1 **Sexual and reproductive health knowledge among adolescents in eight sites across sub-Saharan Africa**

2 **Jocelyn E. Finlay [1*], Nega Assefa[2], Mary Mwanyika-Sando[3], Yadeta Dessie[2], Guy Harling[4,5,6], Tasiana Njau[7],**
3 **Angela Chukwu[8], Ayoade Oduola[8], Iqbal Shah[1], Richard Adanu[9], Justine Bukenya[10]**

4

5 [1] Department of Global Health and Population, Harvard T.H. Chan School of Public Health, 665 Huntington Avenue,
6 Boston, MA 02115, USA

7 [2] College of Health and Medical Sciences, Haramaya University, PO Box 138, Dire Dawa, Ethiopia

8 [3] African Academy for Public Health, Dar es Salaam, Tanzania

9 [4] Institute for Global Health, University College London, Mortimer Market Centre, London WC1E 6JB, UK

10 [5] Africa Health Research Institute, KwaZulu-Natal, South Africa

11 [6] Department of Epidemiology & Harvard Center for Population and Development Studies, Harvard T.H. Chan School of
12 Public Health, 677 Huntington Avenue, Boston, MA 02115, USA

13 [7] Muhimbili University of Health and Allied Sciences (MUHAS), United Nations Road, Dar es Salaam, Tanzania

14 [8] Department of Statistics, University of Ibadan, Oduduwa Road, Ibadan, Nigeria

15 [9] Department of Population, Family and Reproductive Health, University of Ghana, Legon Boundary, Accra, Ghana

16 [10] Department of Community Health and Behavioral Sciences, Makerere University School of Public Health (MUSPH),
17 New Mulago Hill Road,Kampala, Uganda

18

19 *Corresponding author

20

21 **Author Email Addresses:**

22 Jocelyn E. Finlay: jfinlay@hsph.harvard.edu

23 Nega Assefa: negaassefa@yahoo.com

24 Mary Mwanyika-Sando: mmwanyika.sando@gmail.com

25 Yadeta Dessie: yad_de2005@yahoo.com

26 Guy Harling: g.harling@ucl.ac.uk

27 Tasiana Njau: tnjau@muhas.ac.tz

28 Angela Chukwu: unnachuks2002@gmail.com

29 Ayoade Oduola: amjoduola@hotmail.com

30 Iqbal Shah: ishah@hsph.harvard.edu

31 Richard Adanu: rmadanu@yahoo.com

32 Justine Bukenya: jbukenya@musph.ac.ug

33

Authors contributions: Project conception, Instrument development, Data collection, Data management (site), Data management (pooled), Statistical Analysis, Initial Drafting, Editing, Final Drafting, Submission

JF: Project conception, Data management (pooled), Statistical Analysis, Initial Drafting, Editing, Final Drafting, Submission

NA: Data collection, data management, Editing, Agreement for submission

MMS: Data collection, data management, Agreement for submission

YD: Data collection, data management, Editing, Agreement for submission

GH: Data collection, data management (Nouna), Editing, Final drafting, Agreement for submission

TN: Data collection, data management, Editing, Agreement for submission

AC: Data collection, data management, Editing, Agreement for submission

IS: Editing, Final drafting, Agreement for submission

RA: Data collection, data management, Editing, Agreement for submission

JB: Data collection, data management, Editing, Agreement for submission

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Abstract

Objective: Sub-Saharan Africa's (SSA) 10-24 year-old mortality rate is twice that of any other region, with maternal mortality and HIV the leading causes of death and disability. Although the Sustainable Development Goals and the Strategy for Every Women, Every Adolescent and Every Child, now extend to adolescents, much still needs to be understood for effective programmatic interventions to improve adolescent sexual and reproductive health (SRH) across SSA. The aim of this study is to examine knowledge of menstruation, HIV and STIs other than HIV across eight sites in SSA to develop effective programmatic interventions enabling adolescents to achieve positive SRH as they transition to adulthood.

Methods: We combine data from eight Health and Demographic Surveillance Sites across SSA, from an adolescent-specific survey that included 7,116 males and females age 10-19 years old. We provide pooled, and site-specific estimates from multiple analytic models examining the how year-specific age, school attendance, and work correlate with knowledge of menstruation, HIV knowledge, and knowledge of STIs other than HIV.

Results: We find that many adolescents lack knowledge of menstruation (37.3%, 95% CI 31.8, 43.1 do not know of menstruation) and STIs other than HIV (55.9%, 95% CI 50.4, 61.3 do not know of other STIs). In multivariate analysis we find that older age, being in school, and wealth are significant positive correlates of STI knowledge. Older adolescent age, female gender, and being in school are significant positive correlates of knowledge of menstruation. We find that knowledge of HIV is high (89.7%, 95% CI 8.3, 12.7 know of HIV), and this knowledge is relatively similar across adolescent age, gender, wealth, and school and work attendance.

