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ORIGINAL PAPER

Drought and disproportionate disease: an investigation of gendered vulnerabilities to HIV/AIDS in less-developed nations

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Abstract

Environmental change and climate-related disasters are an under-examined factor impacting women's health, globally. Drawing on ecofeminist theory, we conduct analyses examining if the HIV burden among women is higher in nations that experience suffering from droughts. Specifically, we posit that droughts, which typically impact more people and for greater lengths of time than other climate-related disasters, have a unique impact on women's vulnerability to HIV/AIDS. We use a cross-national dataset of less-developed countries and ordinary least squares (OLS) regression to explore and compare relationships between suffering from drought and total HIV prevalence and suffering from drought and women's proportion of HIV cases. Overall, the results demonstrate that while droughts have an inconsistent impact on total HIV prevalence, suffering from drought significantly increases the proportion of HIV cases among women in comparison to men, net of the impact of common economic, social, cultural, and political predictors. The findings suggest that suffering from drought differentially impacts women's health in less-developed countries, where a number of mechanisms, such as transactional sex or displacement, likely underlie the associations identified.

Keywords HIV/AIDS · Gender · Drought · Disaster · Cross-national

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Introduction

Despite some improvements, HIV/AIDS remains a key threat to health and well-being in many less-developed countries.[1] Recent trends also document the increased burden of HIV particularly among women in poor countries (WHO 2018). Although under-examined and seemingly unrelated, environmental changes resulting from climate-related disasters, or disasters linked to extreme meteorological events (Tschumi and Zscheischler 2020), may have a powerful influence on women's vulnerability to HIV in less-developed nations. Ecofeminism offers that women and the environment bear mutual oppression stemming from patriarchal structures that subjugate both, framing them as expendable and in need of domination and control (Gaard 2011; King 1999; Mies 1998). Central to this approach is that men and women hold different connections to the environment because of gendered expectations. Such socially constructed expectations are key in defining responsibilities and resource access, particularly in less-developed nations where individuals are more directly dependent upon the environment in meeting daily necessities. While women are more reliant upon such environmental resources in providing food and sustenance, they are simultaneously denied access to land and property (Frank and Unruh 2008; Mies and Shiva 1993). Disasters such as droughts could exacerbate women's already-hindered access to food and other resources through environmental destruction and degradation, thereby compromising their health.

Disasters in less-developed areas tend to be acutely devastating due to the vulnerability of poor populations (e.g., Tierney 2007; Wisner 2016). Natural hazards include events like droughts, and social, economic, and political factors create vulnerabilities that turn these events into disasters (e.g., Wisner 2016). Droughts are an especially crucial type of disaster to consider in this context, as they have increased in frequency and severity and are less predictable, are more prolonged, and have longer-term impacts than other types of disasters (Fisher and Carr 2015; Gerber and Mirzabaev 2017). Such effects include impaired access to clean drinking water, compromised livestock quality, and deleterious impacts on food production (FAO 2011; Sam et al. 2019). In fact, droughts are viewed as among the most detrimental of disasters because they affect more people than any other disaster type (Gerber and Mirzabaev 2017). For example, from 2000 to 2019, 80% of disaster-affected populations in Africa were affected by droughts (CRED 2019). This statistic is especially striking, considering droughts only comprised 11% of disaster events in Africa over that time period (CRED 2019).

Moreover, scientists predict that droughts will continue to worsen due to warming temperatures, precipitation declines, and decreases in soil moisture due to climate change (Cook et al. 2018). Less-developed nations are especially vulnerable to the devastation of droughts because of concurrent dependence on rain-fed agriculture and large rural populations, alongside inadequate infrastructure and resources to mitigate drought's effects (CRED 2019). Moreover, it is often low-income, rural, and/or ethnic minority women *within* these less-developed countries who disproportionately depend on environmental resources to meet family survival needs and who are more likely to live in high-risk and environmentally fragile zones (e.g., Oglethorpe and Gelman

[1] Throughout this article, less-developed countries are defined as countries falling within the lower three quartiles of the World Bank income classification of countries, which is based on per capita GDP.

2008). Clearly, given drastic effects of climate change on the frequency and severity of droughts, along with the rising HIV burden among women in places most likely to suffer from droughts, it is urgent to deeply consider the relationship between environmental change and women's health.

Insights from ecofeminist thinking emphasize that environmental degradation disproportionately affects women, in part, due to their reliance on the environment. In order to fully assess if droughts are linked to unique vulnerability among women to HIV/AIDS in less-developed countries, we conduct a two-step analysis. We first test for the impacts of suffering from drought on total HIV prevalence, net of other factors, then examine the effects of drought on women's proportion of HIV cases relative to men. To properly determine if women face unique susceptibilities to disease in the context of drought, it is important to assess an outcome that quantifies the distribution of HIV cases among women versus men. Simply considering prevalence rates can provide an incomplete picture of the disproportionate vulnerabilities women face as a consequence of their gender roles and statuses (e.g., Austin and Noble 2014). Droughts, which have grown increasingly severe and acutely devastating, are important to consider in creating disease vulnerabilities for women, as environmental decline can put women into structural situations that comprise their well-being.

Women, HIV, and ecofeminist approaches

While there are some areas of resurgence in developed nations, HIV predominantly affects people in less-developed countries, with 95% of individuals with HIV living in these locations (WHO 2018). Thus, HIV is closely related to international trends of poverty and inequality, including along lines of gender (Heimer 2007). A higher proportion of women acquire HIV compared to men, especially in poorer nations, and HIV/AIDS currently represents the leading cause of death for women of reproductive age (WHO 2018). The disproportionate increase in HIV among women in less-developed countries is likely due to the combination of biological, social, and, as we argue here, environmental factors.

