-level factors such as education, CEF skills and health-related outcomes; such work may yield new insights into the effects of education and help guide the formulation of effective and equitable public policy on sexual and reproductive health.

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RESUMEN

Contexto: *Se sabe poco acerca de las vías que median la relación entre el nivel educativo y la salud. Generalmente se supone que la escolaridad formal conduce a la conciencia de los riesgos para la salud (por ejemplo, las ITS) y, a su vez, a la adopción de un comportamiento preventivo (por ejemplo, el uso del condón); sin embargo, la evidencia que apoya este mecanismo ha sido limitada.*

Métodos: *Los datos de la encuesta se obtuvieron en 2010 de una muestra de 247 adultos de 30 a 62 años que vivían en un distrito andino aislado de Perú; estas personas tenían una exposición muy variable a la escolaridad y su comunidad había experimentado recientemente riesgos elevados de ITS. Se usó el modelo de ecuaciones estructurales para estimar el grado en que la escolaridad se asociaba con los recursos cognitivos, la conciencia de las ITS y el conocimiento de la salud sexual y cómo estos se asocian conjuntamente con el haber usado alguna vez condones.*

Resultados: *El treinta y dos por ciento de los encuestados informaron que alguna vez usaron condones. Un año adicional de escolaridad se asoció con un aumento de 2.7 puntos porcentuales en la probabilidad de uso del condón, después del ajuste por covariables. La vía entre el nivel educativo y el uso del condón estuvo mediada por las habilidades de funcionamiento cognitivo ejecutivo (FCE) (0.26 desviaciones estándar), conciencia de las ITS (0.09) y conocimiento de salud sexual (0.10); Las habilidades de FCE se asociaron con el uso del condón tanto directa como indirectamente, a través de la conciencia de las ITS y los conocimientos sobre salud sexual y representaron dos tercios del gradiente educativo del uso del condón.*

Conclusiones: *La relación entre el nivel educativo y la prevención de las ITS podría ser más compleja de lo que a menudo se supone y está mediada por las habilidades de FCE, la conciencia de las ITS y el conocimiento de la salud sexual. Los estudios deben examinar si las intervenciones de prevención de ITS son más efectivas si mejoran las habilidades cognitivas utilizadas para traducir la información en comportamientos protectores.*

RÉSUMÉ

Contexte: *Les voies de médiation de la relation entre l'éducation et la santé ne sont guère documentées. Il est généralement présumé que la scolarité mène à la conscience des risques de santé (par ex., les IST), qui conduit à son tour à l'adoption d'un comportement préventif (par ex., l'utilisation du préservatif). Les données qui appuient ce mécanisme sont cependant limitées.*

Méthodes: *Des données d'enquête ont été collectées en 2010 auprès d'un échantillon de 247 adultes de 30 à 62 ans vivant dans un district andin isolé du Pérou. Ces personnes présentaient une exposition fort variable à la scolarité et leur communauté était depuis peu confrontée à un risque élevé d'IST. La modélisation par équation structurelle a permis d'estimer le degré d'association entre, d'une part, la scolarité et, d'autre part, les ressources cognitives, la conscience des IST et la connaissance en matière de santé sexuelle, ainsi que de déterminer l'association globale de ces éléments avec le fait d'avoir déjà utilisé le préservatif.*

Résultats: *Trente-deux pour cent des répondants ont déclaré avoir utilisé le préservatif. Chaque année supplémentaire de scolarité s'est avérée associée à une augmentation de 2,7 points de pourcentage de la probabilité d'usage du préservatif, sous correction des covariables. Le lien entre l'éducation et l'utilisation du préservatif était induit par les compétences de fonctionnement exécutif cognitif (FEC) (écarts types de 0,26), la conscience des IST (0,09) et la connaissance en matière de santé sexuelle (0,10). Les compétences FEC étaient associées à l'utilisation du préservatif de façon directe et indirecte, du fait de la conscience des IST et de la connaissance en matière de santé sexuelle; elles représentaient deux tiers du gradient éducation-utilisation du préservatif.*

Conclusions: *La relation entre l'éducation et la prévention des IST peut être plus complexe qu'on ne le pense souvent. Elle est induite par les compétences FEC, la conscience des IST et la connaissance en matière de santé sexuelle. Il serait utile d'examiner si les interventions de prévention des IST sont plus efficaces quand elles améliorent les compétences cognitives qui traduisent l'information en comportements de protection.*