Conclusion: Knowledge of HIV seems widespread across adolescents inthese communities, but knowledge of other dimensions of SRH – menstruation and other STIs in this study – seem lacking especially for early adolescents (10-14 year olds). The dissemination of more comprehensive SRH information is needed within these and similar communities in SSA to help adolescents gain insight on how to make their own decisions towards positive adolescent SRH and protect them from risks.

Keywords: Adolescent, sexual and reproductive health, sub-Saharan Africa, knowledge

Introduction

The World Health Organization, Global Accelerated Action for the Health of Adolescents (AA-HA!) (1) noted that maternal deaths are the leading cause of death for adolescent females in low- and middle-income countries (LMIC) (2). For male adolescents in sub-Saharan Africa (SSA), HIV is the fourth leading cause of death. These extreme outcomes can be mitigated by improved adolescent sexual and reproductive health (SRH) knowledge.

Several high-level strategies have been promoted to improve health outcomes for adolescents, particularly those relating to SRH. The Global Strategy of Every Woman Every Child (3) now includes adolescents, and is the Global Strategy of Every Women, Every Adolescent, and Every Child, in recognition of the unique challenges faced by adolescents in working towards achieving the Sustainable Development Goals (SDGs). In particular, SDG goal number three to "ensure healthy lives and promote well-being for all at all ages", goal four to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" and goal five to "achieve gender equality and empower all women and girls", highlight the needs for adolescents in improving their health and welfare, and their SRH.

Health improvements begin with knowledge of health. Having knowledge enables adolescents to have agency over their own bodies and protects against risky sexual behaviours (early sexual debut, sex without condoms, sex with multiple partners). The continuum of SRH knowledge acquisition builds throughout adolescence, beginning with the need for basic knowledge of the reproductive system in the early teen years and advancing to knowledge of sexual behaviour and the potential risks of sexually transmitted infection (STI) in later adolescence. In this paper, we explore how sexual and reproductive health knowledge varies across the adolescent age spectrum from 10 to 19 years of age, and how year-specific age, gender, school and work attendance, wealth and sexual experience correlated with knowledge of menstruation, HIV, and STIs other than HIV.

From the adolescent's perspective, they do not perceive themselves to be lacking in SRH knowledge (4). Glinski et al (4) find that while a high percentage of adolescents across the developing world report knowledge of at least one method of contraception, they did not know that they could get pregnant the first time they had sex. Adolescents' had an incomplete range of knowledge regarding basic sexual and reproductive health.

It has been found that for older adolescents, 15-19 years olds, knowledge of HIV and other sexually transmitted diseases is important to promote the use of condoms, and prevent sexually transmitted disease transmission and unintended pregnancy. For younger adolescents, knowledge of reproductive health, menstruation for example, and the implications of this for sex and reproduction are important in understanding the consequences of sexual debut.

For adolescents, SRH knowledge is acquired from school-based sex-education programs, friends, parents, extended family, local organizations (including health care clinics) and media. School-based comprehensive sex education has been shown to increase knowledge of SRH (5-7), but not all programs have had a positive impact on SRH behaviour. Those that did have a positive impact on SRH behaviour were school-based sex education programs that had a complementing community-based component that reinforces norms outside of the school environment (i.e. youth-friendly service training for healthcare staff, distributing condoms, and community and parent involvement in curriculum development) (8, 9).

Having conversations regarding SRH with parents (10-18) can have a beneficial impact on adolescent sexual behaviour (19, 20), not just mothers but also when there is good rapport between fathers and daughters (21). Adolescents in the US express that they prefer their knowledge to come from a clinician, and that the clinician initiate the conversation around SRH (22), however in the sub-Saharan African context the stigma of attending clinics (especially for SRH consultation) creates a barrier for the clinician as a preferred source of SRH knowledge as African adolescents can anticipate poor treatment from providers due to stigma surrounding their attendance (23, 24).

Peer-led education programs, which aim to draw on adolescent social networks to communicate SRH information have been found to be largely ineffective (8, 25-28). Though these programs may result in improvements in knowledge, attitudes, and intentions, few programs result in improvements on health outcomes. One review of evidence found that peer-led education mainly benefits the educator (due to training and supervision) rather than the beneficiary (8).

The infrastructure and culture to support knowledge transfer in an age-appropriate way (for 10 year olds, for 19 year olds) is often lacking. Poor infrastructures and low accessibility of rural areas in Northern Ghana may have led to uneven distribution of reproductive health educational programs in the country (29). A recent Ethiopia Demographic and Health Survey (EDHS) data from Ethiopia indicates a decrease in HIV knowledge compared to previous EDHS findings (30).

In this paper, we explore how SRH knowledge varies across the adolescent age spectrum from 10 to 19 years of age, and how age, gender school and work status, wealth, and sexual experience intersect and reflect in knowledge of menstruation, HIV, and STIs other than HIV.