While certain research points to biological susceptibilities to HIV (Campbell et al. 2008; Quinn and Overbaugh 2005; UNAIDS 2017), social and socioeconomic vulnerabilities also enhance women's likelihood of HIV infection. In less-developed nations, where the majority of HIV transmission among women is through heterosexual sex, women's lack of empowerment in the form of compromised access to contraception, education, and healthcare is especially relevant (Bose 2011; Heimer 2007; Smith 2002). Cross-national studies also focus on the potential role of other economic, political, and cultural predictors of women's HIV, including level of democracy or the percentage of the population that is Muslim, arguing that population-level characteristics such as enhanced civil liberties or strict sexual norms can function to promote or protect women's health (e.g., Gray 2004; Shircliff and Shandra 2011). While biological, socioeconomic, and other political or cultural factors can be significant in explaining gendered HIV disparities in less-developed nations, environmental factors likely also play an important role.

Although seemingly unrelated due to HIV being sexually transmitted, environmental change resulting from disasters may influence HIV susceptibility among women in

less-developed nations. Ecofeminism emphasizes the shared structural patriarchal oppression of both women and the environment, where the same logic that rendered nature conquerable does the same to women whose bodies are likewise subjugated (Eaton and Lorentzen 2003; Gaard 2017; Warren 1990). Tangible social structures set in place simultaneously make women more dependent on the environment while also compromising environmental integrity and sustainability, itself, as well as women's access to necessary environmental resources (Ergas and York 2012; Harlan et al. 2015; Shandra et al. 2008). Moreover, and crucially, the logic of domination that undergirds the shared oppression of women and the environment render both expendable (Terry 2009). For instance, women in less-developed nations who are especially dependent on environmental resources are denied land ownership and land inheritance (Frank and Unruh 2008), and, during times of instability, men's access to food and sustenance is prioritized over women's access (Dunaway and Macabuac 2007). Ecofeminist perspectives also point out that women's roles in being stewards of the environment mean that women are more likely to support policies that protect the environment and promote sustainability (Ergas and York 2012; McKinney 2014; Norgaard and York 2005).

The emphasis on social and structural dimensions that inform women's connection to the environment has revealed the inherent intersectionality within ecofeminism, as it encompasses racialized histories of colonialism, along with power and development differences by social and geopolitical locations (Elmhirst 2011; Gaard 2015; Godfrey 2012). That is, ecofeminism recognizes differences in gender expectations as socially constructed, and these roles vary across class, race, location, and culture. Moreover, these expectations change throughout time and across societies (Rocheleau et al. 1996). Ecofeminist thought thus incorporates multiple intersecting identities and statuses yet still uplifts gender as a key determinant in shaping relationships to the environment and corresponding socially constructed expectations. Certainly, women in less-developed nations are not a monolithic group; however, an ecofeminist approach speaks to the direct dependency of women in these locations upon the environment due to social roles that dictate women's use and reliance upon environmental resources daily and throughout life (Denton 2002; Ergas and York 2012; McKinney and Austin 2015; Shandra et al. 2008). Specifically, women are primarily responsible for obtaining food, clean drinking water, firewood, and other resources from their natural surroundings (Denton 2002; Oglethorpe and Gelman 2008; Rocheleau et al. 1996). As we describe in more detail below, such duties become more difficult during and after disasters, particularly prolonged, less predictable ones like droughts.

Disasters and Women's HIV in less-developed nations

A growing body of research demonstrates that disasters disproportionately affect and compromise women's health, morbidity, and mortality compared to men (Austin and McKinney 2016; Enarson et al. 2018; Harlan et al. 2015). Droughts can impact well-being through various mechanisms including environmental devastation, resource and water scarcity, and food insecurity (Arku and Arku 2010; Braun 2011; CRED 2019; Fisher and Carr 2015). Droughts constitute a "creeping disaster" due to their relative lack of predictability, slower onset, and long duration (CRED 2019; FAO 2020). Importantly, disasters such as droughts transcend the geological or meteorological

hazards and events that inform them: social conditions, including unequal power systems, prime vulnerability to disasters that affects individuals' ability to prepare for, cope with, and recover from disasters (Enarson et al. 2018; Fothergill and Peek 2004; Tierney 2007). Such social vulnerability approaches reveal disasters' disproportionate impact on marginalized populations, including women in less-developed nations, debunking the premise that disasters are "acts of God" that indiscriminately and equally affect everyone (Fothergill and Peek 2004; Steinberg 2000; Tierney 2007). Given the dependence of women upon the environment explained above, droughts likely have differentially severe effects on women's health compared to men, including the feminized burden of HIV.

Women's overall health suffers in the wake of disasters in various ways, including through increased informal, unpaid workloads (Arku and Arku 2010; Oglethorpe and Gelman 2008). Disasters destroy physical land and crops that help women provide for themselves and their families (CRED 2019). Thus, in fulfilling their duties as family caretaker, women spend considerably more time and energy obtaining, securing, and transporting resources for themselves and their families after a disaster (Arku and Arku 2010; Austin and McKinney 2016; Oglethorpe and Gelman 2008). Moreover, women's care-work of children and other family members becomes increasingly burdensome in such contexts (Enarson et al. 2018). Disasters thus result in higher levels of emotional stress and greater efforts to obtain needed resources, leading to a hindered ability for women to care for their families and themselves.

In conjunction with an *increased* informal workload, women endure a *decrease* in resource access during and after disasters (Enarson et al. 2018; Murray 2013), as men seek to retain their dominant positions during times of resource scarcity (Dunaway and Macabuac 2007; Mies 1998). Moreover, women experience impaired access to former, pre-disaster formal employment and education due to destruction of physical buildings (Enarson 2000), as well as ideological factors such as women's duty to prioritize their families' health over their own (Murray 2013). Lack of access to formal employment and education have been repeatedly shown to worsen women's health (Austin et al. 2017; Burroway 2010, 2012), and disasters reinforce this connection. Clearly, women's already-impeded access to relied upon, vital natural resources is further constrained in the context of disasters.

