Education and health outcomes: Three papers examining the influence of education on HIV for young adults in low- and middle- income settings

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Abstract

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Introduction

Nearly 37 million people are living with HIV and there are an estimated 2.1 million new HIV infections each year, equating to 5,700 new infections per day[1]. Approximately half of new HIV infections occur in Eastern and Southern Africa[2]. Young people are at particularly high risk of HIV; 35% of new infections are among young people ages 15-24 years[2]. In sub-Saharan Africa, 25% of new infections are among young women[2]. Throughout the course of the HIV epidemic, research has described the associations between social structural and behavioral determinants of HIV acquisition. The influences of socioeconomic status, household characteristics, gender, geographical residence, and risky sexual behaviors on HIV acquisition are well reviewed in the literature[3-7]. Evidence on the impact of education on factors that influence HIV acquisition is less robust and associations have changed over time as both education and the HIV epidemic have evolved[8,9].

Globally, access to education and educational attainment has increased over the past several decades[10]. In developing countries, the number of years enrolled in school for both men and women has significantly increased[10]. The impact of increased educational attainment has contributed to reductions in child mortality, improvements in reproductive health, and reduced HIV transmission[10-14]. In many countries, the gap in education between men and women has reversed, with women now achieving higher levels of educational attainment than men[10]. However, in several low and middle income countries, gender disparities persist[10]. Global public health, development, and policy communities recognize the importance of education and its influence on health outcomes. Over the past decade, education has been highlighted in the Millennium Development Goals (MDG) and now is continuing as a priority for the Sustainable Development Goals (SDG) in the post 2015-agenda. The goal of MDG 2 was to achieve universal primary

education for all children; building on this goal, SDG 4 focuses on quality education, ensuring inclusive and equitable education and promoting lifelong learning opportunities for all[21,22].

The goal of this dissertation is to highlight the importance of education by summarizing the current state of literature that reviews associations between education and HIV infection for adolescents in low- and middle- income countries and illuminating the key entry points for research, policy, and programming by examining the relationship of education on determinants of HIV infection for young people. This dissertation accomplishes the stated goal by: (1) Systematically reviewing associations between education and HIV infection for youth ages 13 – 24 years living in low- and middle- income countries (*Chapter 1*); (2) Examining the relationship between educational attainment on HIV acquisition for young adults ages 20 – 24 years in Rakai, Uganda (*Chapter 2*); and (3) Commenting on the pathways to HIV acquisition and identifying key entry points and best practices in policy and research to promote improved health outcomes for adolescents (*Chapter 3*). This dissertation is guided by both the proximate determinants of health framework as described in Chapter 2 and the socio-ecological theory adapted from the Bronfenbrenner Model as presented in Chapter 3. This dissertation adds to both the field of HIV and education research by synthesizing the literature that currently exists, illustrating the influence of education on known determinants of HIV acquisition, and concluding with actionable research and policy recommendations to continue progress toward educational attainment and improving health outcomes.

Chapter 1: A systematic review of associations between education and HIV infection for young people living in low- and middle- income countries

A systematic review summarizes publications that analyze the association between education and HIV for young people living in low- and middle- income countries. Twenty-two articles include over 315,000 participants from 18 countries. While over half of the articles included in this review indicate that higher education is associated with lower rates of HIV sero-positivity, there is still significant variability in the findings. Two studies indicate that those with higher education have an increased risk of HIV; four studies show no association between education and HIV; and five studies result in mixed conclusions based on gender and age or grade level. Key conclusions from this review echo previous systematic reviews. Dates of data collection influence the conclusion of published studies. In this review, articles that show that

those with more education had a lower HIV prevalence were more likely to have data collected after the year 2000. Although articles from 2007 – 2017 are eligible to be included in this review, the most recent publications identified are from 2015 and the most recent data are from 2013. More updated data collection and publications on the association between education and HIV are needed to continue to improve this field of study. This review highlights the importance of continuing research on the association between education and HIV in low- and middle- income countries to support continued progress toward MDG 2 and SDG 4. Not only is it imperative to study the relationship and magnitude of the association in a variety of settings and populations, but also to gain a better understanding of how and why education influences HIV for young people. This review provides sufficient evidence to show that education does have an impact on HIV and can be used to improve policies and programs to improve school enrollment, attendance, attainment, and the quality of education in low- and middle- income countries for all young people.

Chapter 2: Educational attainment and HIV risk among young adults in Rakai, Uganda, 1996 - 2013

In Uganda, school enrollment rose steadily from 1994 to 2013 among adolescents, due largely in part to changes in national policy. Increasing school enrollment in Uganda was associated with a declining risk for HIV and pregnancy among young people ages 15 – 19 years. Data from the Rakai Community Cohort Study (RCCS) were used to examine the association between educational attainment and proximate risk factors of HIV infection for young adults' ages 20 – 24 years. Results showed that educational attainment was protective against several risk factors for HIV. Compared to those with no education, females with at least a secondary education were less likely to have their first sexual encounter before the age of 18. Compared to those with no education, females with higher educational attainment (attending primary school, secondary school, or beyond secondary school) were more likely to use family planning methods and had fewer sexual partners. Educational attainment was also correlated with riskier behaviors. Females with higher education were more likely to report inconsistent condom use, concurrent sexual partners, and were less likely to know the HIV status of their partners. Similar results were seen in males. Compared to those with no education, males with any education were more likely to use family planning methods. Compared to those with no education, males with higher education (attending primary school, secondary school, or beyond secondary school) were more likely to report concurrent sexual partners.

Educational attainment was not significantly associated with HIV incidence in males or females. The association between educational attainment and risk factors for HIV acquisition are varied. Higher educational attainment is associated with delayed initiation of sexual activity and use of family planning methods; however, it is also associated with inconsistent condom use and more concurrent sexual partners. In an era of enhanced focus on education and educational attainment, this data helps explain how schooling can impact the risk behaviors that influence the HIV epidemic in young people. When developing sexual education in the future, researchers, program, and policy developers should utilize these findings to ensure curricula focus on consistent condom use, concurrent partners, and the importance of HIV disclosure. This study also highlights gaps in the current literature – future research questions should more closely examine the quality and content of education, as well as determining the role that education plays in exerting autonomy over behavior and behavior change.

Chapter 3: The unclear pathway from educational attainment, risk behavior, and HIV

The HIV/AIDS epidemic and access to education have seen parallel improvements in recent decades. Nearly 40 years into the HIV/AIDS epidemic, there have been tremendous gains in care, treatment, and prevention of HIV. Yet, the epidemic still impacts millions of people worldwide. Similarly, access to education has improved for many throughout the twentieth and twenty-first centuries, although major disparities and gaps remain. The importance of education for health and development is highlighted by the United Nations (UN) in the Millennium Development Goal campaign (MDG, 2000 – 2015) and in the Sustainable Development Goals effort (SDG, 2015 – 2030)[21,22]. The UN calls for universal primary education (MDG 2) and inclusive and quality education for all (SDG 4)[21,22]. In the current post-2015 agenda focusing on eliminating disparities and improving quality in education, now is a pivotal time to review what is known and what remains to be discovered about the relationship between educational attainment and the HIV/AIDS epidemic, two driving domains in policy and program planning. More updated data and research needs to be conducted in a variety of diverse settings in order to understand how education can influence the HIV epidemic in the current environment. Moreover, researchers should ensure that they are looking at the entire context of education and desegregating educational attainment from socioeconomic status measured using alternative measures to better target key entry points for change. Policy makers can utilize this research to evaluate existing policies and implement new polices

as needed. The failure to meet the MDG 2 of universal primary education indicates that much work still remains in the policy and program implementation realms of education enrollment and attainment. Beyond primary education, a renewed focus on secondary education, quality education, and gender equality will maximize the benefits of education.

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Table of Contents

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1 A systematic review of associations between education and HIV infection for young people living in low- and middle- income countries

1.1 Background

Approximately 36.7 million people live with HIV worldwide. An estimated 2.1 million new HIV infections occur each year[1], half of which are in Eastern and Southern Africa[2]. Young people are at particularly high risk of HIV; 35% of new infections are among young people ages 15-24 years[2]. In sub-Saharan Africa, 25% of new infections are in young women[2]. Research describes the associations between social structural and behavioral determinants of HIV acquisition; the influences of socioeconomic status, household characteristics, gender, geographical residence, and risky sexual behaviors on HIV acquisition are well reviewed in the literature[3-7].

Access to education and educational attainment has improved around the world[8]. In developing countries, the number of years enrolled in school for both men and women has significantly increased[8]. The impact of greater education contributes to reductions in child mortality and improvements in reproductive health[8-12]. Evidence on the association of education and HIV is less robust; the history of HIV risk and infection and its' relationship with education has changed as the HIV epidemic has changed. Education can significantly reduce vulnerability to HIV acquisition, particularly for vulnerable women. Better educated women are more likely to delay marriage and child bearing, have fewer children, earn better incomes and have greater decision making power within relationships[13]. Previous systematic reviews showed higher education associated with a higher risk of HIV infection in developing countries[14]. More recent literature shows that the association between school enrollment and HIV has shifted, with studies from the mid-to-late 1990's showing lower risk of HIV infection among the most educated[15].

The aim of this systematic review is to explore the association between education and risk of HIV infection for young people living in low- and middle- income countries. This review differs from the previous work in three meaningful ways. First, it updates previous reviews to include articles from the last decade, a time when many advances in education policy and HIV prevention, care and treatment have been implemented globally. Second, it expands the geographical focus beyond sub-Saharan Africa,

including articles from all low- and middle- income countries. Third, this review limits the population of interest to young people, a population most at risk of HIV globally.

1.2 Methods

Similar methods were used to approximate the search methodology of earlier reviews[14,15] with some slight modifications. This systematic review used a two-step search strategy. First, the biomedical databases EMBASE and PubMed were electronically searched using four search terms linked by 'AND' statements. Search terms included *(1) geographic and geo-political terms (Africa, Asia, South America, Caribbean, Central America, low income, middle income, low resource), (2) a term indicating HIV seroprevalence, prevalence, epidemiology, or risk, and (3) a term covering education, including 'litera*', 'school*', and 'educat*' and (4) a term that defines the age range, such as youth, young adult, adolescen**. Among articles identified for a full text review by the above methods, reference lists were reviewed to identify any further relevant references. This review does not include a meta-analysis because the study design, methodology, and reported outcomes from included studies are heterogeneous; thus it is more useful to summarize the body of evidence using a systematic review format.

To be eligible for inclusion in this review, articles had to be published between 2007 - 2017 and contain data or text that presented individually measured education status or educational attainment and HIV status in young people ages 13 – 24. The mean age of the population studied had to be 24 years or below to be included in this review. Studies of specific high-risk populations (i.e. commercial sex workers, injection drug users, men who have sex with men) were excluded from consideration. Variables of interest from selected articles included population, dates of data collection, levels of education compared, HIV status, and the results of the analyses comparing education and HIV status. To be included for review, HIV status could have been ascertained through biological testing and/or HIV status self-report. This systematic review followed the PRISMA guidelines for reporting a systematic review, illustrated in Figure 1[16]. Quality of included studies was assessed using the Newcastle-Ottawa Scale for cross-sectional, cohort, and case-control studies[17-19].

1.3 Results

Using the search methods described, a total of 4,996 articles were identified from electronic databases for title and abstract review (Figure 1). All eligible articles were published between January 2007 and May 2017. Duplicates were removed and a search of titles and abstracts excluded 4,910 publications. The main reasons for exclusion were because the publications did not meet the above stated eligibility criteria, the study population was a specific high risk population, publications focused on HIV-related health education programs and not the impact of general education, articles focused on HIV stigma as an outcome and not HIV epidemiology, and publications looked at the impact of education on proximate factors of HIV (i.e. sexual behavior), but did not measure HIV serostatus as an outcome. After reviewing titles and abstracts, 82 articles were chosen for full text review. Of the 82 articles, reference lists were reviewed and an additional 24 articles were identified and reviewed for eligibility. The main reasons for exclusion at this stage were that the mean age of the study population was above 24 years and the data were not analyzed for the age group of 13 – 24 years, the study did not have HIV prevalence or incidence as an outcome, and the study did not measure the association between individual education and HIV serostatus. Twenty-one articles were deemed eligible from the electronic database review and one article was identified through the reference list review for a total of 22 articles eligible to be included in this review; the details of these studies are described in Table 1.

The articles included in this review represent 18 different countries, the majority of which were located in sub-Saharan Africa. Although all articles were published between 2007 and 2017, the dates of data collection ranged from 1994 to 2013, covering a wide span of the HIV epidemic in the identified countries. There were over 315,000 participants included in the 22 published studies. Study subjects were derived from antenatal clinics (both pregnant and post-partum women receiving care), population-based surveys, and surveys specifically for young people and adolescents. All articles had a population with a mean age of 24 years or less. The included articles were evenly split between urban settings, rural settings, and a mix of both rural and urban. Most studies included in this review were cross-sectional studies, followed in frequency by cohort studies and case-control studies. Information on HIV serostatus was most commonly collected from a variety of assays and national algorithms, usually using at least one ELISA assay; dried blood spots and oral fluid were collected and analyzed. One study used HIV status self-report (Table 1).