Methods

Study Setting and Participants

We conducted an exploratory, observational analysis based on data collected at one point in time from eight sub-Saharan African research sites. We use data from eight Health and Demographic Surveillance Sites (HDSS) in six SSA countries as part of the that are part of the African Research, Implementation Science, and Education (ARISE) Network Adolescent Health Study: Burkina Faso (rural, Nouna), Ethiopia (rural, Kersa), Ethiopia (urban, Harar), Ghana (rural, Ningo Prampram), Nigeria (rural, Ibadan), Tanzania (rural, Dodoma), Tanzania (urban, Dar es Salam), Uganda (rural, Iguanga/Mayuge). HDSSs follow geographically defined populations through regular household surveys to establish a longitudinal database of individuals and social units in the surveillance areas. Details of the selection and socio-demographic characteristics of the eight sites are provided in the Age of Opportunity paper in this issue (31).

The ARISE Adolescent Health Study surveys were conducted in 2016 and 2017. Details of the data collection at each of the sites are documented by Berhane et al. (31) elsewhere (32).

Variables

Outcome measure: We focused on three questions that probed both female and males adolescents' detailed self-reported SRH knowledge: (i) menstruation knowledge – "Have you heard of the term 'menstruation' or 'having one's period?"; (ii) HIV knowledge – "Have you heard of HIV or AIDS?"; and (iii) STI knowledge – "Apart from HIV/AIDS, there are other

diseases that men and women can catch by having sexual intercourse. Have you heard of any of these diseases?" All three
questions had binary responses: 'Yes' or 'No'.

Exposure variables: To capture the pathways of knowledge level and acquisition, we included several social and
demographic factors: age (in completed years at interview between 10-19); gender (male/female); current enrolment in
school at interview (yes/no); whether the participant had worked for money in the past 12 months (yes/no); and whether
the respondent's mother was alive (yes/no), and self-reported sexual debut. We also included household wealth as
quintiles of the first site-specific principle component of a list of assets reported by the participant (32). The Wealth Index
is a relative measure of wealth, and specific to each site and not comparable across sites.

Data Sources/Measurement

Information from adolescent-specific surveys at six Demographic and Health Surveillance Sites (DHSS) in 2016 provided
the data for the analysis in the study. The adolescent health survey was conducted under the auspice of the Africa
Research, Implementation Science, and Education (ARISE) Network, and was not part of the routine HDSS data
collection rounds. The adolescent survey included males and females, and recruited individuals aged between 10-19 years
old. The survey measures were standardized across the eight sites analyzed in this paper and were largely based on the
Global School-Based Health Survey, with some modifications described elsewhere (32). The sampling strategy is
documented in Berhane et al. (31).

Statistical Methods

We used log binomial, random effects, Poisson regression estimation models since these provide relative risk ratios,
which are more appropriate for binary outcomes when the outcome is not rare and thus odds ratios and risk ratios diverge
(33). We first estimated unadjusted models for each of the three outcomes for exposures, and then adjusted models
including all covariates and a dummy variable for each site to capture elements that are common to all people within each
site. Higher relative "risk" ratios are associated with greater knowledge about menstruation, HIV, and STIs, thus reflects a
greater chance of knowledge.

Summary statistics are weighted (32) to take into account over-sampling of minority population within country specific
sites, but regressions are not weighted (34). We used a complete case analysis, dropping any observations missing values
for outcomes, exposures or covariates, or missing sampling or non-response weights.

Ethical Review

The ARISE Adolescent Health Study was approved by the Harvard T.H. Chan School of Public Health Institutional
Review Board. Site-specific approvals were gained for all eight sites (32).

Results

Overall, 7,663 males and females aged 10-19 years old were interviewed across the eight sites. There were 7,523 valid
responses (98.2%) for STIs other than HIV knowledge (Table 1). After removing observations with missing exposures

185 (n=101), covariates (n=133) or sampling and response weights (n=173), our final analytic sample was 7,116 male and
186 female respondents aged 10-19 across the eight sites.

187 Two-thirds of respondents (62.7%; 95% CI 31.8, 43.1) self-reported knowing about menstruation, 89.7% (95% CI 87.3,
188 91.7) about HIV, and 44.1% (95% CI 38.7, 49.6) about STIs other than HIV. Table 2 shows demographic characteristics of
189 the pooled study sample. In the pooled sample, the confidence intervals of each age in years 10-19 overlapped, indicating
190 that across the sample age adolescents were interviewed in equal proportion. Three sites were self-weighting, Ethiopia Rural
191 (Kersa), Ethiopia Urban (Harar) and Nigeria Urban (Ibadan), and the sample means reflect the population mean. More
192 females (n=3,796) than males (n=3,320) were in the study sample. Adolescents currently not in school accounted for 29.4%
193 (95% CI 23.0, 36.7) of the study sample. In the study sample, 33.2% (95% CI 23.3, 44.7) had worked in the past 12 months.
194 The mother was alive (either only mother alive, or both mother and father alive) for 95.7% (95% CI 95.0, 96.2) of the study
195 sample. Adolescents in the study sample were evenly split across the five wealth quintiles, with 19.2% (95% CI 15.9, 23.0)
196 of the sample in the poorest quintile and 19.8% (95% CI 15.8, 24.5) in the richest wealth quintile. Those who reported to
197 have ever had sex made up 14.2% (95% CI 9.3, 21.2) of the study sample, which may be under-reported (35).