In order to cope with the concurrent increase in informal care-work and decreased access to environmental resources during and after disasters such as drought, women may turn to transactional sexual behaviors to secure food or other sustenance for themselves or their families (Hunter et al. 2011; Lungu and Hüsken 2010; Williams et al. 2012). Referred to "survival sex" or "sex for basic needs," transactional sexual relationships are usually non-marital and non-commercial, where money, food, or gifts are given primarily from men to women in exchange for sexual activity (McCleary-Sills et al. 2013; Mojola 2011; Smith 2002; Stoebenau et al. 2016; Wamoyi et al. 2019; Weiser et al. 2007).[2] Indeed, many studies illustrate that women engaging in transactional sex relationships oftentimes suffer from food insecurity, making acquiring

[2] Other types of transactional sex exist and are important to consider, including sex for improvement of social status and sex for material expressions of love (Mojola 2014; Stoebenau et al. 2016) through securing of material goods rather than food (Leclerc-Madlala 2008; Wamoyi et al. 2010, 2019). However, regardless of the motivations being for basic survival items or for more luxury items, we emphasize that devastation from drought may encourage women to engage in transactional sex to obtain the things they need or want.

money for food a key motive in many transactional relationships (e.g., McCleary-Sills et al. 2013; Oyefara 2007; Williams et al. 2012).

Participants in transactional sex are less likely to use STI-preventing barrier contraceptive methods and simultaneously have a higher risk for contracting STIs (Oyefara 2007; Pascoe et al. 2015; Weiser et al. 2007). For instance, migrant worker men, older men, and wealthy men are more likely to engage in such relationships, as they are more able to provide monetary support, yet also have higher rates of HIV (Lungu and Hüsken 2010; Mojola 2011, 2014). Furthermore, women refrain from asking men to use condoms due to the unequal power dynamics and the potential that such requests would deter men from engaging in the relationship (Lungu and Hüsken 2010; Mojola 2011, 2014). Additionally, there is a higher risk for forced sex and other forms of sexual violence in transactional sexual relationships (Dunkle et al. 2004; Mosavel et al. 2012).

In less-developed countries where HIV prevalence is highest, transactional sexual arrangements are increasingly pervasive among women of many ages and marital statuses, compounding the likelihood of HIV transmission (Dunkle et al. 2004; Mojola 2011, 2014). Thus, for women who can no longer access necessary environmental resources during disasters like droughts, engaging in risky sexual behaviors may be an important coping strategy, despite it ultimately putting them at a higher risk for HIV. Droughts are among the longest-lasting disasters and thereby extend the timeframe for both resource depletion and resulting transactional sexual relationships.

As droughts can result in livelihood devastation, hunger, illness, and ultimately displacement and migration, especially among those most disadvantaged (Enarson et al. 2018; Ocello et al. 2015), there are likely to be other factors beyond transactional sex also putting women at risk.[3] Migration itself is an important predictor of disease transmission, and disasters such as droughts can concentrate people in internally displaced persons (IDP) camps (Majid and McDowell 2012; Neumayer and Plümper 2007; Shukla 2014). STI transmission rates and instances of sexual violence against women are high in many IDP camps (Austin et al. 2008; Murray 2013; Neumayer and Plümper 2007). Additionally, access to healthcare and reproductive health resources are extremely low or non-existent in most in IDP camps (Horton 2012; Neumayer and Plümper 2007).

Factors like transactional sex, food insecurity, and displacement in the wake of disasters represent processes that might explain an association between droughts and gendered vulnerabilities to HIV in less-developed nations. Although our goal is to not test for these specific mechanisms, it is important to understand the individual-level social conditions that motivate the large-scale, structural associations we endeavor to investigate. Ecofeminism highlights women's closeness to the environment through shared oppression, where patriarchal ideology frames both as expendable and in need of subjugation, rendering their destruction "justified." Droughts worsen access to necessary resources through environmental degradation and devastation, typically for long periods of time. As women are displaced or turn to transactional sex, their likelihood of contracting HIV increases. Here, we draw on

[3] We acknowledge that violent conflict also likely exacerbates the effects of drought and is also a major contributor to displacement. Droughts are likely to be acutely devastating in nations with pre-existing conflict (e.g., Somalia). While relevant to ideas about displacement and IDP camps, we prefer to focus on drought rather than conflict in the current manuscript for the sake of parsimony, and as the relationship between drought and HIV is a new line of research which first deserves a fundamental approach. Certainly, considering the role of conflict alongside these themes represents an avenue for future research.

these ideas to illuminate that droughts have a unique impact on women's vulnerability to HIV in comparison to men.

Central hypotheses

First, we predict that there is a positive relationship between drought and women's proportion of the population living with HIV across nations, where less-developed countries with increased suffering from drought have higher proportions of HIV among women relative to men, net of other factors. Secondly, and in contrast to the prediction above, we predict that there is an inconsistent or non-significant relationship between drought and total HIV prevalence in less-developed countries, net of other economic, social, political, and cultural factors.

Methods

To test the relationships between drought and HIV prevalence and drought and women's proportion of HIV cases, we employ OLS (ordinary least squares) regression. OLS regression facilitates transparent hypothesis testing, enabling us to examine the significance of suffering from drought while controlling for other known predictors of HIV. In order to facilitate rigorous hypothesis testing, we include a diverse set of control variables that reflect some of the most common economic, social, political, and cultural predictors used in cross-national HIV/AIDS and health research.