Measurement of education and educational attainment varied based on country context. The majority of studies separated education into discrete categories (i.e., no education, primary education, secondary education, and higher education). Some studies used years of education and others dichotomized education (i.e., enrolled in school and not enrolled in school). Measurement of education and educational attainment was solely through self-report data.

Of the 22 included articles, 50% (11 articles) reported a negative association between education and HIV; participants with higher education had significantly lower rates of HIV prevalence and incidence compared to those with lower education[20-30]. Articles that found this negative correlation were more likely to have data collected after the year 2000 and to have restricted analysis to young people or adolescents. These articles were also more likely to have data collected through cross-sectional studies.

Two studies showed a statistically significant positive association between education and HIV; those with higher education had significantly higher rates of HIV. Both studies were from Zambia and collected longitudinal data beginning in the early to mid-1990s. One study from an urban city in Zambia found a significantly elevated risk of HIV among young women ages 15 – 19 who had higher education compared to those with lower education (aOR 1.45, 95% CI 1.0 – 2.1)[31]. The second population-based study of young people (ages 15 – 24) concluded that HIV prevalence was lower among less educated young women compared to those with more education[32]. Although this study found a positive correlation between years of education and HIV status, the authors also found that young women with more than seven years of education experienced a significant decline in HIV prevalence beginning in the mid to late-1990s.

Four articles found no statistically significant association between education and HIV. Data were collected from sub-Saharan African countries (Zimbabwe, Malawi, South Africa, and Mali) [33-36] and mainly between the years of 2000 and 2007. One study longitudinally reported data from 1997 – 2000[35]. Populations ranged from clients at antenatal clinics[34,35], population-based studies[33], and young people (self-selected)[36]; settings were evenly split between rural, urban, and mixed rural and urban areas.

Five articles reported mixed associations[37-41]. Mixed associations were indicated when the conclusion was split based on the methods used to stratify or analyze the data. In four of the five articles with mixed

associations, associations of education and HIV differed by gender. One study compared the association of HIV and education across countries and found that in some countries, HIV prevalence was higher amongst more educated women while in other countries, the opposite association was seen; in the same study, no association was found between education and HIV for men[38]. Other studies reported a significant protective association between education and HIV for male students, however the association between education and HIV for female students was not significant[40,41]. Two additional studies showed mixed associations based on age and grade level. De Neve et al. (2015) illustrated in a cross-sectional study that each additional year of schooling after 9 years was associated with a 3.6% lower risk of HIV infection; however the association between schooling and HIV risk was not significant in the lower grades[37]. The only study from Thailand also concluded with mixed results; the association between HIV and education was both positive and negative. Compared to those with secondary or some college education, those with only primary education were more likely to have HIV (aOR = 1.34, 1.10 – 1.62). In the same study, those with a college degree were more likely to have HIV compared to those with secondary or some college education (aOR = 1.42, 1.06 – 1.89)[39].

1.4 Discussion

The association between education and HIV has varied over time as the HIV epidemic and responses to the epidemic have changed[15]. Early in the HIV epidemic, HIV risk was linked to higher SES, travel, and increased schooling[38]. In 2002, a systematic review showed mixed results when looking at HIV acquisition and educational attainment[14]. In Africa, increased risk of HIV was seen in more educated people. Results from Thailand showed the opposite effect, where education was protective against HIV. In Africa, the association between higher education and HIV was stronger in rural areas and in older people but was similar in men and women[39]. An updated systematic review in 2008 revisited the association between educational attainment and risk of HIV infection changing over time in sub-Saharan Africa[15]. Results showed that in earlier data, there was either no association or the highest risk of HIV infection among the most educated[15]. From 1996 onward, studies found that the association reversed; those with the highest education had a lower risk of HIV infection. HIV prevalence fell consistently among highly educated groups compared to less educated groups whose HIV prevalence rose while the overall population prevalence was falling. Conclusions indicate that the new infections in the late 1990s and early

2000s were occurring disproportionately among the least educated people in sub-Saharan Africa, and that behavior change - safer sex behavior, delayed age at risk sex, reduced partner numbers - to reduce risk of HIV was greater among the most education.[15] Recent research contradicts long standing theories of social determinants of HIV infection, such as those presented in the 2008 systematic review; researchers identify a positive wealth gradient that highlights an inverse relationship between poverty (including education and educational attainment measures) and HIV[42].

This review summarizes publications that analyze the association between education and HIV for young people living in low- and middle- income countries. Twenty-two articles include over 315,000 participants from 18 countries. While over half of the articles included in this review indicate that higher education is associated with lower rates of HIV sero-positivity, there is still significant variability in the findings. Two studies indicate that those with higher education have an increased risk of HIV; four studies show no association between education and HIV; and five studies result in mixed conclusions based on gender and age or grade level.

Key conclusions from this review echo previous systematic reviews. Dates of data collection influence the conclusion of published studies, likely influenced by the changing demographics of the HIV/AIDS epidemic and the changing landscape of HIV prevention, care, and treatment over time. In this review, articles that show that those with more education had a lower HIV prevalence were more likely to have data collected after the year 2000; 8 of 11 studies that showed this association had data that were collected after the year 2000 and 3 additional studies were longitudinal. No study that collected data solely before the year 2000 showed that education had a protective relationship with HIV. Although articles from 2007 – 2017 were eligible to be included in this review, the most recent publications identified are from 2015 and the most recent data are from 2013. More updated data collection and high quality publications on the association between education and HIV are needed to continue to improve this field of study; adding to the body of evidence will both allow for trends to emerge over time and strengthen the ability to see associations between educational attainment, HIV, and other variables that have not yet been examined.

Mixed associations come from studies that report differing conclusions often based on gender. In one study, HIV prevalence was significantly higher amongst more education women, however no significant association was found for men[38]. Yet in other studies, a significant protective association was found between education and HIV for male students, but the association was not significant for women[40, 41]. No specific and consistent pattern emerged from the literature on the impact of gender on the association between educational attainment and HIV. Evidence shows that despite significant progress toward closing the gender gap in education in low- and middle- income countries, gender disparities remain a challenge, particularly in sub-Saharan Africa, South Asia, and the Middle East[43]. Approximately 15 million primary school age girls are out of school compared to 10 million boys. Over half of these girls (9 million), live in sub-Saharan Africa[44]. The studies included in this review highlight differences in associations between education and HIV based on gender, indicating that gender not only plays an important role in determining educational attainment, but also in the relationship between educational attainment and risk factors for HIV infection.

There are several limitations in the body of evidence. For those population-based studies, response rate may impact response bias for participants. For those studies that specifically target subjects within clinics or other settings, results may be biased given that researchers are targeting populations already using services and engaged in care. Demographics and behaviors may be significantly different between clients using services and those who are not using services. Other limitations are inherent in study designs. Cross sectional studies are limited in the ability to determine behavior over time and establish causation; any association between education and HIV can only be attributed to one point in time and one cannot show a temporal relationship between education and HIV. While this review expands the focus to all low- and middle- income countries, the overwhelming majority of studies are from sub-Saharan Africa, making a regional comparison of associations impossible. Studies that are not from sub-Saharan African countries are from India, Haiti, and Thailand. More geographical diversity in publications will enhance the literature in this field.

This review also has several strengths. First, this review approximates the methods of earlier systematic reviews; these methods ensure comprehensive and unbiased sampling of existing literature regarding the association between education and HIV. In addition to including more recently published literature, this

review also focuses on young people, who are most at risk for HIV and are frequently targeted for policies, research, and programs to enhance education and prevent HIV. Moreover, young people are more recently exposed to education compared to an older cohort of participants; therefore, the effect of education on HIV may be more apparent in this population.

This review utilized the Newcastle-Ottawa Scale for quality assessment of cross-sectional, cohort, and case-control studies[17-19] (Table 3). A system of points was allocated under the domains of selection, comparability, and outcomes for each study based on designated criteria. In each domain, one star indicates whether a designated criteria was present in the evidence; in some domains, two stars are used to designate that more than one criteria were present, thus representing the highest quality of evidence in that domain. Using these criteria, the majority of studies were of fair quality – seven cross-sectional studies, two cohort studies, and two case-control studies. Approximately thirty percent of studies were of high quality, including four cross-sectional studies and three cohort studies. One cross-sectional study was designated as poor quality. Of the seven high-quality studies, four showed that those with more education were significantly less likely to have HIV and three studies showed mixed results with associations varying be gender and/or country. Across all of the studies, the strongest quality category was the assessment of the outcome variable; all but one study used verified biological testing to determine HIV status in participants and all statistical tests were clearly described, justified, and presented. The weakest quality measure was selection of participants; several cross-sectional and cohort studies sampled from a selected group of users not deemed representative of the target population and the majority of cross-sectional studies did not compare the characteristics of the respondents vs. non-respondents, which may imply a self-selection bias. All studies used subjective measures of self-reporting to determine educational attainment and some studies did not control for adequate confounding variables. The overall quality of the included systematic reviews was fair; by addressing the presenting weaknesses, particularly in representative sampling, measurement of educational attainment, and more robust comparability in the analysis, future research will further enhance the quality of evidence.

Global public health, development, and policy communities recognize the importance of education and its influence on health outcomes. Over the past decade, education has been highlighted in the Millennium Development Goals and now is continuing as a priority for the Sustainable Development Goals in the post

2015-agenda. The progress that has been made toward MDG 2 has succeeded in increasing enrollment in primary education but is not enough to meet the MDG target[45]. In half of sub-Saharan African countries, at least one in four children are out of school, although enrollment increased by 18% between 1999 and 2008[45]. Despite advances in some countries, more than 30% of primary school students drop out before reaching the final grade[45]. The focus on education shifts from quantity to quality in the Sustainable Development Goal (SGD) 4[46]; targets focus mainly on ensuring that all boys and girls have free, equitable, and quality education throughout their lives – from early childhood education to primary and secondary school and beyond to higher education. Targets for SDG 4 also focus on eliminating gender disparities, increasing literacy, technical, and vocational skills, and increasing the number of qualified teachers to provide education[46].

This review highlights the importance of continuing research on the association between education and HIV in low- and middle- income countries to support continued progress toward MDG 2 and SDG 4. The positive impacts of education are long-lasting, making a focus on improving access to and quality of education a key priority now and in the future. While the relationship of educational attainment on HIV is not yet clear, this review provides sufficient evidence to show that education does have an impact on HIV. Not only is it imperative to study the relationship and magnitude of the association in a variety of settings and populations, but also to gain a better understanding how and why education influences HIV for young people. Improving access to and quality of education will only allow greater opportunities to provide knowledge and skills to young people and encourage positive decision-making that will influence health outcomes; the findings from this review can be used to improve policies and programs to improve school enrollment, attendance, attainment, and the quality of education in low- and middle- income countries for all young people.

