Is migration a risk factor for HIV spread? HIV acquisition and concurrency in Ghana
Susan Cassels, Lisa Manhart, Martina Morris

Introduction

HIV is one of the most devastating epidemics in world history. Around 33 million people world-wide are currently living with HIV, and AIDS has killed more than 25 million people since it was first recognized in 1981 [1]. While HIV occurs throughout the globe, the intensity of the epidemic varies substantially across populations and the determinants of the disparities in HIV prevalence and trends among populations remains an area of debate and intense scientific research. Recently, progress has been made in incorporating and understanding the importance of sexual networks as a key aspect of the transmission system and therefore an important target in HIV prevention [2-4]. Thus far, work on sexual networks and HIV has largely ignored the question of migration, even though "periods of multiple partnerships", an essential building block for concurrency, may be mediated by migration patterns.

Concurrency occurs when an individual has two or more sexual partnerships that overlap in time. Partnership concurrency links individuals together to create large connected components in a network that allow a pathogen to travel rapidly and efficiently. Additionally, the longer the duration of the concurrent partnerships, the more time the pathogen has to spread throughout the population [2]. Polygyny is a unique form of concurrency that has qualitatively different impacts on infectious disease spread, and might even be protective [5].

Migration, in the simplest terms, is the movement of persons from one country or locality to another. Migration and sexually transmitted infection (STI) have long been associated. Migrants not only suffer from STIs more than non-migrants, but are also disproportionately responsible for transmitting infections to others [6-18]. Population migration is thought to play a significant role in the spread of HIV/AIDS in several countries with large generalized epidemics such as Kenya [6], South Africa [10], Uganda [19], and Zimbabwe [20]. Past work has suggested that circular migration in particular can sustain or increase HIV prevalence rates at home, because migrants are more likely than non-migrants to engage in sexual practices conducive to HIV, become infected with HIV while away, and return home to infect their rural partners [21], a form of concurrency [22]. A recent ecological analysis has also established a connection between recent in-migration and HIV prevalence at the population level for rapidly increasing epidemics [23].

However, significantly less work has examined sexual behavior and HIV risk of the stay-at-home partner. Return migration and travel may facilitate partnership concurrency in two distinct ways: (1) if an individual has an ongoing partnership at home and an additional partner while away or (2) if the partner left behind has an additional partner while the migrant is away [24, 25]. Thus, in addition to assessing the relationships between migration, concurrency and HIV on an individual level, it is important to conceptualize migration as a dyadic attribute and explore the behaviors and risks to both the migrant and the stay-at-home partner.

Countries with generalized but urban-concentrated HIV/AIDS epidemics like Ghana afford an opportunity to investigate the role that migration plays in the transmission system. Ghana's national HIV prevalence is near 3%, but HIV prevalence varies significantly across sub-populations throughout Ghana [26]; urban-poor in Accra suffer disproportionately from HIV, with a prevalence measured near 8.3% [26]. HIV prevalence varies across regions as well, ranging from 0.30% among men in the Central region to 4.40% among women in the Eastern region [27]. Migration is common in Ghana; more than 50% of the population age seven and older was either born outside of their current place of residence or had lived outside for a year or more [28]. These characteristics suggest that migration may be playing a role in perpetuating HIV disparities in Ghana. Therefore, here we assess the associations between migration, HIV infection and concurrency at both the individual and dyad-level (among couples) using data from the 2003 Ghana Demographic and Health Survey (DHS).

Methods

Study Population:

The 2003 Ghana DHS is a nationally representative survey of 5,691 women age 15-49 and 5,015 men age 15-59 from 6,251 households covering 412 sample points (clusters) throughout Ghana. This survey is the fourth in a series of national-level population and health surveys conducted as part of the global DHS program and is designed to provide data to monitor the population and health situation in Ghana as a follow-up of the 1988, 1993, and 1998 GDHS surveys. The survey utilized a two-stage sample based on the 2000 Population and Housing Census and was designed to produce separate estimates for key indicators for each of the ten regions in Ghana (e.g., indicators regarding fertility, family planning, maternal and child health, nutrition, childhood mortality, malaria, and HIV/AIDS-related knowledge). Data collection took place over a three-month period, from late July to late October 2003.

In households selected for the 2003 GDHS, all women age 15-49 and men age 15-59 were eligible for interview and HIV testing. Specimens were taken from respondents after they had consented to be tested. Dried blood spots for HIV testing were collected from 89 percent of the 5,949 eligible (interviewed and not interviewed) women and 80 percent of the 5,345 eligible men. All specimens were tested with a screening test, Vironostika HIV Uni-Form Plus O (bioMérieux, Marcy l'Etoile, France) (ELISA I). All samples positive on the first screening test as well as 10 percent of the negatives were further tested in parallel with Wellcozyme HIV-1 Recombinant and Murex HIV-2 (Murex, Dartford, England) (ELISA II) for serotyping. For more information on those that refused testing, see Akwara *et al* (2005) [27]. Further, we only consider respondents who have ever had sex in the analysis, resulting in a total sub-sample of 4,499 women and 3,232 men (see Figure 1).