OLS regression represents an important foundational technique that is a good starting point for this line of research, as examining the relationship between drought and HIV/AIDS cross-nationally represents a new course of inquiry. Indeed, a number of cross-national studies utilize OLS regression methods, especially in HIV research (e.g. Austin et al. 2017; Austin and Noble 2014; Burroway 2012; Shircliff and Shandra 2011). To analyze the data, we use the statistical program STATA. In addition to conducting the regression analyses, we also preformed appropriate diagnostic functions for testing adherence to OLS regression assumptions.[4]

One of the most important concerns in OLS regression, especially when using relatively small samples of country-level data, is multicollinearity (e.g., Allison 1999). In order to limit the impacts of multicollinearity in the models, where independent variables highly correlate with each other, we pay close attention to the variance inflation factors (VIFs) and carefully construct models by including several baseline predictors, and then we add additional predictors one at a time. We note the VIFs for each indicator within each regression model in the results presented below. Not surprisingly, the VIFs are highest for the women's status measures, such as female use of contraceptives and female secondary school enrollments, but are still largely within acceptable range.[5] Furthermore, statisticians identify that multicollinearity is

[4] We employed a number of diagnostic tests, including Cook's D, Breush-Pagan, and modified White's tests to examine potential patterns in heteroscedasticity, the existence of outliers, etc.

[5] We follow Paul Allison (2012), where he conservatively recommends concerns over multicollinearity when individual VIFs exceed 2.5.

most problematic when it involves the key independent variable (e.g., Allison 1999, 2012). In the results presented below, the VIFs for the key independent variable, percent affected by drought, across the models are very low and do not suggest issues with multicollinearity.

Another potential weakness of this study involves the use of a cross-sectional design. However, reliable and expansive longitudinal data on a variety of indicators used, including key control variables such as the number of trained health workers, contraceptive use, and female secondary schooling, are not available over multiple time points with consistency. Importantly, the agencies that collect and publish cross-national HIV estimates explicitly caution against the use of the data in longitudinal studies, as the methods to calculate HIV and AIDS prevalence have changed over time (UNAIDS 2014).

To improve conditions of causality and address the unique nature of HIV, the variables are time-ordered, where the independent variables are measured in time before the dependent variables. Specifically, we measure droughts from 2008 to 2012 as an average over a 5-year period to avoid any idiosyncrasies from a single bad drought event in a given year. The other independent variables, or control variables, are measured for the year 2010. The HIV prevalence and women's proportion of HIV cases outcome variables are measured for the year 2014 in order to take into account the time lag between contracting HIV and detecting infection, which can be several months or years in poor nations.[6]

Sample

The sample includes all less-developed countries for which data are available across all indicators used in the analyses. Due to the focus on themes related to gender and the environment, we restrict our sample to less-developed countries where these factors are most salient. Less-developed countries are defined as countries falling within the lower three quartiles of the World Bank income classification of countries, which is based on per capita GDP for the year 2014 (World Bank 2018). In total, the sample consists of 69 less-developed nations; however, four nations have missing data on the number of health workers; thus, the models including this variable are restricted to 65 cases.[7] The countries included in the sample are noted in Table 1.

Key dependent variables

Total HIV prevalence is the percentage of the population ages 15–49 who are infected with HIV. HIV prevalence rates reflect the rate of HIV infection in each country's population. These data are originally from the Joint United Nations Programme on HIV/AIDS (UNAIDS), but were collected from the World Bank (2018). This variable was log-transformed to reduce the influence of extreme outliers.

[6] We also considered other time-lags (e.g., 4–8-year lags) used in prior research and obtained consistent results.

[7] We also tested all models using the complete sample of 65 cases. The results were entirely consistent with those presented here. However, we prefer to present models on as many cases as possible; thus, we retained all 69 cases in the sample and only have a reduced sample size for those models including number of trained health workers.

Table 1 Nations included in this analysis ($N = 69$)

Afghanistan	Costa Rica	Liberia	Rwanda
Algeria	Côte d'Ivoire	Macedonia, FYR	Senegal
Armenia	Dominican Republic	Madagascar	Serbia
Bangladesh	Egypt, Arab Rep.	Malawi	Sierra Leone
Belize	El Salvador	Mali	Sri Lanka
Benin	Ethiopia	Mauritania	Sudan
Bhutan	Gambia, The	Moldova	Swaziland
Bolivia	Georgia	Morocco	Tajikistan
Burkina Faso	Guatemala	Mozambique	Tanzania
Burundi*	Guinea	Nepal	Thailand
Cabo Verde	Guyana	Nicaragua	Togo
Cambodia	Honduras	Niger	Tunisia
Cameroon	Indonesia	Nigeria	Uganda
Central African Rep.	Jamaica	Pakistan	Uzbekistan
Chad	Kenya	Papua New Guinea	Yemen, Rep.
Colombia	Kyrgyz Republic	Paraguay	
Congo, Dem. Rep.*	Lao PDR	Peru	
Congo, Rep.	Lesotho*	Philippines*	

*Represents countries where there are no data available for "trained health workers" variable, thus these nations are not included in analyses including "trained health workers" as a predictor

Women's proportion of the population living with HIV represents women's proportion of the population ages 15–49 living with HIV relative to men, expressed as a percentage. These data were obtained from the World Bank (2018), based on data originally published by the Joint United Nations Programme on HIV/AIDS or UNAIDS. As current trends emphasize the rising HIV burden among women relative to men (e.g., Mojola 2014), we utilize this measure to explicitly examine the relative burden of HIV among females relative to males, cross-nationally. Measuring the distribution of HIV cases by gender is more appropriate in considering the ecofeminist themes explored above which emphasize the disproportionate impact of environmental decline on women.[8]

Independent variables

Suffering from drought, or *the percent of the population affected by drought*, represents the key independent variable in this analysis. The data used to measure the percent

[8] We also considered analyses predicting female HIV prevalence. However, these models did not yield any interesting or new results. Austin and Noble (2014) provide a clear discussion and analysis of women's HIV prevalence versus women's proportion of HIV cases, demonstrating that total prevalence and female prevalence of HIV are correlated at 0.99 in cross-national data and that analyses of female prevalence rates do not appropriately capture the drivers of women's disproportionate vulnerability to HIV/AIDS. We also utilized data on female HIV prevalence and found consistent results with those presented here for total HIV prevalence. We focused our analyses to presenting the findings for total HIV prevalence and women's proportion of the population living with HIV for parsimony and to more succinctly demonstrate environmental change as a gendered health issue.

affected by drought are from the EM-DAT Database, which defines "affected by" as "people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance" (EM-DAT 2015).