198 Table 3 shows the distribution of covariates by the outcome response. Only 14.3% (95% CI 10.6, 18.9) of 10 year olds
199 knew about menstruation, while 70% (95% CI 64.4, 76.7) knew about HIV, and only 8.5% (95% CI 6.5, 11.0) knew about
200 STIs other than HIV. By the age of 19 nearly everyone knew about menstruation (92.3%, 95% CI 87.3, 95.5) and HIV
201 (97.9%. 95% CI 95.7,98.9), but still only 70.9% (95% CI 64.7, 76.3) knew about STIs other than HIV. Female
202 adolescents were more knowledgeable with regard to menstruation (67.7%, 95% CI 60.3, 74.4) than male adolescents
203 (56.5%, 95% CI 49.2, 63.6), but HIV knowledge was more balanced between females (90%, 95% CI 88.1,91.7) and males
204 (89.4%, 95% CI 86.0,92.1), as was STI knowledge between females (45%, 95% CI 37.9,52.3) and males (43%, 95% CI
205 38.6,47.6). A greater fraction of adolescents in school had knowledge of menstruation (64.4%, 95% CI 60.0,68.6), HIV
206 (92.5%, 95% CI 90.6,94.1), and other STIs (47.4%, 95% CI 42.3,52.5), compared to the fraction out of school who knew
207 of menstruation (58.6%, 95% CI 49.2,67.4), HIV (83%, 95% CI 78.8,86.6), and other STIs (36.2%, 95% CI 28.0,45.2). A
208 greater fraction of adolescents who worked in the past year had knowledge of menstruation (64.4%, 95% CI 60.0,68.6),
209 HIV (92.5%, 95% CI 90.6,94.1)), and other STIs (47.4%, 95% CI 42.3,52.5), compared to the fraction out of school who
210 knew of menstruation (58.6%, 95% CI 49.2,67.4), HIV (83%, 95% CI 78.8,86.6), and other STIs (36.2%, 95% CI
211 28.0,45.2). Of those in the poorest wealth quintile, 56.4% (95% CI 46.3,66.1) knew of menstruation, 84.9% (95% CI
212 77.6,90.2) knew of HIV, and 33.7% (95% CI 28.4,39.4) knew of STIs other than HIV. Of those in the richest wealth
213 quintile, 72% (95% CI 68.5,75.2) knew of menstruation, 92.6% (95% CI 89.4,94.9) knew of HIV, and 53.9% (95% CI
214 44.5,63.0) knew of other STIs. The prevalence of those who had sex was low, (Table 2), but of those who had sexual
215 debut, 82.2%, (95% CI 70.2,90.1) knew of menstruation, 95.4%, (95% CI 93.0,96.9) knew of HIV, and 63.4%, (95% CI
216 57.4,68.9) knew of STIs other than HIV. Of those (majority) who had not had their sexual debut, 59.6% (95% CI
217 53.1,65.7) knew of menstruation, 88.8% (95% CI 86.1,91.1) knew of HIV, and 40.9% (95% CI 36.1,45.8) knew of STIs
218 other than HIV.

219 In Table 4, we used a bivariate Poisson model to calculate the relative risk (chance) of (yes to) knowing about

220 menstruation, HIV, and that there are STIs other than HIV that one can get from unprotected sex. We found that

221 knowledge of menstruation and STIs other than HIV increased sharply with age. Those participants aged 19 were 6.5

222 times (95% CI 5.203, 8.060) more likely to know about menstruation than their reference group (10 year olds). Those

223 participants aged 19 were 8.4 times (95% CI 6.2, 11.2) more likely to know about other STIs than the reference group (10

224 year olds). Age had a small association with HIV knowledge, and those aged 19 at the time of the interview were 1.4

225 times (95% CI 1.302, 1.463) more likely to know about HIV than the reference group 10 year olds.