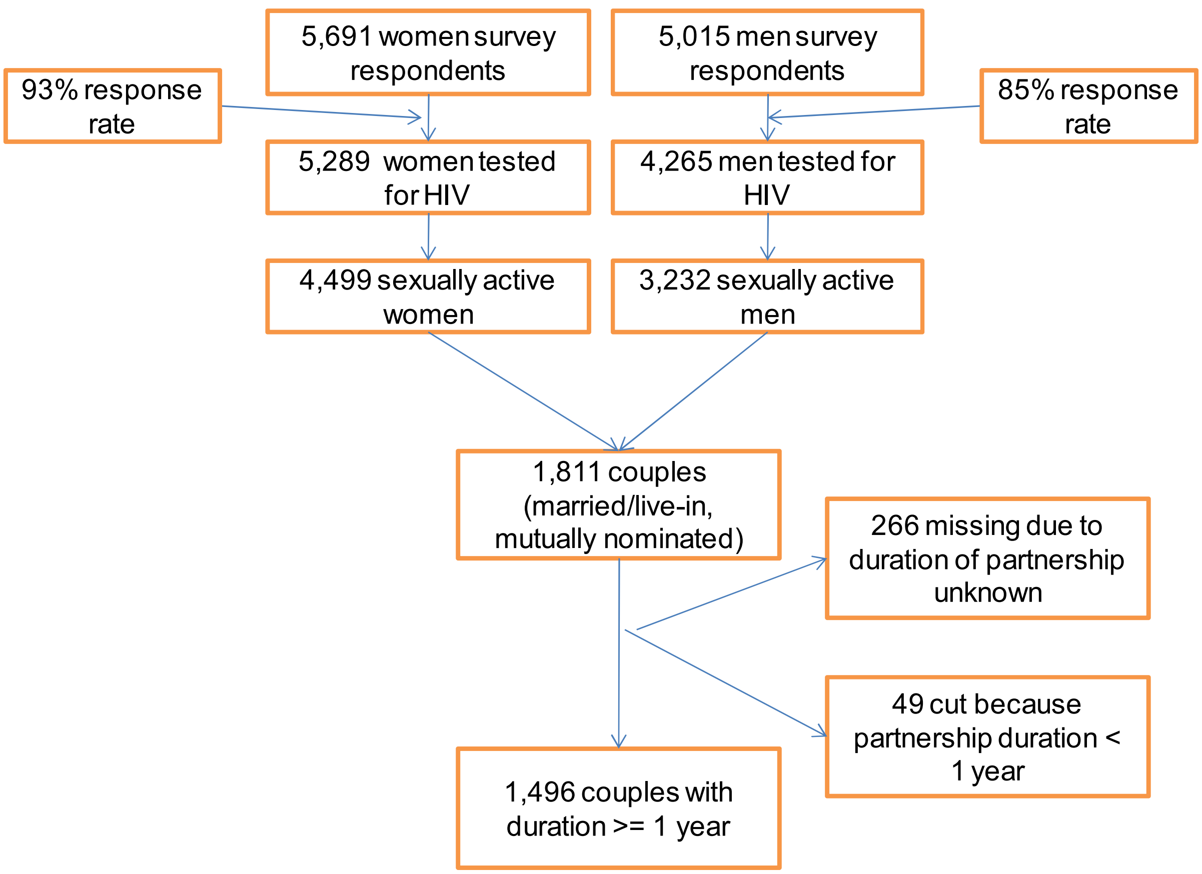

Figure 1: Flow chart of 2003 Ghana DHS analytical sub-sample

The DHS also contains data for married or cohabiting men and women who both declared to be married to each other (or cohabiting) and had complete individual interviews. The couples dataset is the result of linking files from two individuals whom mutually declared each other as a partner. Among the 2,133 couples in the 2003 data, 1,811 couples had HIV results for individuals. Furthermore, we restrict this analysis to couples who have been together for at least 12 months, ensuring that concurrency and migration events in the last 12 months occurred while the couple was together. Out of the 1,811 couples, 266 (14.7%) did not have sufficient data on partnership duration and 49 (2.7%) had been together less than one year, resulting in a total of 1,496 couples.

Measurement:

Migration status: Migration status is measured using three questions: 1) "how long have you been living continuously in your current place of residence?" and for men only 2) "in the last 12 months, on how many separate occasions have you traveled away from your home community and slept away?", and 3) "In the last 12 months, have you been away from your home community for more than a month at a time?" The variable *ever migrant* is defined as ever having lived in a place other than the current place of residence. *Recent migrant* identifies respondents who have moved to their current place of residence within the last year. *Travel* (men only) captures men who had at least one overnight trip away from home in the last 12 months. Since risk of HIV and concurrency depends on both the duration and incidence of travel, I also evaluated men who were gone greater than a month (*travel >1 month*) and those that traveled frequently (*travel ≥ 10 trips in the past year*). These definitions are used for the individual-level analysis. The dyadic-level variables (neither, husband-only, wife-only, or both husband/wife migrant) were constructed using *ever migrant* and *recent migration* definitions, but I also compared dyadic-level attributes to men's *travel* variables since those capture return migration.

HIV status: The outcomes assessed are twofold. First is HIV status as measured in the 2003 Ghana DHS (n = 7,731). For the individual-level HIV status analysis, the outcome is HIV status (positive/negative) and the analysis is stratified by sex because I assumed that the mechanisms in which migration affects HIV vary by sex. Although the data include serotype, HIV status is characterized as a binary outcome. For the dyadic-level HIV analysis, the outcome variable is neither, male-only, female-only, or both HIV positive, restricted to those in partnerships with duration greater than a year (n = 1,496 couples).

Concurrency: A proxy measure for 12-month cumulative concurrency for men only, *other ongoing partnerships (no, yes, polygyny only)*, was used for the individual-level analysis due to insufficient sexual partner questions in the 2003 GDHS. Because the 2003 GDHS data did not ask about dates of last sex for the second and third most recent partner, I could not construct the "gold standard" measure of cumulative or point prevalence concurrency as recommended by UNAIDS [29]. Alternative questions identify men who had regular and occasional partners in the last 12 months. Men who were currently married or cohabiting with a woman were asked: “Apart from the women you have already mentioned, do you currently have other regular or occasional partners?” Unmarried men were asked “Do you currently have regular, occasional, or no sexual partners?” Those that had more than one wife or cohabiting partner but no additional partners were categorized as polygynous only. Married men with additional regular or occasional partners as well as unmarried men who had regular *and* occasional partners were categorized as having other ongoing partners. Lastly, married men without additional partners and unmarried men with either regular or occasional partners were categorized as not having other ongoing partnerships. Women were not included since less than 0.5% reported any additional partners at all, regardless of overlap in time. For the dyadic-level analysis, the sample was restricted to couples with current partnership duration ≥12 months, thus respondents who reported sexual contact with at least one additional partner were counted as concurrent. Men with only polygynous concurrency were identified as well since polygyny is a unique form of concurrency. Thus the dyad-level variable is prevalence of 12 month cumulative concurrency among men (no, yes, polygyny only). No women reported sexual contact with partners other than their husband or cohabiting partner in the couples’ subsample.