1.5 Figures and Tables

Figure 1 Records identified for inclusion and exclusion in the review

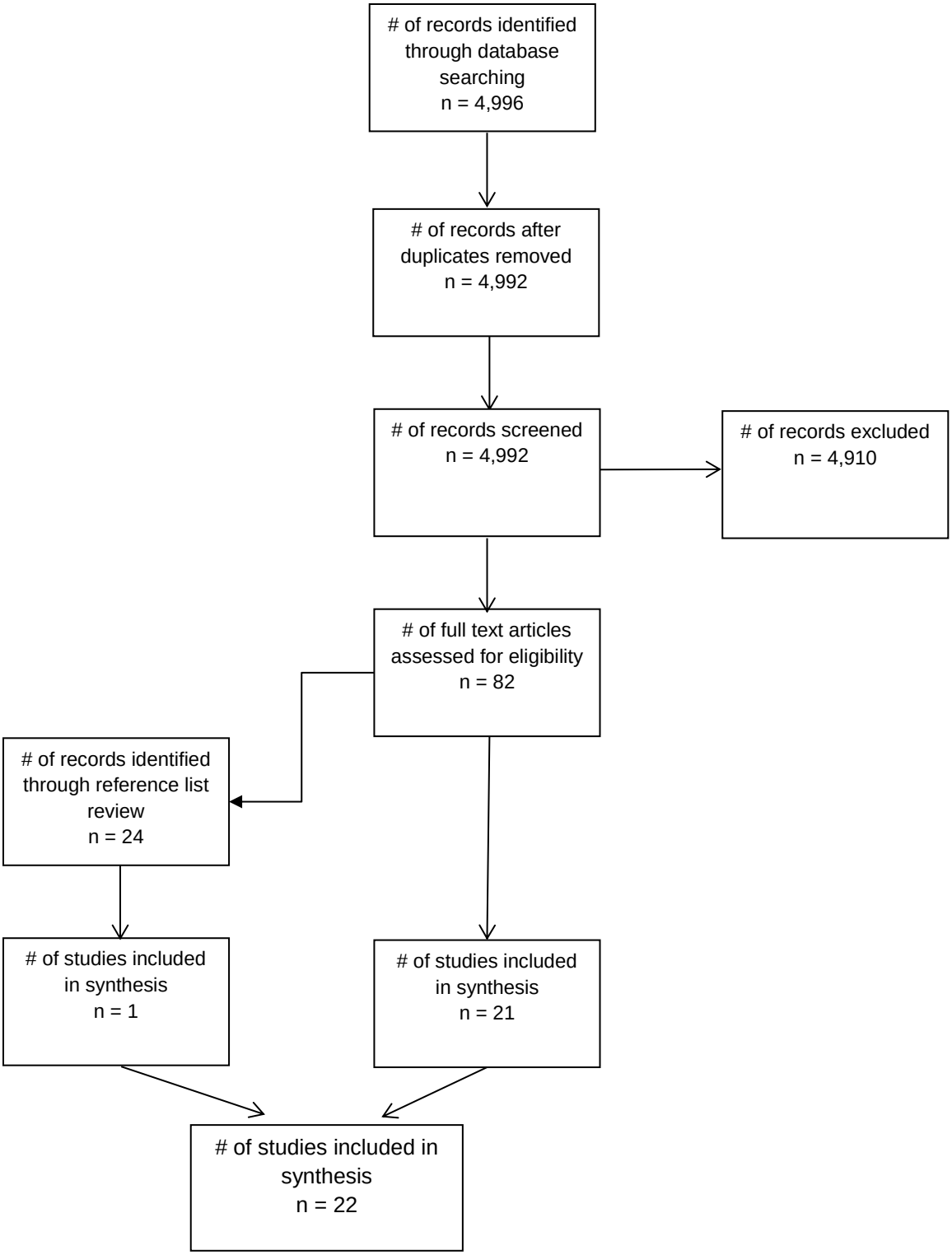

Table 1 Details of identified articles for inclusion in the review

Authors	Setting	Dates of data	Study population (n)	Age	Urban /Rural	Measurement of education	Design	Measurement of HIV status	Results & Conclusion
Alvarez-Uria, G., Midde, M., & Naik, P.K. (2012)[20]	Andhra Pradesh, India	2007 – 2011	ANC clients (17,690)	< 25	Rural	No Education Primary Secondary Higher	Cross-sectional	HIV testing using ELISA	Those who completed only primary school are more likely to have HIV compared to secondary education (aOR = 1.54, 1.01 – 2.35).
Andersson, N. & Cockcroft, A. (2012)[21]	Botswana Namibia Swaziland	2008	Population (7,464)	15 – 29	Urban Rural	Primary complete or less Secondary or more	Cross-sectional	HIV testing using ELISA	Those who have primary or less education are more likely to have HIV compared to with secondary or more education (aOR = 1.87, 1.38 – 2.53)
Birdthistle, I. et al. (2009)[22]	Harare, Zimbabwe	2009	Young people (743)	15 – 19	Urban	Out of school < Form 4 Out of school Form 4+ In school < Form 4 In school Form 4+	Cross-sectional	HIV testing using ELISA	Girls who left school before Form 4 were more likely to have HIV infection compared to those who left school after completing Form 4 (aOR = 3.2, 1.2 – 8.1).
Bradley, H. et al (2007)[23]	Ethiopia	2003 – 2004	VCT clients (34,512)	15 – 49	Urban Rural	None (0 years) Primary (1 – 8 years) Secondary (9 – 12 years)	Cross-sectional	HIV rapid test	For men, odds of HIV infection are lower for those with at least secondary education (aOR = 0.77, 0.61- 0.97) and more than secondary education (aOR = 0.42, 0.31 – 0.56) compared to with no education. For women, the odds of HIV infection are lower for those with at least secondary education (aOR = 0.63, 0.54 – 0.74) and more than secondary education (aOR = 0.34, 0.26 – 0.45).
De Neve, J. et al (2015)[37]	Botswana	2004 – 2008	Population (7,018)	10 – 64	Urban Rural	No schooling 1 – 7 years 8 – 9 years 10 years 11 - 12 years ≥ 12 Years	Cross-sectional	HIV testing using ELISA	Each additional year of schooling after 9 years was associated with a 3.6% lower risk of HIV infection. There was no association between schooling and HIV risk in lower grades.
Dorjgochoo, T. et al. (2009)[24]	Port-au-Prince, Haiti	2005 – 2006	VCT clients (3,391)	13 – 25	Urban	No education Some or all primary Some or all secondary Some or all college/professional	Cross-sectional	HIV testing using ELISA and Western Blot	Compared to those with no schooling, participants who have some or all college/professional education were 75% less likely to have HIV (aOR = 0.25, 0.09 – 0.67).
Gabrysch, S. et al. (2008)[31]	Ndola, Zambia	1997 – 1998	Young people (2,000)	15 – 24	Urban	< Primary Primary > Primary	Cross-sectional	HIV testing using ELISA and Western Blot	For young women ages, there was higher risk of HIV among higher educated compared to those with lower education (aOR = 1.45, 1.0 – 2.1).

Hargreaves, J.R. et al. (2015)[38]	Ethiopia Malawi Lesotho Kenya Zimbabwe Tanzania Rwanda	2003 – 2012	Population (72, 135)	15 – 24	Urban Rural	None Primary Some secondary or more	Cross-sectional	HIV testing using ELISA and Western Blot	Results varied by time, gender and country. For women in Ethiopia and Malawi, HIV prevalence was higher for those with higher education in both surveys. In Lesotho, Kenya, and Zimbabwe, HIV prevalence was lower in higher educated women in both early and later surveys. For men, there was little evidence of a significant association between education and HIV
Hargreaves, J.R. et al. (2009)[33]	South Africa	2001 – 2004	Population (3,881)	< 19 - > 40	Rural	Not attended secondary Attended secondary Completed secondary	Cross-Sectional	Oral fluid ELISA	There was no significant association between education and new HIV infection (aOR = 0.60, 0.31 – 1.17).
Kayeyi, N et al. (2012)[32]	Zambia	1994 – 2008	Population (38,836)	15 – 24	Urban Rural	0 – 4 years 5 – 6 years 7 years 8 – 9 years 10 + years	Cross-sectional	HIV testing with ELISA and Western Blot	HIV prevalence was lower among less educated young women compared to those with more education. For young women with more than seven years of education, there was a sharp decline in HIV prevalence from the mid to late 1990s.
Johnson et al (2009)[25]	South Africa	2000 – 2005	ANC clients (43,657)	15 – 24	Urban Rural	0 – 7 8 – 11 12 +	Cross-sectional	HIV testing using ELISA	Compared to participants with 0 – 7 years of education, those with more than 12 years of education were less likely to have HIV. Results were significant in all survey years except the year 2000 (2001 aOR 0.73, 0.62 – 0.85; 2002 aOR 0.79, 0.69 – 0.91; 2003 aOR =0.82, 0.71 – 0.94; 2004 aOR 0.79, 0.69 – 0.90; 2005 aOR 0.84, 0.72 – 0.98). HIV risk increased by 8% per year in young women with no secondary education but did not increase in those with secondary education.
Kwiek, J.J et al (2008)[34]	Blantyre, Malawi	2000 – 2004	ANC clients (3,824)	< 20 - > 35	Urban	None 4 years primary 8 years primary 2 years secondary 4 years secondary	Cross-sectional	HIV testing using Determine HIV ½ Rapid Test	HIV risk was not associated with education level.
Naidoo, P et al (2014)[47]	South Africa	2008 – 2010	Young adults (3,123)	18 – 24	Urban Rural	Low (≤ grade 7) Medium (grade 8 – 11) High (grade 12 or more)	Cross-sectional	Self-report	Those with medium (aOR = 0.04, 0.01 -0.66) or high education (aOR = 0.04, 0.01 -0.43) were less likely to be infected with HIV compared to those with low education.

Viegas, E.O, et al. (2015)[27]	Maputo, Mozambique	2009 – 2011	Young people (1,380)	18 – 24	Urban	Primary & secondary Technical training University degree	Prospective cohort	HIV testing using DBS following the national algorithm	Compared to those with primary and secondary education, participants with a university degree were less likely to have HIV (aOR = 0.29, 0.14 – 0.62).
Humphrey, J.H. et al. (2007)[35]	Harare, Zimbabwe	1997 – 2000	ANC clients (14,110)	15 – 40	Urban	Secondary > Secondary	Prospective cohort	HIV testing using ELISA	Education was not significantly associated with HIV prevalence (OR = 1.58, 0.99 – 2.53).
Rangsin, R. et al. (2015)[39]	Thailand	2005 – 2009	Young men in army (584)	17 – 29	Urban Rural	Secondary – some college Primary College degree	Case-control	HIV testing using ELISA and Western Blot	Compared to those with secondary or some college education, those with only primary education were more likely to have HIV (aOR = 1.34, 1.10 – 1.62). Compared to those with secondary or some college education, those with a college degree were more likely to have HIV (aOR = 1.42, 1.06 – 1.89).
White, H.L. et al. (2009)[36]	Mali	2005	Youth (950)	15 – 25	Urban	Secondary University	Cross-sectional	HIV testing using ELISA and Western Blot	There was no statistically significant relationship between HIV infection and school level (OR = 1.51, 0.71 – 3.2).
Hargreaves, J.R. (2007)[40]	South Africa	2001	Youth (1,919)	14 - 25	Rural	None Attended primary Attended secondary Completed secondary Attended higher	Cross-sectional	Oral fluid ELISA	Results varied by gender. For women, HIV infection was associated with educational attainment; those with secondary education were less likely to acquire HIV compared to attended primary education or no education (aOR 0.49, 0.28 – 0.85). Results were not significant for men.
Santelli, J.S. et al (2015)[28]	Rakai, Uganda	1994 – 2013	Youth (21,735)	15 – 19	Rural	Enrolled in school Not enrolled in school	Open cohort study	HIV testing using ELISA and Western Blot	For adolescents, school enrollment was significantly associated with a lower HIV prevalence (p <0.001).
Santelli, J.S. et al (2015)[29]	Rakai, Uganda	1999 – 2011	Youth (22,164)	15 – 19	Rural	Enrolled in school Not enrolled in school	Open cohort study	HIV testing using ELISA and Western Blot	Being enrolled in school was significantly associated with a lower incident HIV infection rate (IRR = 0.25, 0.12 – 0.53).
Santelli, J.S. et al (2013)[38]	Rakai, Uganda	1998 – 2008	Youth (15,904)	15 – 24	Rural	No schooling Primary schooling Secondary schooling Tertiary schooling	Open cohort	HIV testing using ELISA and Western Blot	Men were at lower risk of HIV if they had attended secondary school or were currently a student, compared to those who were not students (IRR = 0.42, 0.21 – 0.86). There was no significant relationship between level of schooling and HIV for women, although being currently enrolled in school (compared to not being currently enrolled in school) was protective for women.

Solomon, E. et al. (2011)[30]	South India	2003 – 2009	Pregnant women from ANC clinic (685)	23 years (mean)	Urban	Illiterate Primary and/or secondary schooling High school Graduate/post-graduate	Retrospective case-control cohort	HIV testing using ELISA	Compared to those who had some education, those who were illiterate were more likely to have HIV (OR = 4.89, 2.79 – 8.57).