226 Females were more likely (URR 1.1, 95% CI 1.154, 1.245) than males to know about menstruation, but gender

227 differences were not significantly different (at the 95% level) for knowledge of HIV or STIs other than HIV. Those in

228 school were more likely to know about menstruation (URR 1.099, 95% CI 1.054, 1.147), HIV (URR 1.114, 95% CI

229 1.091, 1.138) and STIs other than HIV (URR 1.309, 95% CI 1.228,1.396). Those who had reported to have worked in the

230 past year were more likely to know about menstruation (URR 1.069, 95% CI 1.029, 1.110), HIV (URR 1.031, 95% CI

231 1.015, 1.048) and STIs other than HIV (URR 1.178, 95% CI 1.117, 1.243), compared to adolescents who reported not to

232 have worked in the past year. Those in the richest wealth quintile were more likely to know about menstruation (URR

233 1.276, 95% CI 1.204, 1.352), HIV (URR 1.090, 95% CI 1.062, 1.120) and STIs other than HIV (URR 1.599, 95% CI

234 1.464, 1.748), compared to adolescents who lived in households within the poorest wealth quintiles within their sites.

235 Those who reported to have ever had sex were more likely to know about menstruation (URR 1.381, 95% CI 1.331,

236 1.432), HIV (URR 1.074, 95% CI 1.056, 1.091) and STIs other than HIV (URR 1.551, 95% CI 1.467, 1.640), compared to

237 adolescents who lived in households within the poorest wealth quintiles within their sites.

238 In the multivariate analysis, Table 5, we show that even after controlling for gender, school and work status, wealth

239 quintile, sexual debut, and site fixed effects, age remains a strong predictor of knowledge of menstruation and STIs other

240 than HIV, with a slight correlation with knowledge of HIV. Adolescents age 19 are more likely to know about

241 menstruation (ARR 6.625, 95% CI 1.056, 1.091), HIV (ARR 1.410, 95% CI 1.331, 1.494), and STIs other than HIV

242 (ARR 7.954, 95% CI 5.913 - 10.70), compared to 10 year olds, even after controlling for school and work status, gender,

243 wealth, sexual debut and site fixed effects. In the multivariate analysis, school attendance remains important correlates of

244 knowledge of menstruation (ARR 1.263, 95% CI 1.214, 1.313), HIV (ARR 1.147, 95% CI 1.120 - 1.174) and STIs other

245 than HIV (ARR 1.625, 95% CI 1.527 - 1.730). But work, wealth, and sexual experience show these factors are less

246 important once the correlation of age and other covariates are controlled for in the estimation.

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Discussion

In this paper, we explored the determinants of adolescents' knowledge of menstruation, HIV and STIs other than HIV across eight sites in sub-Saharan Africa. We examined the pooled sample of 7,116 across the sites in Burkina Faso (rural, Nouna), Ethiopia (rural, Kersa), Ethiopia (urban, Harar), Ghana (rural, Ningo Prampram), Nigeria (rural, Ibadan), Tanzania (rural, Dodoma), Tanzania (urban, Dar es Salam), Uganda (rural, Iguanga/Mayuge). We found that knowledge of menstruation and STI's other than HIV varied greatly across the adolescent age spectrum from age 10 to age 19, with adolescents age 19 much more likely than younger adolescents to know about menstruation and STIs other than HIV. However, HIV knowledge was much higher than knowledge of menstruation and STIs other than HIV, and this high rate of knowledge of HIV was consistent across the adolescent age spectrum.

Knowledge of HIV may be greater than knowledge of menstruation and STIs other than HIV, as it is a visible dimension of sexual and reproductive health. Menstruation can be hidden from other household members; other STIs may not have the same impact on morbidity as HIV. HIV has a high impact on morbidity and reliance on treatment that may not be as easy to hide from household members. Young adolescents may also be primary caregivers of HIV positive relatives, and this may be known within households and across peers of similar age.

Adolescents are under-served when it comes to SRH knowledge dissemination (35). This includes knowledge of the risks of sexual debut, but also knowledge of services and products that would help them achieve positive sexual and reproductive health (36). Taking a unified approach to SRH for adolescents would help to equalize knowledge across various dimensions of SRH, and not be limited to HIV alone (37).

While the data collection, data cleaning, and analysis is conducted within a rigorous framework, some limitations of this study still exist. All data collected were quantitative. In many of the questions, the adolescents are requested yes/no responses. This may mean that the responses reflect a guess either way for the adolescent rather than an indication of their true knowledge. The addition of open ended, qualitative questions in future surveys may provide a better measure of this. Furthermore, the questionnaire used in this study was not validated and therefore may be subject to measurement error. However, the majority of the questions were drawn from an extensively validated tool that has been widely used in this region (32).

The settings where data were collected at the household level could have led to under-reporting of socially undesirable behaviours among adolescents. Adolescent could have fear that parents and guardians could be listening to the interviews though the adults in the home were requested to provide privacy by leaving adolescents alone with the interviewers. However, for an overview of adolescent behavior the brevity and clarity of the survey enabled the participants to respond to respond without hesitation.