Sociodemographic and sexual behavior: Other characteristics considered in this analysis include age, education (no education, primary, secondary, higher), type of place of residence (urban vs. rural), religion (Christian, Moslem, other/none), marital status (never, currently, formerly), region, ethnicity, and sexual behavior variables such as sexual debut before age 15, male circumcision, multiple partners, and ever paid for sex.

<u>Statistical methods:</u>

The individual-level analysis was restricted to those who report ever being sexually active, and the primary exposure variable is migration status. The primary outcome variables are HIV status and other ongoing partnerships in the last 12 months (men only). For the initial bivariate analyses, univariate odds ratios assessed the crude association between migration status and HIV-status and the association between migration status and other ongoing partnerships, as well as for other sociodemographic and sexual behavior variables hypothesized to be associated with the outcome variables. We examined additional factors associated with HIV status and other ongoing partnerships by fitting a logistic regression model (HIV) and a multinomial regression model (other ongoing partnerships). Odds ratios for the logistic regression and risk ratios for the multinomial logistic regression are presented, adjusted for other socio-demographic or sexual behavior characteristics listed above. (Note that exponentiated regression coefficients for multinomial models are ratios of relative risks, not ratios of odds.)

For the dyad-level analysis, contingency tables of couples' migration status and couples' HIV status as well as migration status and male concurrency were constructed. Unadjusted odds ratios were calculated for all possible 2x2 comparisons within the contingency tables to test specific hypotheses (see Appendix A for hypotheses for each individual test). The category "neither partner migrant" represents the non-exposed population and "neither partner HIV-positive" or "neither partner concurrent" represents the non-diseased population.

Results

Individual-level univariate analysis:

Table 1 depicts characteristics of the individual-level sample of sexually active men and women who were tested for HIV in the 2003 Ghana DHS. Migration and travel were common among this population. Women tended to move more than men, both over the life course (67.5% vs. 62.7%, $p<0.05$) and within the last year (4.5% vs. 2.7%, $p<0.05$). Overnight travel was also common among men, with 62.4% taking at least one overnight trip within the last 12 months. This group averaged 5.4 trips. Among men, 21.8% took a trip that lasted greater than a month in duration, and 10.8% took 10 trips or more.

Among men, overall 21.0% reported other possible concurrent partners: 14.5% reported more than one wife or cohabiting partner but no additional regular or occasional partners and an additional 6.5% of men reported that they were married and had additional casual partners, or were unmarried and reported additional regular *and* occasional partners.

There were many significant differences between men and women in the sample. HIV prevalence was significantly lower among men (2.0% vs. 3.1%, $p<0.05$). Men were slightly older than women but the sample included men aged 15 – 59 and women aged 15-49. The population was predominantly Christian: 64.9% and 72.0% of men and women, respectively. Nearly three quarters of the sample was currently married, and men were more likely to report having more than one sexual partner in the last 12 months (12.1% vs. 1.2%, $p<0.05$). However, a greater proportion of women reported sexual debut before the age of 15 (10.1% vs. 4.9%, $p<0.05$).

Table 1: Descriptive characteristics of the 2003 Ghana DHS: sexually experienced & HIV tested women (n = 4,499) and men (n = 3,232) only

	men		women		
	n	(%)	n	(%)	p-value
Outcomes					
HIV status					
positive	65	(2.0)	138	(3.1)	0.004
Other ongoing partners					
no	2554	(79.0)	na		
yes	209	(6.5)			
polygyny only	469	(14.5)			
Sociodemographic variables					
Ever migrant					
yes	2,027	(62.7)	3,036	(67.5)	0.000
Recent migrant					
yes (1 yr)	87	(2.7)	203	(4.5)	0.000
Overnight travel last 12 months					
At least once	2,017	(62.4)	na		
Average # trips if ever (mean)		(5.4)	na		
>1 month away	705	(21.8)	na		
>=10 trips	349	(10.8)	na		
Age					
mean (SD)	35.2	(10.9)	31.3	(9.0)	
Type of place of residence**					
urban	1,129	(34.9)	1,706	(37.9)	
rural	2,103	(65.1)	2,793	(62.1)	0.007
Education					
no education	833	(25.8)	1,679	(37.3)	
primary	463	(14.3)	886	(19.7)	
secondary	1,723	(53.3)	1,843	(41.0)	
higher	213	(6.6)	91	(2.0)	0.000
Religion					
christian	2,098	(64.9)	3,239	(72.0)	
moslem	658	(20.4)	813	(18.1)	
other/none	475	(14.7)	446	(9.9)	0.000
Ethnicity					
akan	1,326	(41.0)	1,983	(44.1)	
ga/dangme	209	(6.5)	319	(7.1)	
ewe	419	(13.0)	557	(12.4)	
guan	124	(3.8)	133	(3.0)	
mole-dagbani	776	(24.0)	868	(19.3)	
grussi	108	(3.3)	148	(3.3)	
gruma	115	(3.6)	143	(3.2)	
hausa	24	(0.7)	46	(1.0)	
other	128	(4.0)	297	(6.6)	0.000
Region					
western	307	(9.5)	425	(9.4)	
central	214	(6.6)	292	(6.5)	
greater accra	366	(11.3)	591	(13.1)	
volta	259	(8.0)	370	(8.2)	
eastern	270	(8.4)	392	(8.7)	
ashanti	542	(16.8)	741	(16.5)	
brong ahafo	379	(11.7)	521	(11.6)	
northern	433	(13.4)	504	(11.2)	
upper west	218	(6.7)	351	(7.8)	
upper east	244	(7.5)	312	(6.9)	0.051
Marital status					
never married	697	(21.6)	605	(13.4)	
currently married	2314	(71.6)	3444	(76.6)	
formerly married	221	(6.8)	450	(0.1)	0.000
Sexual behavior variables					
Age at first sex					
<15 years old	159	(4.9)	454	(10.1)	0.000
# sexual partners last 12 months					
>1	391	(12.1)	56	(1.2)	0.000
Ever paid for sex					
yes	262	(8.1)	na		
Circumcised					
yes	2994	(92.6)	na		
Total	3232		4499		