Table 2 Summary of study details by association

	Total	Pos. association btw education & HIV	Neg. association btw education & HIV	No association	Mixed association
Total	22	2	11	4	5
Country					
India	2	0	2	0	0
Botswana	2	0	1	0	1
Namibia	1	0	1	0	0
Swaziland	1	0	1	0	0
Zimbabwe	3	1	1	1	0
Ethiopia	2	1	1	0	0
Haiti	1	0	1	0	0
Zambia	2	2	0	0	0
Malawi	2	0	0	1	1
Lesotho	1	0	0	0	1
Kenya	1	0	0	0	1
Tanzania	1	0	0	0	1
Rwanda	1	0	0	0	1
South Africa	4	0	2	1	1
Mozambique	1	0	1	0	0
Thailand	1	0	0	0	1
Mali	1	0	0	1	0
Uganda	3	0	2	0	1
Date of data collection					
< 2000	1	1	0	0	0
2000 – 2007	9	0	4	3	2
> 2007	4	0	4	0	0
Longitudinal	8	1	3	1	3
Population type					
Antenatal clinics	5	0	3	2	0
Population	5	1	1	1	2
Young people	9	1	5	1	2
Other	3	0	2	0	1
Setting					
Urban	6	0	3	1	2
Rural	8	1	4	3	0
Mixed	8	1	4	0	3
Study designs					
Cross-sectional study	15	2	7	2	4
Cohort study	5	0	3	1	1
Case-Control	2	0	1	0	1

Table 3 Quality assessment based on the Newcastle-Ottawa Scale of studies included in this systematic review

Cross-Sectional Studies[1]								
Study	**Selection**				**Comparability**	**Outcome**		**Score**[4]
	Representative sample	Sample size	Non-respondents	Ascertainment of exposure	Design and analysis	Assessment of outcome	Statistical test	
Alvarez G., Midde, M., & Naik, P.K. (2012)		*	*	*	*	**	*	7/10
Andersson, N. & Cockcroft, A.	*	*	*	*	*	**	*	8/10
Birdthistle, I. et al. (2009)	*	*	*	*	**	**	*	9/10
Bradley, H. et al (2007)		*		*	*	**	*	6/10
De Neve, J. et al (2015)	*	*	*	*	**	**	*	9/10
Dorjgochoo, T. et al. (2009)		*		*	*	**	*	6/10
Gabrysch, S. et al. (2008)	*	*	*	*	*	**	*	8/10
Hargreaves, J.R. et al. (2015)	*	*	*	*	**	**	*	9/10
Hargreaves, J.R. et al. (2009)[2]		*		*	**	**	*	7/10
Hargreaves, J.R. (2007)	*	*	*	*	**	**	*	9/10
Kayeyi, N et al. (2012)	*	*		*	*	**	*	7/10
Kwiek, J.J et al (2008)[3]		*		*	*	**	*	6/10
Johnson et al (2009)		*		*	**	**	*	7/10
Naidoo, P et al (2014)	*			*	*		*	4/10
White, H.L. et al. (2009)		*		*	*	**	*	6/10

Cohort studies									
	Selection				**Comparability**	**Outcome**			**Score**[5]
	Representative exposed cohort	Representative exposed non-cohort	Ascertainment of exposure	Outcome of interest not present at start	Design and analysis	Assessment of outcome	Follow up time	Adequacy of follow up	
Viegas, E.O, et al. (2015)		*	*	*		*	*	*	6/9
Humphrey, J.H. et al. (2007)		*	*	*	*	*	*		6/9
Santelli, J.S. et al (2013)	*	*	*	*	*	*	*		7/9
Santelli, J.S. et al (2015)	*	*	*	*	*	*	*		7/9

Santelli, J.S. et al (2015)	*	*	*	*	*	*	*		7/9

Case-Control studies

	Selection				Comparability	Outcome			Score[6]
	Is the case definition adequate?	Representative cases	Selection of controls	Definition of controls	Design and analysis	Ascertainment of exposure	Same method to ascertain cases and controls	Non-response rate	
Rangsin, R. et al. (2015)	*		*	*	*		*		5/9
Solomon, E. et al. (2011)	*		*	*	*		*		5/9

1. This scale has been adapted from the Newcastle-Ottawa Quality Assessment Scale for cohort studies to perform a quality assessment of cross-sectional studies for this review. . In each domain, one star indicates whether a designated criteria was present in the evidence; in some domains, two stars are used to designate that more than one criteria were present, thus representing the highest quality of evidence in that domain.
2. Hargreaves, J.R. et al. (2009) is designated as cross-sectional because they conducted an analysis of follow-up data from a cohort of participants recruited to a cluster-randomized trial on a microfinance intervention.
3. Kwiek, J.J et al (2008) is designated as cross-sectional because they conducted an analysis of baseline data from a cohort of participants enrolled in a study on malaria and mother-to-child transmission of HIV.
4. The maximum total score for cross-sectional studies was 10 points. High quality = 9 – 10 points, Fair Quality = 5 – 8 points, and Poor Quality = 0 – 4 points
5. The maximum total score for cohort studies was 9 points. High quality = 7 – 9 points, Fair Quality = 5 - 6 points, and Poor Quality = 0 – 4 points
6. The maximum total score for case-control studies was 9 points. High quality = 7 – 9 points, Fair Quality = 5 - 6 points, and Poor Quality = 0 – 4 points

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2 Educational attainment and HIV risk among young adults in Rakai, Uganda, 1996 - 2013

2.1 Background

Approximately two million young people are living with HIV, comprising 12% of all new HIV infections worldwide[1]. Over eighty percent of young people with HIV live in sub-Saharan Africa. Adolescent girls are disproportionately affected by HIV in sub-Saharan Africa, accounting for 70% of all new infections.[1]

There are an estimated 1.4 million people living with HIV in Uganda[2]. Approximately 33% of adults living with HIV and 53% of children living with HIV are not on treatment, and new HIV infections are expected to rise in the coming years[2]. The HIV epidemic in Uganda disproportionately affects young people, particularly women and girls. HIV prevalence is almost four times higher among young women aged 15 – 24 than young men of the same age. [2] HIV incidence rates are consistently higher among young women than young men[2].

The influences of socioeconomic status, household characteristics, gender, geographical residence, and risky sexual behaviors on HIV acquisition are well reviewed in the literature[3-7]. Evidence on the impact of education on factors that influence HIV acquisition is less robust, and associations have changed over time as both education and the HIV epidemic evolved. Early in the epidemic, HIV risk had been linked to higher socio-economic status (SES), travel, and increased schooling[8]. Systematic reviews have shown mixed associations between HIV acquisition and educational attainment[9,10]. Earlier studies have shown either no association or the highest risk of HIV infection among the most educated[9]. Later studies find that the association reversed; those with the highest education have a lower risk of HIV infection. HIV prevalence fell consistently among highly educated groups compared to less educated groups, whose HIV prevalence has increased while the overall population prevalence was falling. Conclusions indicate that new infections in the late 1990s and early 2000s occurred disproportionately among the least educated people in sub-Saharan Africa, and that behavior change – condom use, delayed age at risk sex, reduced partner numbers - to reduce risk of HIV is greater among the most educated.[9]

The Government of Uganda (GoU) has made strides to improve education. In 1997, GoU implemented Universal Primary Education (UPE), leading to a dramatic increase in school enrollment[11,12]. Despite increased enrollment, progress toward educational attainment remains slow, particularly for young

women, and primary school completion rates lag behind those of neighboring countries[13,14]. Universal Secondary Education (USE) was adopted in 2007 with the goal of improving access to and quality of secondary schooling[14]. USE is limited in its implementation; there is little evidence that this policy has improved attendance or retention in school and mixed evidence for the equity-promoting effects of USE[14]. Determinants of education in Uganda are influenced by gender, family structure, socioeconomic status, and geographic residence[12,15].

Over the past decade, existing research and published studies on the association between educational attainment and risk factors for HIV, specifically with HIV as an outcome measure, are limited. This paper examines the impact of educational attainment on risk factors of HIV acquisition for young people living in Uganda; the hypothesis being that higher educational attainment is correlated with lower risk of proximate factors, particularly related to risky sex, which influence HIV infection.

2.2 Methods

2.2.1 Study Population

The Rakai Health Sciences program has conducted the Rakai Community Cohort Study (RCCS) since 1994 in Rakai, Uganda[16]. This longitudinal study follows an open, population-based cohort that enrolls residents from approximately 30 communities in the Rakai district of Uganda, ages 15 – 49. RCCS is in Rakai District, a mostly rural district with scattered trading centers and approximately 518,000 people[17]. Participants consent to a household and individual interview that collects data on sociodemographic characteristics, behavior, sexual networks, mobility, health, and service utilization. Participants also consent to providing blood specimens for HIV and STI testing. HIV prevalence in this cohort varies, ranging from approximately 12% in rural trading villages to 42% in high risk fishing communities. The overall HIV incidence in this district significantly declined after the scale-up of combination prevention for HIV, from 1.17/100 person-years (PY) to 0.66/100 PY. Recent estimates of HIV incidence were, for women, 0.84/100 PY and for men, 0.46/100 PY[17]. In adults, almost all transmission occurs through heterosexual intercourse.[16]

Eligible participants for the sample included in this study were young people aged 20 – 24 years who reported being sexually active within the past 12 months. RCCS rounds 3 – 15 were included in these

analyses. Institutional review board (IRB) approvals for RCCS are obtained from Uganda Virus Research Institute's Science and Ethics Committee, Uganda National Council for Science and Technology, as well as IRBs at Columbia University and Johns Hopkins University IRB in the U.S.

2.2.2 Variables

Educational attainment was the independent variable and was measured using level of school attended at the baseline interview for male and female participants. Educational attainment referred to the highest educational level reached but not necessarily achieved. Data were self-reported, and categories included never attended school, attended primary school, attended secondary school, and attended beyond secondary school (university/technical education-levels). Potentially confounding variables in this study were factors that are previously known in the literature to be associated with educational attainment (); the variables adjusted for in the analysis were socioeconomic status (SES), orphanhood, geographic residence, time (as measured by study rounds) and childbirth (for women only). An SES index was created based on the structure of the selected dwelling and building materials used to construct the household dwelling and determined by interviewer observation. In the Rakai district, modern construction materials such as cement, iron, or roofing types were a potential indicator of wealth. A dwelling that used modern building materials was classified as high SES, whereas those using little or no modern materials (i.e., grass, mud, wattle) were classified as low SES. A household whose dwelling had at most two parts (i.e. roof, walls, and floor) constructed using modern materials was classified as middle SES.[18] Orphanhood was derived from self-report about the vital status of each parent. Area of residence included urban areas (i.e. on a major road) or rural villages as determined by the location of the dwelling[19]. Time, measured by study rounds, was broken into four time periods. Time 1 consists of RCCS rounds 3 – 6 (1996 – 2000), time 2 consists of RCCS rounds 7 – 9 (2000 – 2003), time 3 consists of RCCS rounds 10 – 12 (2003 – 2008), and time 4 consists of RCCS rounds 13 – 15 (2008 – 2013). The number of participants per time period was comparable across time periods. Childbirth was measured by self-report as to whether the woman has ever given birth.

Dependent variables in this model were based on the known proximate determinants of HIV infection and focused on risky sex behaviors (). Dependent variables in this analysis included the age of first sexual experience for participants, condom use, use of family planning methods, the number of partners a

participant had within a 12-month period, the number of new partners a participant had within a 12-month period, the number of partners from outside the community within a 12-month period, partner concurrency, and partner HIV status disclosure. Dependent variables were categorized into binary variables and dependent variables that are naturally continuous were assigned cut-offs. Incident HIV infection was determined if a participant tested seropositive for the first time after they had an HIV-seronegative result on the previous RCCS visit. One missed visit was allowed, and incident infections were assumed to occur at the midpoint between two survey rounds[17]. A comprehensive review of the study variables is in Table 3.

2.2.3 Statistical Analyses

Bivariate analysis looked at the relationship between socioeconomic and demographic characteristics and educational attainment. Logistic regression modeling examined the impact of calendar time on educational attainment for this sample. Multivariable logistic regression analyses examined the association between educational attainment and proximate factors associated with risk of HIV infection. The multivariable models included potential confounding variables at the individual-level (SES, orphanhood, geographic residence, time (by study round), childbirth for women only), educational attainment as the independent variable, and dependent variables (age at first sex, condom use, family planning, number of sexual partners in the last year, number of new partners, sex with partners outside the community, concurrent partners, and knowledge of partners HIV status). A Poisson regression model was used to examine the association between educational attainment and HIV incidence. The model was adjusted for potential influences on educational attainment, selected dependent variables, and the outcome variable of HIV incidence - SES, orphanhood, geographic residence (urban vs. rural), and childbirth (for women only). The analyses were stratified by gender. Additionally, analyses stratified by time period were examined to determine if the effect of education on risk behaviors was consistent or heterogeneous.

2.3 Results

Between 1996 and 2013, RCCS collected data on 31,697 observations of men and women between the ages of 20 – 24 years who were sexually active. Over sixty percent of the sample was female. Characteristics of the sample and descriptive statistics of the independent and dependent variables are

found in Table 4. Over three-quarters of the sample resided in rural areas (81.7% male and 79.1% female). Nearly forty percent of men and 32.3% of women were classified as low SES as defined by the SES index. Nearly all women (96.9%) had at least one birth. Most men and women did not attend beyond primary school (65.9% men and 61.5% women).

Frequencies describe risky sexual behavior for men and women. Most men and women had their first sexual experience before the age of 18, inconsistently used condoms, did not use family planning methods, and had three or more new partners over the course of 12 months. Half of the men sampled had partners outside their primary relationship and over half of women did not know the status of at least one sexual partner. The HIV incidence rate in this sample was 0.60/100 PY for men and 0.68/100 PY for women.