From the analysis in this paper, we can interpret the results to indicate that many adolescents lack comprehensive knowledge of sexual and reproductive health across its many dimensions. Here we compared knowledge of three dimensions: menstruation, HIV and STIs other than HIV, and found that knowledge of HIV was much more positive

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281 across all ages, than the other two SRH dimensions. This finding complements other studies that found good knowledge

282 of contraception, but poor knowledge of the likelihood of pregnancy from sexual intercourse (4).

283 Although these results are not generalizable to the regional or national adolescent population of any countries, theyare

284 generalizable within the sites, as the statistics are weighted to reflect the demographic composition of the site. The sample

285 had both urban and rural examples, and a range of sub-Saharan African countries. The over-arching results could inform

286 policy in geographically and demographically similar communities across sub-Saharan Africa in a step to improve

287 adolescent SRH through complete and accurate information dissemination – within and out of schools and work places.

288 Table 1: Deduction of the analytic sample

	Observations Dropped	Sample Size
Surveyed Sample		7,663
STI Detailed Knowledge		7,523
no response recorded (.)	*136*	
coded as 9	*3*	
Invalid coding (0)	*1*	
Social and demographic risk factors		
invalid or missing responses	*101*	
Ever had sex variable included		7,422
invalid or missing responses	*133*	
Sample weights included		7,289
Invalid or missing responses	*173*	
Final analytic sample		7,116

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Table 2: N, weighted %, and 95% confidence intervals, of outcome and exposure variables, by site and pooled.

	%	95% CI
Knowledge of menstruation		
No (n=2,544)	37.3	(31.8,43.1)
Yes (n=4,280)	62.7	(56.9,68.2)
Knowledge of HIV		
No (n=730)	10.3	(8.3,12.7)
Yes (n=6,382)	89.7	(87.3,91.7)
Knowledge of STIs other than HIV		
No (n=3,980)	55.9	(50.4,61.3)
Yes (n=3,136)	44.1	(38.7,49.6)

Age of respondent in years	weighted%	95% CI
10 (n=495)	7	(3.9,12.1)
11 (n=585)	8.2	(6.1,11.0)
12 (n=813)	11.4	(10.0,13.1)
13 (n=893)	12.5	(11.3,13.9)
14 (n=909)	12.8	(11.7,13.9)
15 (n=775)	10.9	(9.9,12.0)
16 (n=807)	11.3	(10.3,12.4)
17 (n=682)	9.6	(8.6,10.7)
18 (n=735)	10.3	(8.9,12.0)
19 (n=422)	5.9	(4.3,8.0)
Gender		
Male (n=3,320)	46.7	(44.0,49.3)
Female (n=3,796)	53.3	(50.7,56.0)
In School		
No (n=2,090)	29.4	(23.0,36.7)
Yes (n=5,026)	70.6	(63.3,77.0)
Worked in the past 12 months		
No (n=4,756)	66.8	(55.3,76.7)
Yes (n=2,360)	33.2	(23.3,44.7)

Mother alive

No (n=309)   4.3   (3.8,5.0)

Yes (n=6,807)   95.7 (95.0,96.2)

Wealth quintile

Poorest (n=1,368)   19.2 (15.9,23.0)

Poor (n=1,474)   20.7 (18.5,23.2)

Middle (n=1,458)   20.5 (19.3,21.8)

Rich (n=1,406)   19.8 (17.9,21.8)

Richest (n=1,410)   19.8 (15.8,24.5)

Ever had sex

No (n=6,103)   85.8 (78.8,90.7)

Yes (n=1,013)   14.2 (9.3,21.2)

Table 3: Weighted prevalence of knowledge of menstruation, HIV and STIs other than HIV by age, gender, school and work status, wealth, and sexual debut

Age of respondent in years	Knowledge of menstruation		HIV Knowledge		STI Knowledge	
	Yes	Yes	Yes	Yes	Yes	Yes
	%	95% CI	%	95% CI	%	95% CI
10	14.3	(10.6,18.9)	70.9	(64.4,76.7)	8.5	(6.5,11.0)
11	21.9	(12.6,35.3)	82.7	(78.1,86.5)	14.5	(11.0,18.9)
12	35	(26.4,44.6)	82.3	(74.2,88.2)	21.5	(16.9,27.0)
13	51.5	(41.0,61.9)	87.6	(82.7,91.2)	33.8	(27.3,41.0)
14	69	(62.0,75.3)	92	(87.4,95.0)	44.4	(37.9,51.2)
15	77.2	(65.8,85.6)	93.9	(91.5,95.7)	53.7	(46.7,60.5)
16	82.3	(71.1,89.8)	93.8	(91.5,95.5)	57.7	(52.0,63.3)
17	87.9	(81.2,92.4)	96	(94.0,97.4)	65.2	(59.6,70.5)
18	90.3	(85.8,93.5)	96.7	(95.4,97.7)	68.3	(62.2,73.8)
19	92.3	(87.3,95.5)	97.9	(95.7,98.9)	70.9	(64.7,76.3)