Chi-square test used to compare differences between men and women
Men's age ranges from 15 - 59 while women's range from 15 - 49
Age at first sex has missing data: women n = 4,195 men n = 3,210

Results from bivariate analyses of sociodemographic characteristics and sexual behaviors associated with HIV status and other ongoing partnerships are reported in Table 2. Migration was not independently associated with HIV status for women; however, the odds of HIV were significantly higher for men who travel. Specifically, each additional trip was associated with 1.03 higher odds of HIV for men compared to men who do not travel. The odds of HIV were also almost twice as high for men who traveled more than 10 times in the last 12 months (OR = 1.90, 95% CI: 0.92 – 3.65) compared to men who traveled less than 10 times. The odds of HIV were significantly higher for women in urban areas compared to rural areas, Christian women (compared to Muslim and other), and women who had their sexual debut before age 15. The odds of HIV were higher for men who were currently married, but lower for women. Lastly, HIV varied significantly by ethnicity and region – prevalence was highest among the Ga/Dangme ethnicity, who are found predominantly in Greater Accra and Eastern regions, and among those living in the Eastern region.

Migration was significantly associated with other ongoing partnerships as well; the reference category was no other ongoing partnerships. Men who have ever moved in their lifetime had significantly lower odds of polygyny only compared to those who have never moved (OR = 0.74, 95% CI: 0.61 – 0.91). Men who had taken 10 trips or more in the past year had higher odds of other casual ongoing partnerships compared to those with fewer than 10 trips (OR = 1.54, 95% CI: 1.01 – 2.30). Generally, migration and travel were associated with greater odds of casual-other ongoing partnerships and lower odds of polygynous-other ongoing partnerships.

Other significant associations were seen between sociodemographic characteristics, sexual behavior, and other ongoing partnerships. Men in urban areas, men with higher education, Christian men, men of the Ga/Dangme ethnicity and in the Eastern region, and circumcised men had lower odds of polygynous-other ongoing partners. In contrast, Ga/Dangme men had higher odds of casual-only other ongoing partnerships, as well as men who had their sexual debut by age 15. Older men had lower odds of casual-other ongoing partnerships.

Table 2: Characteristics and behaviors of individuals who were HIV positive or reported other ongoing partnerships among the sexually experienced sub-sample of the 2003 Ghana DHS (n = 4,499 women and n = 3,232 men)

		HIV status		Other ongoing partners			
				Yes		Polygyny only	
		OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Sociodemographic variables							
Ever migrant							
	men	1.34	(0.77 - 2.41)	1.19	(0.88 - 1.63)	0.74	(0.61 - 0.91)
	women	1.32	(0.89 - 1.99)				
Recent migrant							
	men	–		1.70	(0.74 - 3.47)	0.59	(0.24 - 1.23)
	women	1.13	(0.44 - 2.45)				
Travel (continuous)							
	men	1.03	(1.00 - 1.06)	1.40	(1.03 - 1.93)	0.93	(0.76 - 1.15)
Travel: >1 month							
	men	1.08	(0.56 - 1.96)	1.20	(0.85 - 1.68)	0.92	(0.72 - 1.18)
Travel: >=10 trips							
	men	1.90	(0.92 - 3.65)	1.54	(1.01 - 2.30)	1.01	(0.72 - 1.39)
Age > 35							
	men	2.31	(1.34 - 4.10)	0.73	(0.54 - 0.98)	1.76	(1.43 - 2.16)
	women	1.17	(0.81 - 1.67)				
Urban place of residence							
	men	1.02	(0.58 - 1.75)	1.02	(0.75 - 1.38)	0.61	(0.49 - 0.77)
	women	1.43	(1.00 - 2.04)				
Education: secondary or more							
	men	1.15	(0.67 - 1.99)	1.13	(0.84 - 1.53)	0.47	(0.38 - 0.57)
	women	1.34	(0.94 - 1.91)				
Religion: Christian							
	men	1.13	(0.66 - 2.02)	1.13	(0.83 - 1.54)	0.42	(0.35 - 0.52)
	women	1.55	(1.01 - 2.44)				
Ethnicity: Ga/Dangme							
	men	4.26	(2.13 - 8.00)	1.88	(1.14 - 3.00)	0.64	(0.38 - 1.02)
	women	2.74	(1.65 - 4.40)				
Region: Eastern							
	men	2.29	(1.06 - 4.49)	1.24	(0.74 - 2.00)	0.28	(0.14 - 0.49)
	women	1.71	(0.98 - 2.82)				
Marital status: currently married							
	men	1.97	(1.01 - 4.20)	1.24	(0.89 - 1.76)	na	
	women	0.64	(0.44 - 0.95)				
HIV status: positive							
	men			1.21	(0.38 - 3.03)	0.95	(0.41 - 1.94)
Sexual behavior variables							
Sexual debut by age 15							
	men	0.93	(0.18 - 2.89)	2.23	(1.29 - 3.68)	0.60	(0.32 - 1.04)
	women	1.93	(1.17 - 3.07)				
Multiple partners in last 12 months							
	men	0.87	(0.33 - 1.93)	5.85	(4.26 - 7.98)	2.97	(2.30 - 3.81)
	women	2.47	(0.64 - 6.86)				
Ever paid for sex							
	men	1.85	(0.79 - 3.82)	1.37	(0.82 - 2.19)	0.84	(0.55 - 1.23)
Circumcised							
	men	0.95	(0.38 - 3.07)	1.62	(0.85 - 3.49)	0.51	(0.37 - 0.71)
Other ongoing partners: yes							
	men	1.21	(0.38 - 3.03)				