Logistic regression modeling was used to examine the impact of time on educational attainment for this sample (Figure 2). Compared to those surveyed between 1996 and 2000, results showed that the number of participants who attended any school increased significantly over time for both males and females – the percentage of those who reported never attending school decreased from 6.7% in Time 1 (1996 – 2000) to 1.9% in Time 4 (2008 – 2013). During the reference time (Time 1, 1996 – 2000), UPE was mandated by GoU, however USE was not yet implemented. The number of people who went on to attain any amount of secondary education also increased over time, from 24.3% in Time 1 to 38.4% in Time 4. Results were significant for both males and females.

Bivariate analyses showed that socioeconomic and demographic factors were significantly associated with educational attainment for both men and women (Table 5). Variables significantly associated with primary education only relative to no education included SES, orphanhood, and geographic residence. Compared to those with high SES, men and women with low SES were significantly less likely to attend primary school. Double orphanhood was significantly associated with not attending primary education for women. Death of the mother was significantly associated with not attending primary education for both men and women. Bivariate analyses indicated that socioeconomic and demographic factors played a significant role in determining who attained secondary education compared to those who attained primary education. Compared to those with high SES, men and women with middle and low SES were

significantly less likely to attend secondary school. Double, maternal, and paternal orphans were significantly less likely to attend secondary school. Compared to those living in rural areas, participants in urban locations were more likely to attend secondary school. Women who had ever given birth were significantly less likely to attend secondary school. Analyses stratified by time period indicated there is unexplained heterogeneity among men in time period 4 relative to the other time periods.

Multivariable logistic regression estimated the association between educational attainment, sexual behavior, and HIV infection, stratified by gender and adjusting for potentially confounding variables (Table 6). Results for women showed that compared to those with no education, those who reached secondary education were 55% less likely to have their first sexual experience before the age of 18 (aOR=0.45, 95% CI [0.32, 0.62]) and those who had beyond a secondary education were 80% less likely to have earlier sexual debut (aOR=0.20, 95% CI [0.12, 0.33]). Compared to those who never attended school, women with any education were more likely to use family planning methods; the likelihood of this behavior increased as educational attainment increased (Primary School aOR=0.55, 95% CI [0.45, 0.66]; Secondary School aOR=0.33, 95% CI [0.27, 0.40]; Beyond Secondary School aOR=0.22, 95% CI [0.15, 0.30]). Relative to those who had never attended school, women with higher education were less likely to have three or more sexual partners in a 12-month period; women who attained primary education were 41% less likely and women who attained secondary education were 67% less likely to have three or more partners (Primary School aOR=0.59, 95% CI [0.37, 0.84]; Secondary School aOR=0.33, 95% CI [0.19, 0.56]). Compared to those with no education, women with primary education were more likely to report inconsistent condom use (aOR = 4.91, 95% CI [1.11, 21.83]) and more likely to report concurrent partners (Primary School aOR = 1.38, 95% CI [1.11, 1.71]; Secondary School aOR=2.27, 95% CI [1.82, 2.82]; Beyond Secondary School aOR=3.12, 95% CI [2.15, 4.53]). Women who attained primary education were nearly four times more likely to not know the HIV status of their partner compared to those who did not attend school (aOR=3.85, 95% CI [1.37,10.79]).

Men with higher education were more likely to use family planning methods; men with a primary education were 43% more likely and men with a secondary education were 67% more likely to use family planning methods (Primary School aOR=0.57, 95% CI [0.44, 0.74]; Secondary School aOR=0.33, 95% CI [0.25, 0.43]; Beyond Secondary School aOR=0.31, 95% CI [0.21, 0.44). Men with at least secondary

education were more likely to have concurrent sexual partners (Secondary School aOR=1.87, 95% CI [1.49, 2.35]; Beyond Secondary School aOR= 1.65, 95% CI [1.18, 2.30). Educational attainment was not significantly associated with HIV incidence for either men or women.

2.4 Discussion

Educational attainment was protective against several risk factors for HIV. Compared to those with no education, females with at least a secondary education were less likely to have their first sexual encounter before the age of 18. Females with higher educational attainment were more likely to use family planning methods and had fewer sexual partners. Educational attainment was also correlated with riskier behaviors. Females with higher education were more likely to report inconsistent condom use, concurrent sexual partners, and were less likely to know the HIV status of their partners. Similar results were seen in males. Compared to those with no education, males with any education were more likely to use family planning methods. Males with higher education were more likely to report concurrent sexual partners. Educational attainment was not significantly associated with HIV incidence in males or females.

Access to and utilization of education has increased worldwide throughout the twentieth and twenty-first centuries. Between 1970 and 2009, the mean number of years of education globally increased from 4.7 to 8.3 years for men and 3.5 to 7.1 years for women[20]. Education has a consistent and compounding effect on nearly all aspects of health, well-being, and economic growth[21,22]. Lack of education is a major obstacle to accessing tools and resources that could improve people's lives and unequal access perpetuates poor health, high adolescent birth rates, and diminishes opportunities for social and economic advantages. While work has been done to improve education, the relationship between educational attainment, risk behaviors, and HIV incidence remains unclear. This paper adds to a small body of evidence that tests the association of educational attainment on risk factors for HIV incidence.

The data from Rakai, Uganda indicate that enrollment in education beyond primary school has significantly increased over time for both men and women in Rakai, Uganda, consistent with global data. The percentage of young people who have never attended school has significantly decreased and at the same time, the numbers of individuals who are reaching secondary school are significantly increasing. Good progress has been made towards HIV prevention in Uganda, however access to treatment and viral

load suppression are below the 90-90-90 targets[2]. Annual new infections are projected to grow rapidly to from 52,000 in 2016 to approximately 340,500 in 2025[2].

This paper was based on the proximate determinant of health framework which has been used in HIV research as a way to structure HIV epidemiology[23, 24]. Proximate determinants are behavioral or biological variables that link underlying variables to the spread of an infection[23,25-28]. The spread of HIV can be a complex web of variables; gaining a better understanding of the influences on various proximate determinants of HIV acquisition can illustrate key entry points through which targeted interventions could prevent the spread of HIV. The proximate determinants of health framework was the foundation for the conceptual model for this paper (Figure 1). This study highlights the unclear pathway between educational attainment, risk behavior, and HIV incidence. Results showed mixed associations between educational attainment and risk factors for HIV incidence. For both men and women, higher education was a risk factor for having concurrent partners. The role of concurrent sexual relationships in the transmission of transmission of HIV and other sexually transmitted diseases has been previously studied[29,30]. Frequency of concurrent relationships varies by context; research shows that 12% of men and women in Kampala, Uganda reported having two or more regular partners, including one identified as a spouse[31,32]. In this sample, partner concurrently was measured by asking participants if they currently have a sexual relationship with someone to whom they are not officially married or in a consensual union. Fifty percent of men and nearly 20% of women noted that they had a sexual relationship outside of their marriage or consensual union. Importantly, this variable measured concurrency among the primary participant; it did not measure concurrency with the participant's partners. The role of educational attainment and partner concurrency has not been previously studied in this context, though the role of partner concurrency and concurrent sexual relations are frequently contested in the literature. Given the complexity of measuring partner concurrency and the outcome of this analysis, future research should include education when reviewing the role of concurrent partnerships in the HIV epidemic.

The relationship between educational attainment and risk behaviors for women is complex. In this study, higher education was protective for several risk behaviors in the female sample. Educational attainment was associated with delayed first sexual experience; these results are consistent with previous studies that show that youth enrolled in school, particularly females, are less likely to engage in early sexual

behavior[33]. Data from this study also show that educational attainment was associated with fewer sexual partners in women; this result is divergent from previous research that shows that educated young people may be more likely to have multiple sexual partnerships[34].

This analysis also confirms results from previous studies that show more educated young people are more likely to have riskier behaviors. Higher education for women in this sample was significantly associated with inconsistent condom use and less partner HIV status disclosure. These results are consistent with previous studies[35-38].

Previous research indicates that sexual behavior of youth enrolled in school varies depending on the type of school environment – national or provincial, single gender or co-educational, day school or boarding school[33]. For many young people, school settings are the most important and consistent socialization outside of the family. The school setting has the potential to influence behavior of students in both positive and negative ways; schools and their curricula may reinforce societal norms on gender role and the setting provide opportunity for close contacts between boys and girls. The adult-to-student ratio in schools may provide either greater or less supervision of pupils than a young person would receive at home or in their community[33]. Future research should include the association between the school environment and sexual behaviors of students.

The strengths of the study include the use of a population-based sample which is representative of the district. Interviewers were well trained and have been implementing this survey for over 20 years. Data collection techniques are high quality and verified by the Rakai Health Sciences program and the RCCS study. However, there are some limitations in this study. Data reported by young adults are subject to recall and social desirability bias. Several questions asked the participants to think back to the past 12 months and estimate responses; recall may be less reliable when looking back over time. In addition, questions asked are sensitive and since results were self-reported, participants may have felt uncomfortable answering honestly. To attempt to mitigate social desirability bias, interviewers for RCCS were well-trained and experienced and the survey setting was confidential. While this study was able to measure the level of school attended, other factors such as the quality of education, attendance patterns, and early dropout rates were not available for analysis. While some participants indicate they had primary

education, it is not clear how much education they received. Certain data for variables used in the analyses were missing from some survey rounds because data were not collected in those rounds. Finally, this analysis represents a sample of young people from a one district in Uganda; these associations may not be generalizable to other settings.

In an era of enhanced focus on education and educational attainment, this data helps explain how schooling can impact the risk behaviors that influence the HIV epidemic in young people. Rigorous evaluations should be conducted considering the negative associations between higher education and risk factors for HIV. When developing sexual education in the future, researchers, program, and policy developers should utilize these findings to ensure curricula focus on consistent condom use, concurrent partners, and the importance of HIV disclosure. This study also highlights gaps in the current literature – future research questions should more closely examine the quality and content of education, as well as determining the role that education and school setting plays in exerting autonomy over behavior and behavior change.

2.5 Figures and Tables

Figure 2 Framework for logistic regression analysis and relationship between educational attainment, proximate risk factors, and HIV incidence