Because the frequency and magnitude of droughts and other disasters can vary widely from year to year, we calculate an average percentage of the population affected by droughts over a 5-year window, from the years 2008 to 2012. This date range was used to capture a decently wide breadth of time, but to also to be recent enough to be relatable to current HIV data.[9] To reach this average, we first divided the number of people affected by droughts in each country by that country's population for every year spanning from 2008 to 2012. Then, we averaged the affected rate, to yield the average percentage of the population affected by droughts from 2008 to 2012. For many cases included in our sample, no droughts were reported for any of the years under investigation, signifying that no major drought was recorded in that country over the entire time span. These nations were coded with a 0 for the drought measure.

Levels of economic development are important to control for in any cross-national analysis. Traditionally, gains in GDP per capita are expected to be correlated with reductions in disease. We measure the level of economic development by using data on the *gross domestic product (GDP) per capita*. GDP per capita is the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment, and government spending, divided by the mid-year population. It is converted into current international dollars using purchasing power parity (PPP) rates, which provides a standard measure allowing for cross-country comparisons of real price levels (World Bank 2018).

We control for a number of additional variables, including those found to be important in prior cross-national studies of women's HIV. *Women's use of contraceptives* is imperative to consider, as some methods of contraception, such as condoms, can directly protect against HIV transmission. Even if alternative forms of contraceptives are captured in this measure, such as the use of oral contraceptives, use of any contraception speaks to high levels of reproductive autonomy or empowerment that could protect women against HIV transmission in other ways. The contraceptive use rate is the percentage of women ages 15–49 who are practicing, or whose sexual partners are practicing, any form of contraception (World Bank 2018).

We also examine the influence of *secondary school enrollments for women*. We utilize a gross enrollment ratio, which refers to the ratio of female educational enrollment regardless of age, to the female population of the age group corresponding to secondary level education (World Bank 2018). Women's participation in education is a well-researched indicator of women's health and empowerment, and a number of studies make explicit links between female participation in secondary level education and women's HIV rates (e.g., Austin and Noble 2014; Burroway 2010). Education can provide women with ideas on negotiating safe sex and delaying marriage by refocusing young women's goals on future aspirations outside of the home. Educated women are also more able to make healthcare-related decisions that protect their reproductive and sexual health (e.g., Heimer 2007).

[9] We also tried additional time windows when calculating the droughts measure, ranging from 3 to 15 years. The impacts of droughts on women's proportion of the population living with HIV and total HIV prevalence were overwhelmingly consistent with the results presented here regardless of the timespan used to measure the variable.

Certainly, susceptibility to HIV can be greatly influenced by accessibility to healthcare resources. We measure the *number of trained health workers* using data from the World Bank (2018) on the number of physicians per 100,000 people. This measure includes nurses, midwives, generalists, and specialist practitioners. We also consider the role of health spending by including *total health expenditures as a percent of GDP* (World Bank 2018). We carefully include both of these measures as, while it is common to consider health expenditures in cross-national analyses, health expenditures are utilized for all types of health provisions, including those for surgeries, treatments for chronic diseases, and specialty equipment, which have no impact on diseases like HIV. Thus, it is important to take into account the more proximate health resources might promote HIV prevention, especially for women, such as trained health workers.

We include a measure of *democracy*, obtained from the Freedom House's political rights and civil liberties index (Freedom House 2011). Civil liberties and political rights are measured using a 7-point ordinal scale ranging from 1 (most free) to 7 (least free), and an average is used to create a single measure of democracy with a range from 1 to 7. The measure is coded such that higher scores represent higher levels of democracy. Cross-national research often finds that more democratic nations have better health outcomes, including lower HIV rates among women (e.g., Shircliff and Shandra 2011).

Percent urban and external debt stocks represent other common control variables in cross-national analysis of human well-being. *Percent urban* refers to the percentage of the population living in urban (non-rural) areas (World Bank 2018). *External debt stocks* are the total external debt stocks as a proportion of the gross national income (GNI). Total external debt is the sum of public, publicly guaranteed, and private nonguaranteed long-term debt, use of IMF credit, and short-term debt (World Bank 2018). Urbanization is often associated with increases in development and well-being, while foreign debt is commonly associated with decreases in health (e.g., Maynard and Ong 2016).