Univariate odds ratios (95% confidence intervals) reported

Individual-level multivariate analysis:

Adjusted odds ratios and risk ratios from the multivariate individual-level analysis are reported in Table 3. The odds of HIV infection associated with ever being a migrant, recent migrant and travel (men only) did not change significantly when accounting for a number of other covariates. However, the adjusted odds ratio for travel 10 times or more in the past year was lower and no longer statistically significant after accounting for confounding factors. Specifically, age and ethnicity confounded the association between travel as measured by greater than 10 trips per year and HIV status for men. Ga/Dangme men had a higher HIV prevalence compared to the sample average (6.7% vs. 2.0%), and they were also more likely to have traveled greater than ten times in the past year (16.8% vs. 10.8%). Second, older men were more likely to be HIV-positive and more likely to travel ≥ 10 times in the last year. Therefore, the adjusted odds ratio for travel ≥10 trips was smaller and non-significant when only accounting for age and ethnicity (AOR = 1.74, 95% CI: 0.92 – 3.33 – data not shown in table), and slightly smaller in the full model (AOR = 1.65, 95% CI: 0.84 – 3.20).

Table 3: Adjusted odds ratios (AOR) and relative risk ratios (ARR) for HIV positive serostatus and risk of other ongoing partners (reference category is no other ongoing partners) among sexually experienced men and women in the 2003 Ghana DHS

	HIV status				Other ongoing partners			
	Men		Women		yes		polygyny only	
	AOR	(95% CI)	AOR	(95% CI)	ARR	(95% CI)	ARR	(95% CI)
Sociodemographic variables								
Mobility/migration/travel								
Ever migrant	1.29	(0.71 - 2.35)	1.25	(0.84 - 1.87)	1.19	(0.86 - 1.65)	1.07	(0.85 - 1.36)
Recent migrant	–		1.08	(0.46 - 2.53)	1.53	(0.74 - 3.17)	0.92	(0.43 - 1.97)
# overnight trips (continuous)	1.03	(1.00 - 1.06)	–		1.02	(1.00 - 1.04)	1.02	(1.00 - 1.04)
Travel >1 month (binary)	0.97	(0.53 - 1.80)	–		1.12	(0.80 - 1.58)	1.04	(0.80 - 1.34)
Travel >= 10 trips (binary)	1.65	(0.84 - 3.20)	–		1.51	(1.00 - 2.30)	1.47	(1.05 - 2.06)
Age	incl		incl		incl		incl	
Type of place of residence	incl		incl		incl		incl	
Education	incl		incl		incl		incl	
Religion	incl		incl		incl		incl	
Ethnicity (dummy Ga/Dangme)	incl		incl		incl		incl	
Region	incl		incl		incl		incl	
Marital status	incl		incl		–		–	
Sexual behavior variables								
Sexual debut by age 15	incl		incl		incl		incl	
Multiple partners in last 12 months	incl		incl		–		–	
Ever paid for sex	incl		–		incl		incl	
Circumcised	incl		–		–		–	

Results from logistic regression (adjusted odds ratios reported) for HIV status model
Results from multinomial regression (adjusted risk ratios reported) for other ongoing partners model

In the multinomial regression model, travel measured as a continuous variable or travel ≥ 10 trips in the past year continued to be significantly associated with having other casual ongoing partnerships in the last 12 months, even when controlling for other factors associated with other ongoing partnerships. However, there appeared to be factors confounding the relationship between other polygynous ongoing partners and travel. Individuals ever having migrated had significantly lower risk of polygyny compared to those with no additional ongoing partners, but this association was no longer significant after controlling for additional factors. Region and religion were key confounders of this association: non-Christian men were less likely to migrate or ravel, and more likely to be in polygynous marriages. Men in the three northern regions (Northern, Upper West, Upper East) were much less likely to travel and more likely to be in polygynous marriages. In addition, non-Christian men were more likely to live in these regions. For ever migrant men, the risk of having other polygynous ongoing partners increased and become non-significant after adjusting for region and religion only (ARR: 1.09, 95% CI: 0.87 – 1.37, data not shown in table); it was slightly lower in the full model (see Table 3). After adjusting for region and religion, the risk of having other polygynous ongoing partners among those that traveled greater than 10 times also increased (ARR = 1.59, 95% CI: 1.00 – 1.94; data not shown in table), and was slightly lower but still significant in the full model.

Dyad-level analysis

Table 4 shows HIV, concurrency, and migration and travel characteristics of couples in the sample: those together >12 months duration and both tested for HIV. Slightly more than 3% of the couples had at least one partner infected with HIV: 1.5% male-only, 1% female-only, and 0.9% both. The proportions that had ever been a migrant, were a recent migrant, and had traveled were similar to the proportions in the individual-level sample. Lastly, only 11.7% of the men in the couples sample had concurrent partners, compared to 21% in the individual-level analysis. The couples-level measure is based on sexual contact with other partners in the last year, whereas the individual-level measure is based on questions about other possible ongoing partnerships. The rates of casual-other ongoing partners (individual-level) and non-polygynous concurrency (dyad-level) are comparable at 6.5% and 5.9%, but the rates of sexual contact with additional wives of cohabiting women are significantly lower in the couples sample (14.5% vs. 5.7%). This may be due to men having multiple married or cohabiting partners but sexual contact with only one in the last year.