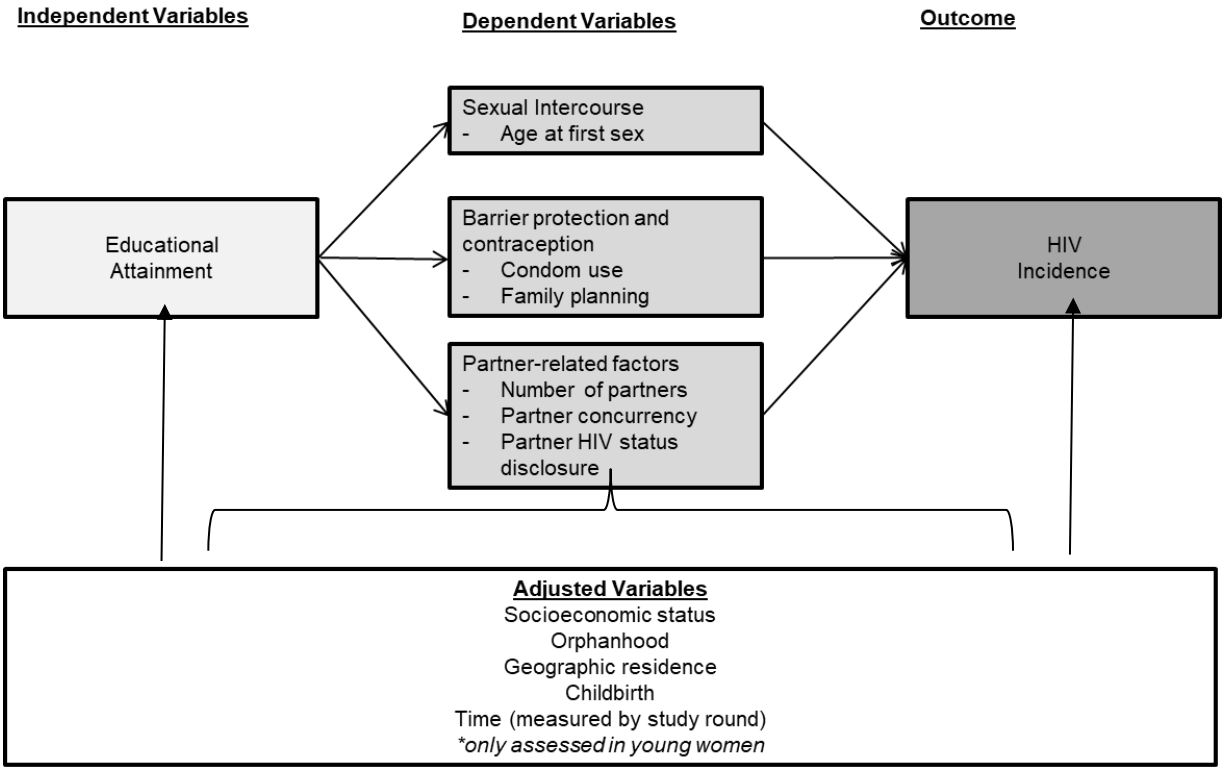
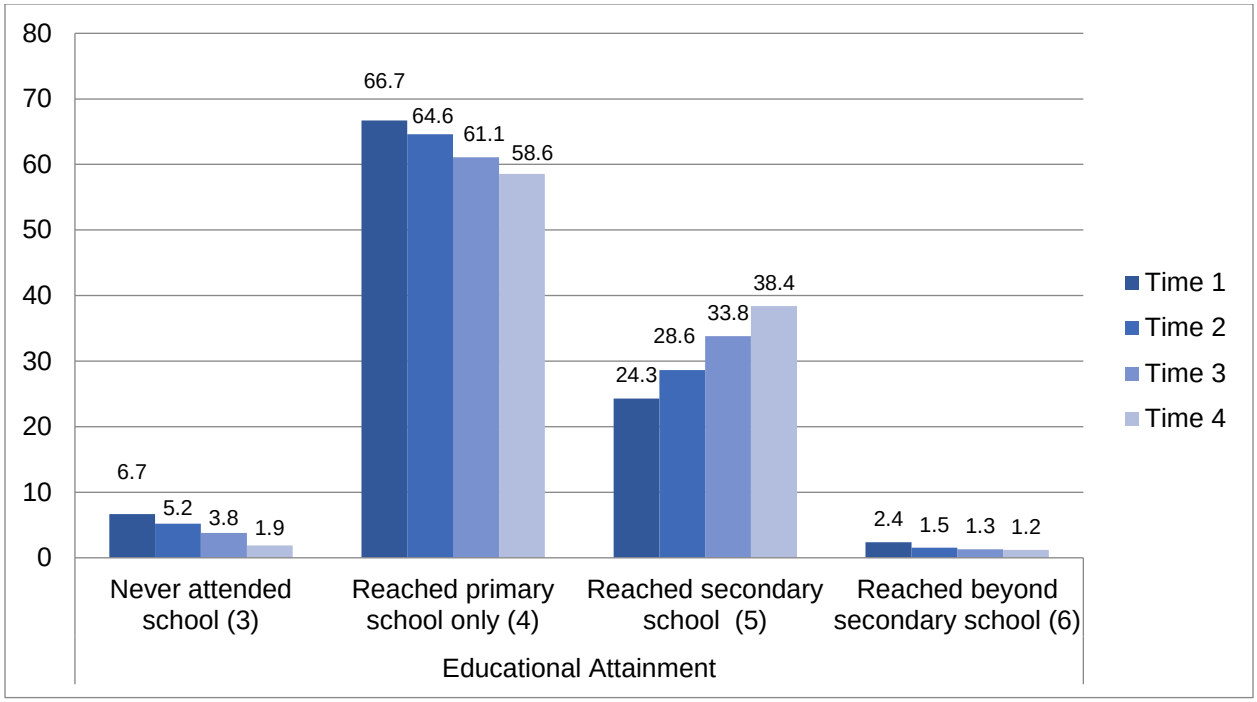


Figure 3 Educational attainment over time for young people in Rakai, Uganda 1996 – 2013[1, 2]



1. Time 1 consists of RCCS rounds 3 – 6 (1996 – 2000). Time 2 consists of RCCS rounds 7 – 9 (2000 – 2003). Time 3 consists of RCCS rounds 10 – 12 (2003 – 2008). Time 4 consists of RCCS rounds 13 – 15 (2008 – 2013).
2. Logistic regression modeling looked at the impact of time on educational attainment for this sample. The reference group was Time 1 (1996 – 2000).
3. Compared to Time 1, participants were less likely to have never attended school. Results were significant across all time periods and for males and females.
4. Compared to Time 1, participants were less likely to be enrolled only in primary school. Results were significant across all time periods and for males and females.
5. Compared to Time 1, participants were more likely to be enrolled in secondary school. Results were significant across all time periods and for males and females.
6. Compared to Time 1, participants were less likely to be enrolled in education beyond secondary school. Results were significant across all time periods and for males and females.

Table 3 Summary and description of variables included in analyses

Variable	Description	Study round/Visit
Independent and Adjusted Variables		
Educational attainment	The level of highest educational level reached but not necessarily achieved by participant. Categories were: never attended school, attended primary school, attended secondary school, and attended beyond secondary school (including university/technical education). Data were self-reported.	R3 – R15 Baseline interview
Socioeconomic Status (SES)	Determined based on the structure of the selected dwelling and building materials used to construct the household dwelling. A dwelling that used modern building materials was classified as high SES, whereas those that used little or no modern materials (i.e., grass, mud, wattle) were classified as low SES. A household whose dwelling had at most two parts (i.e. roof, walls, and floor) constructed using modern materials was classified as middle SES. Data were collected by interviewer observation.	R3 – R15 Baseline interview
Orphanhood	Determined by asking participant the vital status of both parents at the time of the interivew. Categories were: both parents alive, both parents died, mother died, father died. Data were self-reported.	R3 – R15 Baseline interview
Geographic residence	Dwellings were classified as in urban or rural communities as previously described[19]	R3 – R15 Baseline interview
Time	Time 1 consists of RCCS rounds 3 – 6 (1996 – 2000). Time 2 consists of RCCS rounds 7 – 9 (2000 – 2003). Time 3 consists of RCCS rounds 10 – 12 (2003 – 2008). Time 4 consists of RCCS rounds 13 – 15 (2008 – 2013).	R3 – R15 Baseline interview
Childbirth	Variable asked to female participants who self-reported as ever being pregnant. Women were asked “how many live births have you had?”. Data were self-reported.	R3 – R15 Baseline interview
Dependent Variables		
Age of first sex	Question asked “how old were you the first time you had sexual intercourse?”. Variable was recoded binary and the cut off set at 18 years. Categories were: < 18 years and $\geq$ 18 years. Data were self-reported.	R6 – R15 Baseline interview
Condom use	Composite variable that calculated participant’s reported condom use with partners. Variable was recoded as binary and the categories were: always using condoms with every partner or reported inconsistent condom use (i.e. sometimes uses condoms, never uses condoms, or a mix of all responses).	R9 – R15 Baseline interview
Use of family planning methods	Variable asked about use of family planning methods (pills, condom, depot, IUD/coil, implant/norplant, BTL, spermicides, abstinence, calendar, lactation, herbs, or other method). Variable was recoded as binary and the categories were: do not use family planning and do use family planning. Data were self-reported.	R3 – R15 Baseline interview
No. of sexual partners (last 12 months)	Variable that asked the number of sexual partners the participant had within the previous 12 months. Variable was recoded as binary and the categories were recoded according to RCCS protocol: a few (1 – 2 partners) and a lot/many ($\geq$ 3 partners). Data were self-reported.	R3 – R15 Baseline interview
No. of partners outside community (last 12 months)	Variable that asked the number of sexual partners the participant had outside of their community within the previous 12 months. Variable was recoded as binary and the categories were recoded according to RCCS protocol: a few (0 – 2 partners) and a lot/many ($\geq$ 3 partners). Data were self-reported.	R3 – R15 Baseline interview
No. of new sexual partners (last 12 months)	Variable asked the number of sexual partners the participant had for the first time (“new partners”) within the previous 12 months. Variable was recoded as binary and the categories were recoded according to RCCS protocol: a few (0 – 2 partners) and a lot/many ($\geq$ 3 partners). Data were self-reported.	R3 – R15 Baseline interview
Partner concurrency	Variable asked the number of partners the participant had outside their marital or primary partnership. Does not measure the number of concurrent partners their sexual partners have outside of their relationship. Variable was recoded as binary and the categories were: yes (concurrent partners) and no (no concurrent partners). Data were self-reported.	R3 – R15 Baseline interview
Partner HIV Status Disclosed	Composite variable asked about whether the participant knows the HIV status of their partners. Variable does not measure whether the participant disclosed their HIV status to their partners. Variable was recoded as binary and the categories were: do not know status of at least one partner and all partners disclosed their status. Data were self-reported.	R14 – R15
HIV Incidence	Determined if participant tested seropositive for the first time after they had an HIV-seronegative result on the previous RCCS visit. One missed visit was allowed and incident infections were assumed to occur at the midpoint between two survey rounds. Data were self-reported.	R3 – R15 Baseline interview

Table 4 Characteristics of men and women ages 20 – 24 years in Rakai, Uganda, 1996 – 2013[1]

Variables	Men		Women	
	Frequency	Percentage	Frequency	Percentage
Total	12,019	37.9	19,678	62.1
SES				
High	4,150	35.7	7,990	40.7
Middle	3,109	26.7	5,305	27.0
Low	4,379	37.6	6,343	32.3
Orphanhood				
Both parents alive	5,438	46.7	9,353	47.6
Both parents died	2,343	20.1	3,610	18.4
Mother died	1,051	9.0	2,134	10.9
Father died	2,807	24.1	4,538	23.1
Geographic residence				
Rural	9,399	81.7	15,059	79.1
Urban	2,111	18.3	3,976	19.9
Time				
Time 1	2,849	23.7	4,538	23.1
Time 2	3,333	27.7	5,730	29.1
Time 3	2,672	22.2	4,995	25.4
Time 4	3,165	26.3	4,415	22.4
Childbirth				
No births	--	--	605	3.1
$\geq$ 1 birth	--	--	19,073	96.9
Educational attainment				
Never attended school	349	3.2	1,000	5.4
Attended primary school	7,116	65.9	11,369	61.5
Attended secondary school	3,087	28.6	5,886	31.9
Attended beyond secondary school	253	2.3	222	1.2
Age at first sex				
< 18 years	2,328	60.3	5,016	73.0
$\geq$ 18 years	1,536	39.8	1,858	27.0
Condom-use				
Inconsistent use	1,397	75.2	322	89.0
Always use	460	24.8	41	11.0
Use of family planning methods[2]				
Do not use family planning	7,054	58.7	13,619	69.2
Use family planning	4,965	41.3	6,059	30.8
No. of sexual partners (last 12 months)				
A few (1 – 2)	9,839	81.9	19,483	99.0
A lot/many ($\geq$ 3)	2,180	18.1	195	1.00
No. of partners outside community (last 12 months)				
A few (0 – 2)	11,314	99.6	19,601	99.9
A lot/many ($\geq$ 3)	45	0.4	10	0.1
No. of new sexual partners (last 12 months)				
A few (0 – 2)	84	0.7	148	0.8
A lot/many ($\geq$ 3)	11,916	99.3	19,528	99.3
Concurrent partners				
No	5,906	50.0	15,792	80.3
Yes	5,914	50.0	3,874	19.7
Partner HIV status disclosed				
Do not know status	335	39.0	1,192	53.5
All partners disclose	524	61.0	1,038	46.6
HIV incidence (person-years)	0.60/100 PY		0.68/100 PY	

1. All data were collected from rounds 3 – 15 with the exception of the following variables: Age at first sex (rounds 6 – 15), condom use (rounds 9 – 15), and partner disclosure (rounds 14 – 15)
2. Family planning methods included: pills, condom, depot, IUD/coil, implant/norplant, BTL, spermicides, abstinence, calendar, lactation, herbs, or other method (specified).