We also control for percent Muslim and location in Sub-Saharan Africa in the analysis. *Percent Muslim* refers to the percentage of the national population that identifies Islam as their religious affiliation. This measure was obtained from the Pew Research Center's World Muslim Population by Region and Country. Previous comparative studies demonstrate that nations with large Muslim populations tend to have lower HIV prevalence (e.g., Gray 2004; McIntosh and Thomas 2004). This relationship between Muslim populations and lower HIV prevalence may be due to strict religious tenets dictating conservative sexual norms, such as emphasizing abstinence before marriage and condemning extramarital sex (Gray 2004; McIntosh and Thomas 2004). *Sub-Saharan Africa* measures whether a country is located in the Sub-Saharan region of Africa. A value of "1" indicates that the country is located in Sub-Saharan Africa, while a "0" reflects non-Sub-Saharan African status. A number of reports document the increased burden of HIV among people, and especially women, in Sub-Saharan Africa (UNAIDS 2014; WHO 2018); thus, we expect nations located in this region to have a higher HIV burden among women relative to men and higher total prevalence rates.[10]

[10] We also tested models with additional control variables related to women's empowerment, including fertility rates, the percent of births attended by trained health staff, female primary school enrollments, and the Gender Inequality Index. These models were excluded from the main results for the sake of parsimony, but they are available in the Appendix Table 5.

Results

Table 2 displays the correlation matrix and univariate statistics for all of the variables used in the regression analyses. Of particular interest, the percent affected by drought has a moderate association with women's proportion of the population living with HIV (0.38) and a weaker association with total HIV prevalence (0.22).

Table 3 first presents the regression results assessing the impacts of suffering from drought on the total HIV prevalence rate (ln), and Table 4 presents the regression results assessing the impacts of suffering from drought on women's proportion of the population living with HIV. In addition to drought, we include as baseline predictors GDP per capita, percent Muslim, and female contraceptives across all the models presented. Our baseline predictors are chosen based on relevance in prior analyses focused on women's HIV and conventional practices in cross-national studies of including a control for level of economic development. Models 2–8 explore the effects of additional known predictors of HIV and health outcomes in developing nations. Additional variables are added one at a time in subsequent models to avoid complications due to multicollinearity. A more saturated model is also presented in model 9 in Tables 3 and 4, including all baseline predictors and any statistically significant predictors from prior models for each set of analyses respectively.

Looking first at the regression results presented in Table 3 for HIV prevalence, we find that the percent of the population affected by droughts has an inconsistent impact on total HIV prevalence in less-developed nations. In model 1, the baseline model, suffering from droughts is significantly and positively associated with total HIV prevalence, net of the effect of GDP per capita, percent Muslim, and contraceptive use. Percent Muslim is also statistically significant in model 1, as well as in models 2–7 with the addition of supplementary control variables. Percent Muslim is non-significant in predicting HIV prevalence in models 8 and 9 once the Sub-Saharan African dummy indicator is introduced.

Model 2 of Table 3 adds female secondary school enrollments to the baseline predictors and is non-significant. The importance of droughts is also attenuated in this model. Models 3–7 introduce controls for trained medical staff, health expenditures, percent urban, democracy, and external debt. Results shown in model 3 illustrate that trained medical staff approaches conventional statistical significance standards, where more medical workers are associated with declines in HIV prevalence across less-developed countries. However, none of the other new predictors in models 4–7 are important in predicting HIV prevalence, net of the influence of the baseline indicators. In these models, the relevance of suffering from droughts on HIV prevalence oscillates, non-significant in the models including trained health workers and percent urban, but statistically significant in others.

Model 8 of Table 3 includes a predictor for location in Sub-Saharan Africa.[11] The effects of location in Sub-Saharan Africa are robust, indicating that nations in

[11] In early models, we also tested for the influence of the other key macro-regions represented by the countries in the sample, including Latin America and Southeast Asia. However, the dummy indicators for these two regions were non-significant.

Table 2 Correlation matrix and univariate statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Women's proportion of HIV burden	1.00												
(2) HIV prevalence (ln)	0.46	1.00											
(3) Average % affected by droughts	0.38	0.22	1.00										
(4) GDP per capita	− 0.58	− 0.24	− 0.29	1.00									
(5) Percent Muslim pop.	0.03	− 0.25	0.25	− 0.13	1.00								
(6) Female contraceptive use	− 0.63	− 0.11	− 0.31	0.72	− 0.40	1.00							
(7) Female sec. school enrollment	− 0.64	− 0.24	− 0.32	0.76	− 0.20	0.77	1.00						
(8) Trained health workers	− 0.57	− 0.31	− 0.22	0.46	− 0.03	0.39	0.62	1.00					
(9) Health expenditures as % of GDP	− 0.03	0.18	0.01	− 0.02	− 0.25	0.13	0.12	0.37	1.00				
(10) Percent urban	− 0.50	−0 .32	− 0.37	0.65	− 0.07	0.45	0.56	0.38	− 0.05	1.00			
(11) Democracy	− 0.25	− 0.02	− 0.18	0.32	− 0.36	0.33	0.35	0.03	0.13	0.31	1.00		
(12) External debt stocks	− 0.18	− 0.19	−0.12	0.14	− 0.18	0.15	0.30	0.33	0.05	0.19	0.18	1.00	
(13) Sub-Saharan Africa	0.66	0.49	0.43	− 0.58	0.02	− 0.63	− 0.67	− 0.52	− 0.01	− 0.35	− 0.15	− 0.34	1.00
Mean	46.24	2.45	1.46	4551.39	33.73	42.97	57.20	0.73	5.79	41.42	3.80	41.08	0.42
SD	13.33	0.25	2.69	3479.07	39.87	23.13	28.59	1.00	2.24	17.21	1.44	23.95	0.49
Minimum	11.70	2.31	0.00	671.01	0.10	4.80	10.06	0.01	1.98	10.64	1.00	2.06	0.00
Maximum	61.99	3.65	13.62	12,562.43	99.70	82.10	106.41	4.76	11.28	76.92	7.00	110.70	1.00