Table 4: HIV status, concurrency, and migration characteristics of 2003 Ghana DHS couples sample, restricted to couples together >=12 months and both tested for HIV (n = 1,496)

	Neither		Male only		Female only		Both		Total
	n	(%)	n	(%)	n	(%)	n	(%)	
HIV status	1,447	(96.72)	22	(1.47)	14	(0.94)	13	(0.87)	1,496
Concurrency	1,320	(88.29)	175	(11.71)		–		–	1,495
Ever migrant	243	(16.25)	186	(12.44)	366	(24.48)	700	(46.82)	1,495
Recent migrant	1,434	(95.92)	14	(0.94)	32	(2.14)	15	(1.00)	1,495
Ever travel last 12 months	607	(40.57)	889	(59.43)		–		–	1,496
Travel > 1 month	1,185	(79.21)	311	(20.79)		–		–	1,496
Travel >= 10 trips	1,348	(90.11)	148	(9.89)		–		–	1,496

**Of the 175 men who reported concurrent partners in the last 12 months, 86 were polygyny only and 89 had additional non-wife or cohabitating partners in last 12 months

Four-by-four (or for male-only definitions of travel or concurrency 4X2 or 2x2) contingency tables were used to test whether migration by one or both partners in a couple was associated with HIV or concurrency risk in one, the other, or both partners. Table 5 presents univariate odds ratios for each possible 2x2 comparison within the contingency table for migration and HIV as well as for migration and concurrency status. The odds ratios were undefined when zero cases were observed in certain cells. For instance, no cases of HIV were seen among any couples (male-only, female-only, nor both) when either or both partners were recent migrants.

No association was observed between ever being a migrant, being a recent migrant, or travel at least once and HIV. Only frequent travel (≥ 10 trips per year) was significantly associated with couples' HIV status. The percentage of couples in which at least one member is HIV-positive was higher if the male partner was a migrant, and this was true for all couple-types (e.g., male-only positive, female-only positive, and both positive). The odds of female-only HIV infection within a couple in which the male was a frequent traveler were nearly 4 times the odds that the female partner only was infected when the male was not a frequent traveler (OR = 3.82, 95% CI: 0.86 – 13.46).

Table 5: Unadjusted odds ratios for migration and other ongoing partner and for migration and HIV status for couples in the 2003 Ghana DHS (n = 1,496)

	HIV status (positive)				*Concurrency*		
	Neither	Male-only: OR (95% CI)	Female-only: OR (95% CI)	Both: OR (95% CI)	No	Yes: OR (95% CI)	Only polygyny: OR (95% CI)
Ever migrant							
Neither	--	--	--	--	--	--	--
Male-only	--	0.33 (0.01 - 3.34)	na	na	--	0.42 (0.10 - 1.43)	0.88 (0.41 - 1.84)
Female-only	--	1.54 (0.42 - 6.90)	na	na	--	1.17 (0.84 - 2.67)	0.49 (0.24 - 0.99)
Both	--	0.71 (0.19 - 3.25)	na	na	--	1.55 (0.80 - 3.24)	0.48 (0.27 - 0.89)
Recent migrant -- < 1 yr							
Neither	--	--	--	--	--	--	--
Male-only	--	na	na	na	--	na (0.00 - 4.62)	na (0.00 - 4.44)
Female-only	--	na	na	na	--	3.85 (1.26 - 9.91)	1.07 (0.12 - 4.34)
Both	--	na	na	na	--	2.57 (0.28 - 11.63)	na (0.00 - 4.14)
Travel							
Neither	--	--	--	--	--	--	--
Male-only	--	0.82 (0.32 - 2.14)	2.52 (0.66 - 14.10)	1.10 (0.32 - 4.29)	--	2.31 (1.38 - 4.02)	0.77 (0.49 - 1.23)
Travel >1 month							
Neither	--	--	--	--	--	--	--
Male-only	--	2.21 (0.80 - 5.70)	1.06 (0.19 - 4.03)	1.16 (0.20 - 4.55)	--	1.53 (0.91 - 2.51)	1.01 (0.56 - 1.75)
Travel >=10 trips							
Neither	--	--	--	--	--	--	--
Male-only	--	2.12 (0.52 - 6.57)	3.82 (0.86 - 13.46)	2.87 (0.50 - 11.31)	--	2.69 (1.48 - 4.68)	0.32 (0.06 - 0.97)

Odds ratios for each category were calculated with “neither partner migrant” representing the non-exposed population and “neither partner HIV-positive” or “neither partner concurrent” representing the non-diseased population.
na: the odds ratio was undefined due to 0 cases in certain cells

Risk of non-polygynous concurrency was generally higher for all measures of migration and travel, with the exception of couples in which only the male had ever migrated. Couples where the man traveled at least once, traveled > 1 month in duration, and reported frequent travel in the past year were all more likely to report non-polygynous concurrency. Couples in which men traveled 10 or more trips in a year had over 2.5 times higher odds of non-polygynous concurrency (OR 2.69; 95% CI: 1.46 – 4.68) than couples in which the man did not travel as much. We also see that the odds of a man with a recent-migrant wife having non-polygynous concurrency were 3.85 times higher (95% CI: 1.26 – 9.91) than men in couples where both partners were non-migrants.

The odds of polygynous concurrency, on average, were negatively associated with migration and travel. Couples in which only the female had ever migrated, as well as those where both members had ever migrated were associated with lower odds of polygyny-only concurrency (OR = 0.49, 95% CI: 0.24 – 0.99 and 0.48, 0.27 – 0.89), as were couples in which there was frequent travel by men (OR = 0.32, 95% CI: 0.06 – 0.97). Given results from the individual-level analysis, this finding may be confounded by patterns of polygyny by region and religion. However, multivariate analyses of the dyad-level data were not performed due to extremely small numbers in each of the subgroups.