Gender						
Male	56.5	(49.2,63.6)	89.4	(86.0,92.1)	43	(38.6,47.6)
Female	67.7	(60.3,74.4)	90	(88.1,91.7)	45	(37.9,52.3)
In school						
No	58.6	(49.2,67.4)	83	(78.8,86.6)	36.2	(28.0,45.2)
Yes	64.4	(60.0,68.6)	92.5	(90.6,94.1)	47.4	(42.3,52.5)
Worked in the past year						
No	61.3	(56.1,66.2)	88.8	(85.5,91.5)	41.6	(35.4,48.1)
Yes	65.5	(56.4,73.6)	91.6	(88.4,94.0)	49	(43.9,54.2)
Mother alive						
No	73.6	(66.5,79.7)	93.2	(89.9,95.5)	47.9	(37.7,58.3)
Yes	62.2	(56.4,67.8)	89.6	(87.1,91.6)	43.9	(38.6,49.3)
Wealth quintile						
Poorest	56.4	(46.3,66.1)	84.9	(77.6,90.2)	33.7	(28.4,39.4)
Poor	56.4	(51.6,61.1)	86.9	(84.7,88.9)	38.9	(34.6,43.5)
Middle	63.1	(56.0,69.7)	91.5	(89.6,93.1)	44.1	(39.7,48.6)
Rich	65.7	(60.8,70.4)	92.7	(89.7,94.8)	49.6	(43.4,55.9)
Richest	72	(68.5,75.2)	92.6	(89.4,94.9)	53.9	(44.5,63.0)
Ever had sex						
No	59.6	(53.1,65.7)	88.8	(86.1,91.1)	40.9	(36.1,45.8)
Yes	82.2	(70.2,90.1)	95.4	(93.0,96.9)	63.4	(57.4,68.9)

*by site statistics provided in the online appendix

Table 4: Bivariate predictors of SRH knowledge among adolescents in eight African sites (pooled)

		Knowledge of menstruation	HIV knowledge	STI knowledge
		Unadjusted RR	Unadjusted RR	Unadjusted RR
Age	reference: age 10			
	age 11	1.536***	1.166***	1.712***
		(1.174 - 2.009)	(1.090 - 1.248)	(1.207 - 2.430)
	age 12	2.453***	1.160***	2.537***
		(1.936 - 3.109)	(1.087 - 1.238)	(1.846 - 3.486)

	age 13	3.615***	1.235***	3.986***
		(2.883 - 4.533)	(1.161 - 1.313)	(2.942 - 5.399)
	age 14	4.843***	1.297***	5.238***
		(3.881 - 6.043)	(1.222 - 1.377)	(3.887 - 7.059)
	age 15	5.412***	1.325***	6.326***
		(4.342 - 6.746)	(1.249 - 1.406)	(4.702 - 8.511)
	age 16	5.772***	1.323***	6.806***
		(4.635 - 7.188)	(1.247 - 1.403)	(5.066 - 9.143)
	age 17	6.163***	1.354***	7.690***
		(4.952 - 7.671)	(1.278 - 1.436)	(5.729 - 10.32)
	age 18	6.332***	1.364***	8.050***
		(5.090 - 7.878)	(1.287 - 1.446)	(6.002 - 10.80)
	age 19	6.476***	1.380***	8.351***
		(5.203 - 8.060)	(1.302 - 1.463)	(6.213 - 11.22)
Gender	Reference: male			
	female	1.199***	1.007	1.046*
		(1.154 - 1.245)	(0.991 - 1.023)	(0.992 - 1.103)
In school	Reference: no			
	Yes	1.099***	1.114***	1.309***
		(1.054 - 1.147)	(1.091 - 1.138)	(1.228 - 1.396)
Worked in the past year	Reference: no			
	Yes	1.069***	1.031***	1.178***
		(1.029 - 1.110)	(1.015 - 1.048)	(1.117 - 1.243)
Mother alive	Reference: no			
	Yes	0.846***	0.961**	0.916
		(0.787 - 0.909)	(0.932 - 0.992)	(0.813 - 1.033)
Wealth quintile	Reference: poorest			
	Poor	0.999	1.023	1.156***
		(0.935 - 1.068)	(0.993 - 1.054)	(1.048 - 1.275)
	Middle	1.118***	1.077***	1.309***
		(1.051 - 1.190)	(1.048 - 1.107)	(1.191 - 1.438)
	Rich	1.165***	1.091***	1.473***

		(1.096 - 1.239)	(1.062 - 1.121)	(1.345 - 1.614)
	Richest	1.276***	1.090***	1.599***
		(1.204 - 1.352)	(1.062 - 1.120)	(1.464 - 1.748)
Ever had sex	Reference: no			
	Yes	1.381***	1.074***	1.551***
		(1.331 - 1.432)	(1.056 - 1.091)	(1.467 - 1.640)
	Observations	6,824	7,112	7,116