Table 5 Socioeconomic and demographic characteristics associated with educational attainment of men and women ages 20 – 24 years in Rakai, Uganda, 1996 – 2013[1], Simple Logistic Regression

	Male		Female	
	OR	(95% CI)	OR	(95% CI)
Total (n)	*12,019*		*19,678*	
Attained primary education only[2]				
SES				
Low SES	**0.73**	**(0.55, 0.95)**	**0.40**	**(0.34, 0.76)**
Middle SES	0.92	(0.68, 1.26)	**0.62**	**(0.51, 0.76)**
High SES	*REF*		*REF*	
Orphanhood				
Both parents died	1.02	(0.76, 1.37)	**0.82**	**(0.69, 0.97)**
Mother died	**0.55**	**(0.39, 0.77)**	**0.62**	**(0.51, 0.75)**
Father died	0.85	(0.65, 1.12)	1.06	(0.89, 1.26)
Both parents alive	*REF*		*REF*	
Geographic residence				
Urban	0.90	(0.68, 1.19)	**1.89**	**(1.53, 2.33)**
Rural	*REF*		*REF*	
Childbirth				
Never given birth	--	--	1.04	(0.66, 1.64)
Ever given birth	--	--	*REF*	
Attained secondary education[3]				
SES				
Low SES	**0.29**	**(0.26, 0.35)**	**0.23**	**(0.21, 0.25)**
Middle SES	**0.48**	**(0.43, 0.53)**	**0.45**	**(0.42, 0.49)**
High SES	*REF*		*REF*	
Orphanhood				
Both parents died	**0.56**	**(0.50, 0.63)**	**0.81**	**(0.74, 0.88)**
Mother died	**0.75**	**(0.64, 0.87)**	**0.75**	**(0.67, 0.84)**
Father died	**0.80**	**(0.73, 0.90)**	**0.90**	**(0.83, 0.98)**
Both parents alive	*REF*		*REF*	
Geographic residence				
Urban	**1.25**	**(1.12, 1.39)**	**1.62**	**(1.51, 1.75)**
Rural	*REF*		*REF*	
Childbirth				
Ever given birth	--	--	**0.43**	**(0.37, 0.51)**
Never given birth	--	--	*REF*	

1. All data were collected from rounds 3 – 15
2. Simple logistic regression modeled the odds of attaining some primary education (vs. no schooling) associated with each category of the socioeconomic and demographic variables
3. Simple logistic regression modeled the odds of attaining some secondary education (vs. primary education) associated with each category of the socioeconomic and demographic variables

Table 6 Educational attainment[1], HIV risk behaviors, and HIV incident infection among young adults 20 – 24 years, Rakai, Uganda, 1996 – 2013[2], Multivariable Logistic Regression

	Male		Female	
	Adj. OR[3]	(95% CI)	Adj. OR[3]	(95% CI)
Total (n)	*12,019*		*19,678*	
First sexual experience before 18 years (vs. after age 18)				
Primary school	1.45	(0.98, 2.13)	0.92	(0.67, 1.26)
Secondary school	1.22	(0.82, 1.83)	**0.45**	**(0.32, 0.62)**
Beyond secondary school	0.78	(0.45, 1.37)	**0.20**	**(0.12, 0.33)**
Inconsistent condom use (vs. always using condoms)				
Primary school	0.59	(0.25, 1.42)	**4.91**	**(1.11, 21.83)**
Secondary school	0.44	(0.18, 1.07)	4.00	(0.85, 18.88)
Beyond secondary school	0.49	(0.16, 1.50)	4.40	(0.29, 65.87)
No family planning (vs. any family planning)[4]				
Primary school	**0.57**	**(0.44, 0.74)**	**0.55**	**(0.45, 0.66)**
Secondary school	**0.33**	**(0.25, 0.43)**	**0.33**	**(0.27, 0.40)**
Beyond secondary school	**0.31**	**(0.21, 0.44)**	**0.22**	**(0.15, 0.30)**
Three or more sexual partners (last 12 months) (vs. 1-2 sexual partners)				
Primary school	1.27	(0.94, 1.70)	**0.59**	**(0.37, 0.94)**
Secondary school	0.98	(0.72, 1.33)	**0.33**	**(0.19, 0.56)**
Beyond secondary school	0.75	(0.47, 1.21)	--	--
Concurrent partners (vs. no concurrent partners)				
Primary school	1.21	(0.97, 1.51)	**1.38**	**(1.11, 1.71)**
Secondary school	**1.87**	**(1.49, 2.35)**	**2.27**	**(1.82, 2.82)**
Beyond secondary school	**1.65**	**(1.18, 2.30)**	**3.12**	**(2.15, 4.53)**
No disclosure of HIV status from partners (vs. knowing the HIV status of at least one sexual partner)				
Primary school	0.41	(0.05, 3.50)	**3.85**	**(1.37, 10.79)**
Secondary school	0.20	(0.02, 1.75),	2.52	(0.91, 6.98)
Beyond secondary school	0.43	(0.02, 9.76)	--	--
HIV sero-positive (vs. HIV negative)[5]				
Primary school	6.74	(0.92, 49.14)	1.47	(0.71, 3.08)
Secondary school	4.20	(0.55, 32.12)	1.68	(0.78, 3.61)
Beyond secondary school	--	--	--	--

1. Reference group was respondents who have never attended school. Educational attainment was recoded to the following categories to account for small or empty cell observations: Never attended school, Attended primary school, Attended secondary school or beyond (including technical/vocational schools).
2. All data were collected from rounds 3 – 15 with the exception of the following variables: first sexual experience (rounds 6 – 15), condom use (rounds 9 – 15), and partner disclosure (rounds 14 – 15)
3. Odds ratios (OR) are adjusted for socioeconomic status, orphanhood, geographic residence, time, and child birth (for females only).
4. Family planning methods included: pills, condom, depot, IUD/coil, implant/norplant, BTL, spermicides, abstinence, calendar, lactation, herbs, or other method (specified)

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3 The unclear pathway from educational attainment, risk behavior, and HIV

3.1 Introduction

Education has a consistent and compounding effect on nearly all aspects of health, well-being, and economic growth[1]. Unequal access to schooling perpetuates poor maternal and child health, high adolescent birth rates, and diminishes opportunities for social and economic advantages and growth[2] Evidence on the association of education and HIV is less robust; the history of HIV risk and infection and its' relationship with education has changed as the HIV epidemic has changed. Early systematic reviews showed higher education associated with a higher risk of HIV infection[3]. More recent reviews of the literature show that the association between school enrollment and HIV has shifted and the association between education and HIV is less straight-forward[4,5]. Researchers are currently unable to say definitively whether education leads to less risk behaviors that impact HIV infection.

The HIV/AIDS epidemic and access to education have seen parallel improvements in recent decades. Nearly 40 years into the HIV/AIDS epidemic, there have been tremendous gains in care, treatment, and prevention of HIV. Yet, the epidemic still impacts millions of people worldwide. Similarly, access to education has improved for many throughout the twentieth and twenty-first centuries, although major disparities and gaps remain. The importance of education for health and development is highlighted by the United Nations (UN) in the Millennium Development Goal campaign (MDG, 2000 – 2015) and in the Sustainable Development Goals effort (SDG, 2015 – 2030)[6,7]. The UN calls for universal primary education (MDG 2) and inclusive and quality education for all (SDG 4)[6,7]. The failure to meet the MDG 2 of universal primary education indicates that much work still remains in education enrollment and attainment. In the current post-2015 agenda focusing on eliminating disparities and improving quality in education, now is a pivotal time to review what is known and what remains to be discovered about the relationship between educational attainment and the HIV/AIDS epidemic, two driving domains in policy and program planning.

This commentary is developed to examine in more detail findings from a recent systematic review and insights gleaned from data analyzed in Uganda on educational attainment, risk behaviors, and HIV incidence[4]. This commentary reviews access to education and key determinants of educational

attainment, using data from Uganda as a case study to describe the opportunities and challenges to increasing education enrollment and attainment. This paper examines the literature and data to understand the association between education and behaviors that influence risk of HIV infection. Finally, the paper discusses next steps in education and public health policy and research to further prevent HIV infections and promote improved health outcomes.

3.2 Access to education and the determinants of education worldwide

3.2.1 Access to education

While educational attainment has increased worldwide, challenges and disparities remain[8]. Recent estimates indicate approximately 263 million children and adolescents are out of school, including 61 million primary school age children, 60 million lower secondary school age children, and 142 million upper secondary school age children[9]. Years of education for people ages 15 and older ranges from 11.3 years in high-income countries to 7.2 years in low- and middle- income countries[10]. Sub-Saharan Africa and South Asia have the lowest years of education, with 5.3 years on average for those ages 15 and older[10]. In sub-Saharan Africa, estimates of youth out of school range from 20% of children ages 6 – 11, over 30% of children ages 12 – 14, and nearly 60% of children ages 15 – 17[9].

Significant progress has been made to close the gender gap in educational attainment in low- and middle-income countries. The ratio of female-to-male average years of schooling increased from around 62.5% in 1950 to 85.9% in developing countries[10]. Approximately 15 million primary school age girls are out of school compared to 10 million boys. Over half of these girls (9 million), live in sub-Saharan Africa[9]. Despite progress, the gender disparity in developing countries is comparable to advanced countries over half a century ago[10]. The gender disparity in education remains a particular challenge in sub-Saharan Africa, South Asia, and the Middle East[10]. In developing regions overall, girls in the poorest 20% of households are 3.5 times more likely to be out of school than girls in the richest households and 4 times more likely to be out of school than boys from the richest households[6]. Children living in rural areas are twice as likely to be out of school as children living in urban areas[6]. Reported reasons for children not enrolling in school include cost, social and cultural barriers, and disabilities[6].

3.2.2 A Socio-Ecological Model framework for education

The relationship between educational attainment and HIV is complex; a recent systematic review[4] and data from Uganda highlight the need for greater understanding of the multiple factors and pathways that may influence educational attainment. The Socio-Ecological Model (SEM) was developed as a conceptual model for understanding human development by Urie Bronfenbrenner[11]. The model looks at how health is affected by the interaction between characteristics of the individual, community, and surrounding environments; this model is used by the U.S. Centers for Disease Control and Prevention (CDC) and has been used by researchers in many domains, including health promotion, violence prevention, and preventative health[11]. SEM (Figure 1)[12] allows researchers to assess the multi-layer factors that influence educational attainment over time and determine how research, policy, and programs can align to improve education.

The country of Uganda has experienced both a changing HIV/AIDS epidemic and education landscape. This environment, along with the presence of the long-running population-based open cohort study, the Rakai Community Cohort Study (RCCS)[13], provides an opportunity to explore the opportunities and challenges to increasing education enrollment and attainment. Prior research from RCCS shows that HIV incidence in this population is greater among young women compared to young men[14]. Trends in HIV prevalence and incidence in Rakai, Uganda suggest that HIV infections are associated with changes in risk behaviors, sexual experience, school attendance, male circumcision, and social transitions in young people[14-16]. Research looking specifically at factors predicting school enrollment showed that rising socioeconomic status and declining orphanhood over time were associated with rising school enrollment, and that increasing school enrollment was associated with declining risk for HIV and pregnancy[17]

Societal Factors

Societal factors in the socioecological model (SEM) include local, state, national and global laws and policies. In 1997, the Government of Uganda implemented Universal Primary Education (UPE). The purpose of UPE was to eliminate the cost of primary schooling for up to four children per household – of which, at least two had to be girls[18,19]. Uganda was an early adopter of UPE, but the policy has a long history in sub-Saharan Africa. UPE became popular in the mid-1990s and was implemented by over fifteen low-income countries by 2011[20]. UPE in Uganda led to a dramatic increase in school enrollment,

from 2.8 million children enrolled in 1997 to 7.6 million children in 2004[19]. The direct and indirect costs of education were a significant barrier to education in Uganda. UPE increased school enrollment amongst Uganda's poorest children from 46% enrollment before UPE to 79% enrollment after UPE[18]. Girls' enrollment rates increased significantly after UPE; amongst the poorest girls, enrollment increased from 28% to 76% and amongst the wealthiest girls, enrollment increased from 66% to 85%. Although enrollment in school increased, progress toward educational attainment remains slow in Uganda[21]. Fifteen years after the adoption of UPE, educational attainment increased by only 1.09 years[21]. For women, educational attainment progress lags behind men (3.2 mean years vs. 5.3 mean years in 2002 compared to 4.2 mean years vs. 6.5 mean years in 2012)[21]. Primary school completion rates remain low; data estimate completion rates to be between 54 – 57%, well below the sub-Saharan Africa average completion rates of 67% and of neighboring Tanzania and Kenya (83% and 72% respectively)[22].

After the adoption of UPE, the Government of Uganda adopted University Secondary Education (USE) in 2007. The goal was to improve access to and quality of lower secondary schooling through three avenues: 1) expand access and improve attendance in secondary education, 2) reduce high cost of secondary education and 3) increase equitable access to secondary education. A principal factor is funding to offset tuition and related fees, which have been passed on to families or absorbed at the school level. Eligibility is determined by passing primary leaving examination, which only approximately 75% of students achieve. Whereas UPE was intended to make access to primary educational universally available for Ugandans, the purpose of USE was only to improve access to secondary education.[22] The USE policy shares the responsibility of education between parents, schools, and government – parents remain responsible for providing accommodation, lunch, uniforms, medical care, and school materials and the government subsidizes costs by providing school fees, textbooks and materials for students and teachers, school administration and maintenance[22]. USE is limited in its implementation, only applying to certain secondary levels and only implemented in selected schools that have tuition fees under a certain threshold. Based on these limitations, it is important to recognize that USE is neither "universal nor free"[22]**.** There is little evidence that this policy has improved attendance or retention in school and mixed evidence for the equity promoting effects of the policy. Between 2005 – 2011, overall lower secondary school attendance rates increased only slightly. Youth in the poorest quintile have 5% net attendance

rate while youth in the wealthiest quintile have 40% attendance rate, which suggests USE had little effect on the poorest households. Geographical disparities also remain; rural regions have the lowest attendance rates compared to urban regions which see attendance two-to-three times higher.[22] Improving policies related to accessing secondary education and improving the quality of education, in line with SDG 4, should be a focus of policy makers.