Discussion

On both the individual and dyadic level, migration and travel are generally associated with higher odds of HIV and non-polygynous concurrency, but lower odds of polygynous concurrency. The strongest associations were seen among men who took 10 or more overnight trips within the last year, thus the association might be driven by men who travel frequently. Additionally, the dyad-level analyses suggested that male travel >1 month at a time may be positively associated with male HIV infection and non-polygynous concurrency.

HIV risk was associated with travel in the individual level analysis. HIV prevalence, although lower in Ghana than many other countries in sub-Saharan Africa, also varied significantly by sex, region, and ethnic groups. Many of these groups with higher HIV prevalence were also more likely to travel, such as the Ga/Dangme ethnic group. Migration could be a significant determinant in this prevalence disparity, although given the data limitations causality can not yet be established. Non-polygynous concurrency was also associated with frequent travel, but varied significantly by many other factors as well. Again, the Ga/Dangme had levels of concurrency significantly higher than other ethnic groups, possibly suggesting that travel, non-polygynous concurrency, and HIV risk are directly connected especially among this sub-population.

A previous analysis of HIV prevalence in Ghana, using the same dataset, found that having moved in the past 5 years was associated with higher odds of HIV for men but not women [27]. This same study also concluded that the number times slept away from home in the past year (none, 1-2, 3-4, 5 or more) was not significantly associated with HIV risk for men. This study conceptualized migration in a slightly different way, and comparing both results is informative. Among men, ever migrating or migrating within the last year was not associated with HIV risk, but migrating within the last 5 years was. This suggests that ever having migrated does not capture characteristics of individuals who are at greater risk of HIV. This might be due to migration being quite common in Ghana. Additionally, it is possible that the window of exposure for HIV among men who migrated within the year was too small to see significant differences in HIV prevalence, and by 5 years the effect of migration on HIV status was apparent. Regarding travel, sleeping away from home using the measure in the previous study was not significant at the bivariate level, but sleeping away greater than 10 times in the current study was. Again, given relatively low incidence of HIV in Ghana, a substantial duration of exposure, such as frequent travel, might be necessary to observe an effect of travel on HIV status.

Other studies have assessed correlates of sexual partnership concurrency [30, 31], but have not considered migration or travel as a risk factor. Overall prevalence of concurrency in Ghana, which was measured precisely at the dyadic level, was relatively low compared to estimates from other sub-Saharan Africa [32, 33].

At the dyad level, prevalence of HIV was generally higher for males, females, and both partners when the male partner traveled. Female-only HIV infection in couples was strongly associated with having a male partner who traveled frequently. As hypothesized, this could be due to the female stay-at-home partner engaging in risky sexual behavior such as additional partners while her partner is away. All measures of travel were associated with higher odds of non-polygynous concurrency at the dyad-level.

Behind each dyadic-level comparison, there are multiple pathways in which the observed outcome could be obtained. It is difficult to tease apart the processes in which migration, concurrency, and HIV infection interact given a number of interrelated components. Migration may lead to concurrency and HIV infection in the migrating partner, who may then infect the staying partner. However, the staying partner may have a concurrent partnership and become infected as well, and infect the return migrant partner. Lastly, both the staying and migrating partner could be infected by additional outside partners before they reunite. These last few hypotheses assume that the couple was concordantly HIV-negative prior to the migration events. Of course, one or both partners may be infected before the migration event, an individual with a concurrent partner may not become infected, or an infected individual may not infect their partner. This analysis could not definitively assess the pathways because of the cross-sectional nature of the data, but offered some insight into the process. For instance, male frequent travel was associated with higher odds of male-only, female-only, and both-partner HIV infection as well as with concurrency, suggesting that male-only migration may be a mechanism in which migration leads to HIV acquisition and transmission.

An especially interesting finding is that odds of male concurrency were significantly higher when the female-only was a recent migrant. Since this definition only captures a move to a new residence as opposed to travel, we can not necessarily hypothesize about what the male was doing while the female was away. Nonetheless, these couples had been married or cohabiting for the entire duration of the year, and the male was not categorized as a recent migrant. Thus there most likely was a period of time when the male and female partners were not living under the same roof, and the male stay-at-home partner may have had additional partners during this time. Indeed, a study conducted in Tanzania found similar results; non-migrant men with long-term mobile wives had more non-spousal, casual, or multiple sex partners in the last year compared to non-migrant men with resident wives [34].

A unique strength of this analysis was the distinction between definitions of migration and travel. Migration is an amorphous concept, which is often difficult to measure. What constitutes a "move" to a current place of residence, such as the GHD asks? This could capture both a move within a village as well as a move from a different region. The travel definition, on the other hand, captures circular migration and ensures that a migrant was away overnight. Further, both the duration and frequency of travel are important to consider given that the risk of concurrency and HIV acquisition depend on the duration of exposure, i.e. the total amount of time that individuals are separated from their partners. The results of this analysis suggest that frequency of travel matters most in terms of HIV and concurrency risk. The dyad-level analyses suggested that male travel >1 month may predict male HIV infection, in addition to non-polygynous concurrency.

A second strength of these analyses was the inclusion of partners. Migration is a dyadic-level process, and this work contributed to understanding how migration may impact the sexual risk behavior of both the migrant and the partner left behind.

The ultimate goal is to understand whether migration directly leads to concurrency by either the migrant or the stay-at-home partner and whether migration increases the risk of HIV acquisition by the migrating partner or the stay-at-home partner. These two processes combined could lead to enhanced HIV transmission at a population-level. The current analysis compared migration with HIV infection and migration with concurrency separately. This is an important first step to understand how the process of migration is related to HIV risk and behavior. This work also helped to clarify the best methodological framework to examine possible causal pathways in which migration leads to concurrency and HIV infection; future work will examine the interrelationships and possible causality between all three variables.