Table 3 OLS regression results of droughts predicting HIV prevalence (ln)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Percent affected by drought	0.244* (0.023) *0.010* [1.15]	0.228+ (0.021) *0.011* [1.17]	0.083 (0.007) *0.011* [1.19]	0.236* (0.023) *0.011* [1.16]	0.195 (0.018) *0.011* [1.24]	0.243* (0.023) *0.011* [1.16]	0.234* (0.022) *0.011* [1.16]	0.073 (0.007) *0.011* [1.35]	− 0.066 (0.005) *0.010* [1.34]
GDP p/c PPP	− 0.180 (0.001) *0.001* [2.25]	− 0.095 (0.001) *0.001* [2.76]	− 0.082 (0.001) *0.001* [2.30]	− 0.164 (− 0.001) *0.001* [2.28]	− 0.032 (− 0.001) *0.001* [3.05]	− 0.171 (− 0.001) *0.001* [2.33]	− 0.159 (− 0.001) *0.001* [2.26]	− 0.103 (− 0.001) *0.001* [2.29]	− 0.053 (− 0.001) *0.001* [2.31]
Percent Muslim	− 0.351** (− 0.002) *0.001* [1.32]	− 0.338* (− 0.002) *0.001* [1.33]	− 0.343* (− 0.002) *0.001* [1.39]	− 0.330* (− 0.002) *0.001* [1.37]	− 0.343** (− 0.002) *0.001* [1.32]	− 0.363** (− 0.002) *0.001* [1.45]	− 0.382** (− 0.002) *0.001* [1.35]	− 0.183 (− 0.001) *0.001* [1.51]	− 0.192 (− 0.001) *0.001* [1.53]
Percent contractive use	− 0.024 (− 0.001) *0.002* [2.60]	0.059 (0.001) *0.002* [3.33]	− 0.121 (− 0.001) *0.002* [2.65]	− 0.060 (− 0.001) *0.002* [2.63]	− 0.058 (− 0.001) *0.002* [2.61]	− 0.042 (− 0.001) *0.002* [2.60]	− 0.042 (0.001) *0.002* [2.60]	0.282 (0.003) *0.002* [3.29]	0.194 (0.002) *0.002* [3.28]
Female sec. education		− 0.211 (− 0.002) *0.002* [3.19]							
Trained medical staff per 1000			− 0.217+ (− 0.048) *0.029* [1.31]						− 0.073 (− 016) *0.028* [1.45]
Health expenditures				0.101 (0.011) *0.013* [1.09]					
Percent urban					− 0.227				

Table 3 (continued)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
					(− 0.003) *0.002* [1.89]				
Democracy						− 0.037 (− 0.006) *0.022* [1.26]			
External debt stocks							− 0.117 (− 0.001) *0.002* [1.05]		
Sub-Saharan Africa								0.581*** (0.294) *0.077* [2.22]	0.600*** (0.267) *0.072* [2.32]
Mean VIF	1.83	2.36	1.77	1.70	2.02	1.76	1.68	2.13	2.04
N	69	69	65	69	69	69	69	69	65
R^2	0.18	0.20	0.20	0.20	0.22	0.19	0.23	0.35	0.35

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $^{+}$ $p < 0.10$ (two-tailed tests); standardized regression coefficients are flagged for statistical significance; the unstandardized regression coefficient are labeled in parentheses; standard errors are reported in italics; and the VIFs are labeled in brackets

Table 4 OLS regression results of droughts predicting women's proportion of HIV cases

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Percent affected by Drought	0.229** (1.14) *0.359* [1.15]	0.210* (1.04) *0.457* [1.17]	0.200* (0.871) *0.391* [1.19]	0.231** (1.20) *0.450* [1.16]	0.202* (0.964) *0.461* [1.24]	0.227** (1.15) *0.404* [1.16]	0.224* (1.10) *0.458* [1.16]	0.194* (1.29) *0.482* [1.35]	0.171* (1.17) *0.453* [1.34]
GDP p/c PPP	− 0.127 (0.001) *0.001* [2.25]	− 0.026 (0.001) *0.001* [2.76]	− 0.021 (0.001) *0.001* [2.30]	− 0.132 (− 0.001) *0.001* [2.28]	− 0.011 (− 0.001) *0.001* [3.05]	− 0.104 (− 0.001) *0.001* [2.33]	− 0.116 (− 0.001) *0.001* [2.26]	− 0.090 (− 0.001) *0.001* [2.29]	− 0.040 (− 0.001) *0.001* [2.69]
Percent Muslim	− 0.282** (− 0.094) *0.033* [1.32]	− 0.267** (− 0.089) *0.033* [1.33]	− 0.285** (− 0.090) *0.030* [1.39]	− 0.289** (− 0.097) *0.034* [1.37]	− 0.276** (− 0.092) *0.033* [1.32]	− 0.311** (− 0.104) *0.035* [1.45]	− 0.299** (− 0.100) *0.033* [1.35]	− 0.204* (− 0.070) *0.033* [1.51]	− 0.254* (− 0.081) *0.032* [1.53]
Percent contractive use	− 0.587*** (− 0.338) *0.080* [2.60]	− 0.467** (− 0.269) *0.090* [3.33]	− 0.589*** (− 0.320) *0.071* [2.65]	− 0.582*** (− 0.335) *0.081* [2.63]	− 0.599*** (− 0.345) *0.079* [2.61]	− 0.586*** (− 0.338) *0.080* [2.60]	− 0.587*** (− 0.339) *0.080* [2.60]	− 0.436** (− 0.251) *0.088* [3.29]	− 0.555** (− 0.302) *0.086* [3.82]
Female sec. education		− 0.250* (− 0.189) *0.071* [3.19]							0.082 (0.037) *0.073* [4.16]
Trained medical staff per 1000			− 0.297** (− 3.78) *1.14* [1.31]						− 0.291** (− 3.70) *1.36* [1.76]
Health expenditures				− 0.029 (0.172) *0.538* [1.09]					
Percent urban					− 0.179				