Community Factors

Community factors in the socioecological model (SEM) refer to settings in which social relationships occur and the characteristics of these settings that are associated with the outcome. Community-level determinants of education in Uganda include poverty and geographic residence. Research from RCCS shows that higher school enrollment is associated with higher socio-economic status (SES) for both men and women[17]. In this study, SES was measured using a survey of the structure of the participants dwelling and categorized into high SES (modern building materials), middle SES (at most two parts constructed using modern materials), and low SES (little to no modern materials). Geographic residence is a known community-level factor in accessing education in Uganda. Data from RCCS show that geographic residence influences educational attainment; a 2015 study showed that young women who reside in a rural village (compared to a trading village) were more likely to attend school, though the finding was not significant for young men[17]. Unpublished data from 2018 looks at the difference between rural and urban villages and found that living in an urban area (compared to a rural area) was significantly associated with secondary education for both young men and young women.

Interpersonal Factors

The most influential interpersonal determinants of educational attainment relate to family structure. For girls, marriage and pregnancy are the strongest determinants of education attainment or leaving school; 35% of girls drop out of school because of marriage and 23% of girls drop out because of pregnancy[23]. Other relationship-level determinants of school enrollment in Uganda for girls include age, mother's education, religion, and the age of the head of household[19]. For boys, one of the most significant associations with school enrollment is household expenditures; higher household expenditures are associated with higher school enrollment[19,24]. Research shows that the experience of orphanhood in

Uganda has an adverse impact on school enrollment[17,25]. In particular, paternal orphans are less likely to enroll and continue with school[25]. Orphans from the poorest households are significantly less likely to continue schooling[25]. Other relationship level reasons for non-enrollment in school in Uganda include a financial barrier to enrollment because families cannot pay school tuition or fees and for young girls, being pregnant or married[19,24].

Individual Factors

Individual factors in SEM refer to personal characteristics that may influence the outcome. The strongest personal characteristic that influences educational attainment is gender. Gender is a determinant of educational attainment that can be interwoven into all levels of SEM; gender norms and expectations are socially and culturally determined and the manifestations of these norms lie within interpersonal relationships. Although research shows that the gender gap in Uganda is closing regarding school enrollment[17], girls drop out of school more often than boys, exam scores remain lower for girls compared to boys, and girls are less likely to be age-appropriately enrolled in school[26]. Previous research from RCCS concluded that the gender gap for current school enrollment emerges for older adolescents, ages 18 – 19 years[17]. School enrollment was more likely for younger individuals, indicating that educational attainment declines as individuals' age and priorities of individuals and families change[17]. Qualitative data show that financial constraints often cause individuals to decide to drop out of school, foregoing attending school so as to not burden their family or prevent younger siblings from receiving education[17].

3.3 The relationship between educational attainment and HIV

Social structural and behavioral determinants of HIV acquisition include socioeconomic status, household characteristics, gender, geographical residence, and sexual behaviors; these are well reviewed in the scientific literature[27-31]. Evidence on the impact of education on HIV infection is less robust and associations have changed over time[3-5]. Early in the HIV epidemic, risk was linked to higher SES, more frequent travel, and increased educational attainment[32]. In 2002, a systematic review showed mixed results when looking at HIV and educational attainment[3]. Results from African studies showed increased risk of HIV in more educated people; this association was stronger in rural areas and in older people, but was similar for men and women[3]. Studies from Thailand in the same review showed the opposite effect -

education was protective against HIV[3]. An updated systematic review revisited the association between educational attainment and risk of HIV infection in sub-Saharan Africa[5]. Results showed that in earlier data, there was either no association or the highest risk of HIV infection among the most educated[5]. Later studies found that the association reversed; those with the highest education had a lower risk of HIV infection[5]. Over time, HIV prevalence fell consistently among highly educated compared to less educated groups, whose HIV prevalence rose while the overall population prevalence was falling. Conclusions from this review indicate that new infections in the late 1990s and early 2000s were occurring disproportionately among the least educated people, and behavior change (safer sex behavior, delayed age at risk sex, reduced partner numbers) to reduce risk of HIV was greater among the most educated[5].

An unpublished systematic review from 2018 reviewed twenty-two articles with over 315,000 participants from 18 countries[4]. While over half of the articles included in this review indicated that higher education was associated with lower rates of HIV incidence, there was still significant variability in the findings. Two studies indicated that those with higher education had an increased risk of HIV; four studies showed no association between education and HIV serostatus; and five studies resulted in mixed conclusions based on gender and age or grade level[4]. Mixed associations came from studies that reported differing conclusions often based on gender. The studies included in this review highlighted differences in associations between education and HIV based on gender; articles that identified a negative correlation between education and HIV were more likely to have data collected after the year 2000[4]. Although articles from 2007 – 2017 were eligible to be included in this review, the most recent publications identified were from 2015 and the most recent data were from 2013. Utilizing the Newcastle-Ottawa Scale for quality assessment of cross-sectional, cohort, and case-control studies[33-35], the majority of studies included in this review were of fair quality. Across all of the studies, the strongest quality category was the assessment of the outcome variable; all but one study used verified biological testing to determine HIV status in participants and all statistical tests were clearly described, justified, and presented. The weakest quality measure was selection of participants; several cross-sectional and cohort studies sampled from a selected group of users not deemed representative of the target population and the majority of cross-sectional studies did not compare the characteristics of the respondents vs. non-respondents, which may imply a self-selection bias. All studies used subjective measures of self-reporting to determine

educational attainment and some studies did not control for adequate confounding variables, such as socioeconomic status. By addressing the presenting weaknesses in quality, particularly in representative sampling, measurement of educational attainment and more robust comparability in the analysis, future research will further enhance the quality of evidence. Updated data collection and publications on the association between education and HIV and represent diverse settings are needed to contribute to this field of study.

An analysis of data from Uganda and RCCS confirmed mixed associations between educational attainment and risk factors for HIV incidence, and highlighted important differences between men and women. Educational attainment proved to be protective in relation to some risk factors among women compared with men. Educational attainment was associated with delayed first sexual experience and fewer sexual partners in women – these associations were not significant in men. In contrast, higher education for women was significantly associated with inconsistent condom use and less partner HIV status disclosure; these variables were not significantly associated among men in the sample. For both men and women, higher education was a risk factor for having concurrent partners. The role of concurrent sexual relationships has been identified as important for the transmission of HIV and other sexually transmitted diseases[36,37]. Fifty percent of men and nearly 20% of women noted that they had a sexual relationship outside of their marriage or partnership.

Reviews of the literature and analysis of data from Uganda highlight the differences in associations between educational attainment and HIV infection. Limitations of the research may contribute to these varying associations. The first major limitation is quality of the evidence available; the most recent synopsis of the literature shows that of 22 research studies with HIV as an outcome, fifteen were cross-sectional studies, five were cohort design, and two were case-control studies[4]. Cross sectional studies are limited in the ability to determine behavior over time and causation; researchers are currently unable to say whether education leads to less HIV infection or whether becoming infected with HIV leads to less education. Second, it is often difficult to parse educational attainment from socioeconomic status. Educational attainment is among the most widely used indicators of SES, often due to its influence on future economic opportunities and growth[38]. Studies often utilized a resource-based composite measure of SES, including measures of educational attainment, occupation, family income, and material wealth.

Given that educational attainment is influenced by socioeconomic status, it may well be that socioeconomic status is more of an appropriate indicator for risk behavior and associated health outcomes than education. Alternative recommendations for conceptualizing and measuring socioeconomic status that do not include educational attainment include measures of occupational prestige, absolutely poverty measures (where available), measures of relative poverty, and subjective social status measures[39]. Particularly in this time of focusing on enrolling and encouraging all socioeconomic classes into school, more nuanced measures of socioeconomic status that desegregate educational attainment from socioeconomic status may give those planning programs and implementing policies more targeted entry points for influencing risk behavior and health outcomes.

3.4 Conclusion

Despite progress in both the HIV/AIDS epidemic and in educational attainment, major disparities and gaps remain. This commentary reviews what is known and what remains to be clarified about the relationship between educational attainment and the HIV/AIDS epidemic, two driving domains in policy and program planning. More updated data and high-quality research needs to be conducted in a variety of diverse settings in order to understand how education can influence the HIV epidemic in the current environment. Moreover, researchers should ensure that they are looking at the entire context of education and desegregating educational attainment from socioeconomic status measured using alternative measures to better target key entry points for change. The SEM model provides a framework to evaluate the multi-layer factors that influence educational attainment over time and determine how research, policy, and programs can align to improve education. By understanding the societal, community, interpersonal, and individual level factors that influence educational attainment, researchers will to provide a three-dimensional view of the facilitators and barriers to education and identify key points for further examination. Moreover, understanding the spheres of influence presented in the SEM will allow us to explore and better understand how school-based health promotion curricula in primary and secondary education can focus on community, relationship, and individual factors to enhance skills needed to prevent risk behavior. Policy makers can utilize this research to evaluate existing policies and implement new polices as needed. The failure to meet the MDG 2 of universal primary education indicates that much work still remains in the policy and program implementation realms of education enrollment and

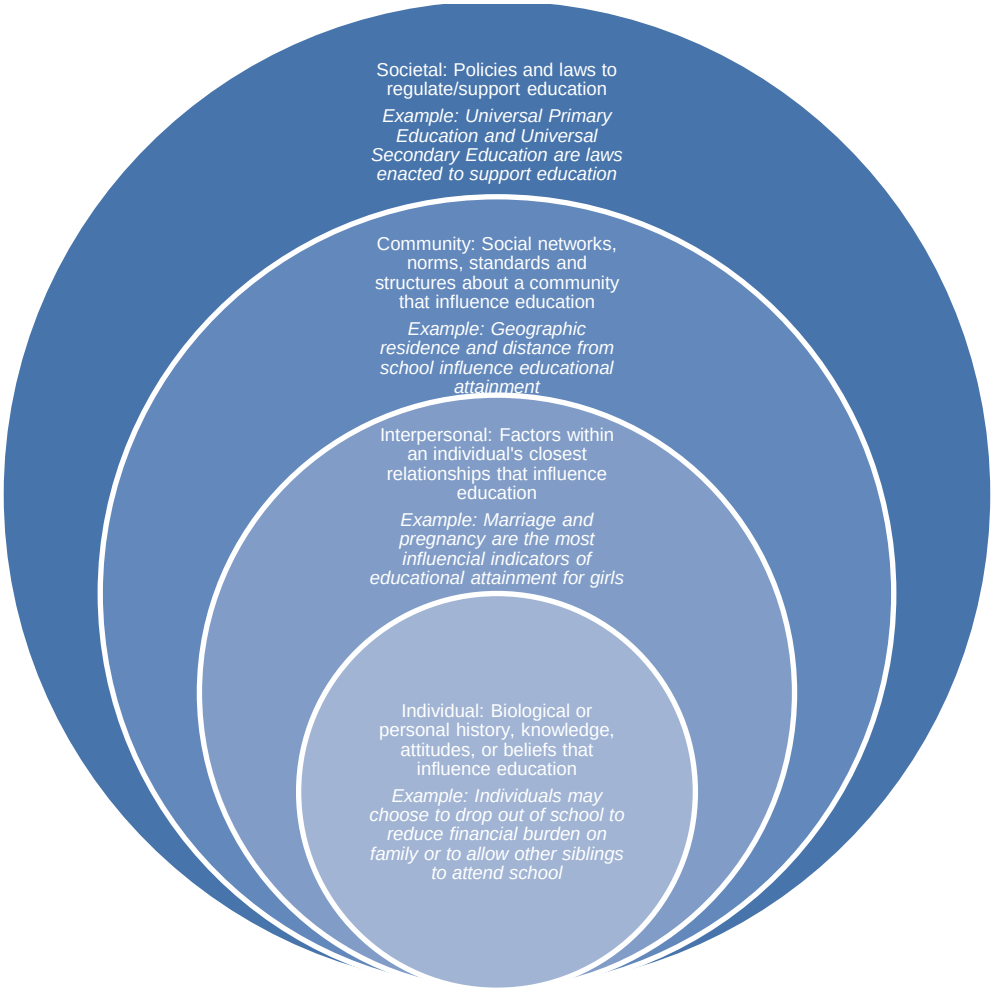
attainment. Beyond primary education, a renewed focus on secondary education, quality education, and gender equality will maximize the benefits of education.

3.5 Figures and Tables

Key points for research, policy, and program planning

- Collect, analyze, and publish updated and rigorous evidence on the association between education, risk behavior, and health outcomes, including HIV infection;
- Improve methodology for measuring socioeconomic status, desegregating educational attainment from socioeconomic status measures
- Improve policies related to accessing secondary education and improving quality of education, in line with Sustainable Development Goal 4;
- Explore and better understand how school-based health promotion curricula in primary and secondary education can focus on community, relationship, and individual factors to enhance skills needed to prevent risk behavior.

Figure 4 A Socio-Ecological Model framework for education in Uganda



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