Many more significant results were seen in the concurrency analysis than in the HIV analysis; this may be due to the relatively low prevalence of HIV in Ghana compared to many other countries in sub-Saharan Africa. Further work in higher prevalence settings would be useful to disentangle the hypothesis that migration promotes concurrency by either or both the migrating and stay-at-home partner, leading to HIV infection and transmission between the couple.

A significant limitation to this study was that the data are cross-sectional. HIV testing occurred only at one time point, thus we could not distinguish whether migration led to HIV infection or concurrency, or whether HIV infection or concurrency led to migration. Future data collection efforts should gather linked information on migration events and partnership history, as well as HIV status over time. Additionally, these data should contain information on where the migrants traveled to, or from where they moved. This information would inform the population-level relationship between migration and variable HIV prevalence within Ghana. Longitudinal data would link movement and location of partners with timing of HIV acquisition.

The data used for this analysis are somewhat old; nonetheless, they provide an opportunity to examine the interactions between migration, concurrency, and HIV whereas the more recent 2008 Ghana DHS data do not directly measure HIV infection. Lastly, although the UNAIDS recommendation is to use point prevalence of concurrency 6 months prior to the date of interview, this is not measured correctly in the DHS data [33]. Despite the aforementioned limitations, this analysis is an important first step in identifying whether migration affects sexual network structure in ways that may contribute to ongoing HIV transmission.

This paper is unique in that it considered migration and travel as a risk factor for concurrency at the individual and dyad-level as well as considering migration as a risk for HIV in partnerships. Additionally, it extended previous work on migration and HIV risk by clarifying what types of migration and travel are associated with HIV risk. Men who travel frequently appear to not only have a higher risk of HIV infection and concurrency, but they are putting their partners at risk as well. Thus migrants may be a key target for behavioral prevention interventions aimed at reducing HIV acquisition as well as secondary transmission.

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Appendix A: Dyad-level hypotheses regarding causal pathways between couples' migration and HIV status.

	Couples' HIV status			
Couples' migration status	Neither	Male-only	Female-only	Both
Neither	A	B	C	D
Male-only	E	F	G	H
Female-only	I	J	K	L
Both	M	N	O	P

ODDS RATIOS:

F: Male-only migration and male-only HIV-positive [(F/E)/(B/A)]

Hypothesis: Male-only migration is associated with increased risk for male HIV infection only. A male migrant with a female non-migrant partner is more likely to be HIV positive in a HIV-discordant partnership than a male in a neither-migrant couple.

Possible causal pathway: A couple is concordant HIV-negative. Male migrates, becomes infected while away, but has not yet transmitted HIV to female at home. The female stay-at-home partner is not at increased risk of acquisition.

G: Male-only migration and female-only HIV-positive (G/E)/(C/A)

Hypothesis: Male-only migration is associated with increased risk of HIV by the female only.

Possible causal pathway: Male-only migration leads to female HIV-infection via her having additional partners while home alone.

H: Male-only migration and both HIV-positive (H/E)/(D/A)

Hypothesis: Male-only migration is associated with HIV-infection in both couples.

Possible causal pathway: 1) The male partner migrates, becomes HIV infected by having additional partners, and transmits the infection to the stay-at-home partner, or 2) The female stay-at-home partner has a concurrent partnership, becomes HIV-positive, and transmits to the return migrant, or 3) Both the female stay-at-home and the male-migrant partner have additional partners and separately become HIV-infected from outside the partnership.

J: Female-only migration and male-only HIV-positive (J/I)/(B/A)

Hypothesis: Female-only migration is associated with male-only HIV infection

Possible causal pathway: The male stay-at-home partner has additional partners while the female is away. The female-migrant is not at increased risk of HIV acquisition while migrating

K: Female-only migration and female-only HIV-positive (K/I)/(C/A)

Hypothesis: Female-only migration is associated with female-only HIV infection within couples

Possible causal pathway: A female has additional partners while migrating and becomes infected.

L: Female-only migration and both HIV-positive (L/I)/(D/A)

Hypothesis: Female-only migration is associated with HIV infection in both partners.

Possible causal pathway: 1) The female partner migrates, becomes HIV infected by having additional partners, and transmits the infection to the stay-at-home partner, or 2) The male stay-at-home partner has a concurrent partnership, becomes HIV-positive, and transmits to the return female-migrant, or 3) Both the male stay-at-home and the female-migrant partner have additional partners and separately become HIV-infected from outside the partnership.

N: Both migration and male-only HIV-positive (N/M)/(B/A)

Hypothesis: Migration is only associated with increased risk of HIV infection by the male-migrant partner only. Female migration is not associated with increased risk

Possible causal pathway: Migration leads to HIV infection by male migrants via additional partners, but not for women. Or men are infected at home while their female migrant partners are away if the migrating events are not aligned in time.

O: Both migration and female-only HIV-positive (O/M)/(C/A)

Hypothesis: Migration is only associated with increased risk of HIV infection by the female-migrant partner only.

Possible causal pathway: Migration leads to HIV infection by female migrants via additional partners, but not for men. An alternative is females are infected at home while their male migrant partners are away, if the migrating events are not aligned.

P: Both migration and both-HIV-positive (P/M)/(D/A)

Hypothesis: Migration leads to HIV infection in both partners.

Possible causal pathway: Migrants either become infected while away while having additional partners, or the stay-at-home partner becomes infected while the other is away.

Alternative pathways to infection:

In all these scenarios, the HIV infection in either or both partners could have preceded a) the partnership, or b) the migration event in time. Additionally, the HIV infection may have been due to additional partners not during a migration event.