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Appendix Table 1. Simple correlations among variables included in the models

Variable	Years of schooling	Cognitive executive functioning tests							STI awareness	Sexual health knowledge	Condom use	Demographic controls		
		COWAT	Backwards Digits	Tower	Raven	Woodcock–Johnson	PPVT	Stickman				Age	Male	Village/town
COWAT	0.44*	1.00												
Backwards Digits	0.58*	0.35*	1.00											
Tower	0.25*	0.25*	0.38*	1.00										
Raven	0.56*	0.37*	0.48*	0.30*	1.00									
Woodcock–Johnson	0.70*	0.34*	0.56*	0.31*	0.54*	1.00								
PPVT	0.77*	0.46*	0.53*	0.30*	0.62*	0.64*	1.00							
Stickman	0.18*	0.23*	0.18*	0.14*	0.21*	0.25*	0.22*	1.00						
STI awareness	0.65*	0.34*	0.43*	0.25*	0.41*	0.51*	0.61*	0.16*	1.00					
Sexual health knowledge	0.58*	0.31*	0.44*	0.28*	0.39*	0.48*	0.59*	0.09	0.85*	1.00				
Condom use	0.46*	0.20*	0.39*	0.18*	0.37*	0.39*	0.41*	0.10	0.41*	0.42*	1.00			
Age	–0.14*	–0.02	–0.17*	–0.18*	–0.19*	–0.09	–0.03	–0.07	–0.09	–0.11	–0.26*	1.00		
Male	0.05	0.02	0.04	0.05	0.14*	0.09	0.09	0.05	0.06	0.06	0.12	0.06	1.00	
Village/town	0.49*	0.22*	0.33*	0.08	0.36*	0.36*	0.48*	0.09	0.53*	0.49*	0.37*	–0.00	0.01	1.00
Wealth index score	0.62*	0.32*	0.36*	0.16*	0.42*	0.43*	0.59*	0.20*	0.49*	0.46*	0.37*	0.01	–0.01	0.65*

*p<.05.

Appendix Table 2. Robustness tests

Test	CEF skills	STI awareness	Sexual health knowledge	Condom use
Model D (for comparison)				
Years of schooling	0.74 (0.05)**	0.31 (0.15)*	0.18 (0.07)**	0.06 (0.09)
CEF skills		0.26 (0.06)**	0.37 (0.05)**	0.26 (0.05)**
STI awareness				0.14 (0.09)
Sexual health knowledge				0.15 (0.07)*
RT1: Reasons for not attending school				
Years of schooling	0.75 (0.04)**	0.30 (0.18)†	0.16 (0.09)†	0.10 (0.07)
CEF skills		0.28 (0.07)**	0.39 (0.06)**	0.29 (0.05)**
STI awareness				0.11 (0.08)
Sexual health knowledge				0.12 (0.05)*
RT2: Occupation categories				
Years of schooling	0.80 (0.05)**	0.31 (0.14)*	0.31 (0.05)**	–0.01 (0.07)
CEF skills		0.30 (0.06)**	0.24 (0.04)**	0.27 (0.04)**
STI awareness				0.14 (0.06)*
Sexual health knowledge				0.18 (0.06)**
RT3: Parental education				
Years of schooling	0.71 (0.06)**	0.32 (0.15)*	0.17 (0.08)*	0.04 (0.10)
CEF skills		0.26 (0.07)**	0.38 (0.05)**	0.28 (0.04)**
STI awareness				0.14 (0.09)
Sexual health knowledge				0.15 (0.08)†
RT4: Only nonmarried persons				
Years of schooling	0.71 (0.04)	0.33 (0.16)*	0.22 (0.09)*	0.13 (0.16)
CEF skills		0.20 (0.11)†	0.36 (0.10)**	0.07 (0.16)
STI awareness				0.17 (0.08)*
Sexual health knowledge				0.26 (0.04)**

*p<.05. **p<.01. †p<.10. *Notes:* In addition to the variable specified in each robustness test, all models control for gender, age, area of residence, wealth index score and community clusters. Reasons for not attending school were no institution in area, need to work outside home, need to work at home, not interested, and economic and health problems. Occupation categories were unemployed, military/police, farming/fishing, services (nonqualified), services (qualified), industry/construction, technician and professional. Parental education levels were none, preschool, primary, secondary and postsecondary. Coefficients are standardized. Standard errors are in parentheses. CEF=cognitive executive functioning.