Robust cieform in parentheses

*** p<0.01, ** p<0.05, * p<0.1

*univariate regressions by site provided in the online appendix

Table 5: Multivariate predictors of SRH knowledge among adolescents in eight African sites (pooled)

		Knowledge of menstruation	HIV knowledge	STI knowledge
		adjusted RR	adjusted RR	adjusted RR
Age (years)	reference: age 10			
	age 11	1.495***	1.151***	1.411**
		(1.149 - 1.944)	(1.079 - 1.228)	(1.001 - 1.990)
	age 12	2.567***	1.171***	2.340***
		(2.036 - 3.236)	(1.101 - 1.245)	(1.712 - 3.198)
	age 13	3.729***	1.249***	3.597***
		(2.988 - 4.654)	(1.178 - 1.324)	(2.667 - 4.851)
	age 14	4.893***	1.301***	4.617***
		(3.935 - 6.083)	(1.229 - 1.377)	(3.437 - 6.201)
	age 15	5.483***	1.331***	5.712***
		(4.414 - 6.810)	(1.257 - 1.408)	(4.258 - 7.662)
	age 16	5.712***	1.321***	6.047***
		(4.599 - 7.094)	(1.249 - 1.398)	(4.511 - 8.106)
	age 17	6.069***	1.358***	6.933***
		(4.883 - 7.543)	(1.284 - 1.437)	(5.172 - 9.292)
	age 18	6.376***	1.373***	7.491***
		(5.132 - 7.921)	(1.298 - 1.452)	(5.589 - 10.04)
	age 19	6.625***	1.410***	7.954***
		(5.322 - 8.247)	(1.331 - 1.494)	(5.913 - 10.70)
Gender	Reference: male			
	female	1.159***	1.013*	1.026
		(1.122 - 1.197)	(0.998 - 1.029)	(0.980 - 1.074)
In school	Reference: no			
	Yes	1.263***	1.147***	1.625***
		(1.214 - 1.313)	(1.120 - 1.174)	(1.527 - 1.730)
Worked in the past year	Reference: no			
	Yes	1.040**	1.063***	1.176***
		(1.005 - 1.076)	(1.044 - 1.083)	(1.117 - 1.239)
Mother alive	Reference: no			
	Yes	0.964	0.984	1.058
		(0.906 - 1.024)	(0.954 - 1.015)	(0.957 - 1.170)
Wealth quintile	Reference: poorest			
	Poor	1.012	1.029**	1.153***

		(0.960 - 1.067)	(1.000 - 1.058)	(1.060 - 1.256)
	Middle	1.072***	1.061***	1.248***
		(1.019 - 1.127)	(1.035 - 1.089)	(1.149 - 1.355)
	Rich	1.078***	1.065***	1.295***
		(1.025 - 1.134)	(1.039 - 1.092)	(1.196 - 1.402)
	Richest	1.160***	1.060***	1.416***
		(1.106 - 1.218)	(1.034 - 1.087)	(1.309 - 1.531)
Ever had sex	Reference: no			
	Yes	1.123***	1.042***	1.139***
		(1.082 - 1.166)	(1.022 - 1.063)	(1.073 - 1.208)
Site	Reference: Bukina Faso Rural (Nouna)			
	Ethiopia Rural (Kersa)	1.125***	1.046**	0.629***
		(1.041 - 1.216)	(1.008 - 1.085)	(0.541 - 0.731)
	Ethiopia Urban (Harar)	1.571***	1.176***	1.661***
		(1.489 - 1.657)	(1.148 - 1.205)	(1.537 - 1.795)
	Ghana Rural (Ningo Prampram)	1.279***	1.022	1.068
		(1.201 - 1.362)	(0.986 - 1.059)	(0.958 - 1.191)
	Nigeria Rural (Ibadan)	1.500***	1.077***	0.929
		(1.420 - 1.584)	(1.045 - 1.110)	(0.830 - 1.039)
	Tanzania Rural (Dodoma)	1.166***	1.058***	1.647***
		(1.094 - 1.242)	(1.027 - 1.091)	(1.522 - 1.782)
	Tanzania Urban (Dar)	1.443***	1.154***	1.613***
		(1.368 - 1.524)	(1.126 - 1.183)	(1.486 - 1.750)
	Uganda Rural (Iguanga/Mayuge)	1.273***	1.169***	1.238***
		(1.188 - 1.364)	(1.138 - 1.201)	(1.117 - 1.371)
	Constant	0.0819***	0.558***	0.0374***
		(0.0651 - 0.103)	(0.518 - 0.600)	(0.0272 - 0.0514)
	Observations	6,824	7,112	7,116

Robust cieform in parentheses

*** p<0.01, ** p<0.05, * p<0.1

*multivariate regressions by site provided in the online appendix

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