Table 4 (continued)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
					(− 0.139) *0.091* [1.89]				
Democracy						− 0.089 (− 0.824) *0.895* [1.26]			
External debt stocks							− 0.106 (− 0.059) *0.049* [1.05]		
Sub-Saharan Africa								0.271* (7.27) *3.34* [2.22]	0.131 (3.38) *3.21* [2.38]
Mean VIF	1.83	2.36	1.77	1.70	2.02	1.76	1.68	2.13	2.53
N	69	69	65	69	69	69	69	69	65
R^2	0.52	0.54	0.62	0.52	0.54	0.53	0.53	0.56	0.63

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $^{+}$ $p < 0.10$ (two-tailed tests); standardized regression coefficients are flagged for statistical significance; the unstandardized regression coefficient are labeled in parentheses; standard errors are reported in italics; and the VIFs are labeled in brackets

this region tend to have higher levels of HIV prevalence in comparison to other world regions. In model 8, as well as model 9, the more saturated model, the Sub-Saharan Africa indicator is the only statistically significant predictor of HIV prevalence. The R^2 across the models in Table 3 are relatively low, with only around 20–35% of the variation in HIV rates explained by the predictors included. Moreover, the inconsistent effects of suffering from drought on HIV prevalence suggests that drought is not very robust in predicting differences in total HIV prevalence rates across less-developed nations.

In contrast, the results presented in Table 4 exemplify the importance of droughts in creating gendered vulnerabilities to HIV. The regression results depicted in Table 4 demonstrate that suffering from drought contributes positively the proportion of HIV cases among women relative to men in less-developed nations. Across all models (1–9) in Table 4, the percentage of the population impacted by drought remains significant and robust in predicting women's percentage of population living with HIV, net of other factors. In addition to the consistent relationship of suffering from drought, we find that percent Muslim and female contraceptive use have stable and significant impacts on women's proportion of the population living with HIV, net of other factors. More specifically, we find that less-developed countries with larger Muslim populations and higher levels of contraceptive use tend to have a lower proportion of women living with HIV, as expected. Across all models, we find no significant association between GDP per capita and women's percentage of population living with HIV in developing countries.

Models 2 and 3, respectively, demonstrate the importance of female secondary schooling and number of trained health workers, net of the baseline predictors, in predicting women's percentage the of population living with HIV in the expected direction. Model 4 considers health expenditures as a percent of GDP, but the results suggest that health spending has no significant impact on women's vulnerability to HIV. Likewise, models 5, 6, and 7, respectively, consider the influence of percent urban, democracy, and external debt stocks. None of these variables are found to have a significant association with women's percentage the of population living with HIV, net of the influence of drought, GDP per capita, percent Muslim, and contraceptive use. Model 8 tests location in Sub-Saharan Africa on the female HIV burden. The findings presented in model 8 demonstrate that Sub-Saharan African nations tend to have higher proportions of women living with HIV, net of the impact of droughts and the other baseline predictors.

Model 9 represents a more saturated model, including all baseline predictors and the statistically significant predictors from prior models. Specifically, this model tests the impacts of percent affected by drought, GDP per capita, percent Muslim, female contraceptive use, female secondary schooling, number of health workers, and location in Sub-Saharan Africa on women's percentage the of population living with HIV. In this model, the associations involving percent affected by drought, percent Muslim, contraceptive use, and number of health workers on women's HIV remain significant.

Overall, the results presented in Table 4 suggest the importance of suffering from drought in increasing the proportion of women living with HIV in developing nations. Also, the R^2 estimates across the models in Table 4 range from 0.52 to

0.63, suggesting that a notable portion of the cross-national variation in women's percentage of the population living with HIV is explained by the variables considered in this analysis. In considering the findings presented across Tables 3 and 4, suffering from drought appears to represent a notable factor in explaining women's unique vulnerability to HIV, but not necessarily in accounting for differences in total HIV prevalence across less-developed countries.

Conclusion

Climate-related disasters are an under-examined force potentially impacting women's HIV burden in less-developed countries. Droughts continue to increase in number and intensity because of climate change, and poor nations are in the weakest position to be able to manage the catastrophic impacts of these events (Guha-Sapir 2012; UNDP 2016). As the HIV burden grows larger among women in less-developed countries, it is necessary to take a holistic approach to examine all possible contributing factors. Our research makes an important contribution by considering the effects of droughts on the exacerbation of gendered inequalities in health and well-being.

Generally used as a theoretical base in non-quantitative research (e.g., Eaton and Lorentzen 2003; Gaard 2011; Mies 1998; Mies and Shiva 1993; Rocheleau et al. 1996), ecofeminism represents a relatively new contribution to comparative, cross-national research. Highlighting the shared systemic oppression of women and nature, ecofeminist perspectives posit that women and nature are closely connected. Environmental changes and resource scarcity resulting from climate-related disasters, therefore, yield alarming impacts on women's health. This close link between women and the environment must be considered when examining vulnerabilities to HIV.

Our results clearly demonstrate that suffering from environmental decline is a gendered issue. While droughts have an inconsistent and relatively modest impact on HIV prevalence in less-developed nations, we find a robust, consistent statistically significant relationship between droughts and women's proportion of the population living with HIV in less-developed countries, net of other factors. The findings emphasizing the unique vulnerabilities of women suggest a range of possible mechanisms linking suffering from drought to women's HIV which we explore in prior literature, such as transactional sex and displacement. In addition to the importance of droughts in contributing specifically to women's health declines, our results demonstrate that, generally, factors related to women's status, including contraceptive use and secondary schooling, were more important in models predicting women's proportion of the population living with HIV than in models predicting HIV prevalence. As the women's proportion outcome accurately captures the distribution of HIV cases between women and men, it makes sense for these indicators capturing elements of women's status to be more relevant in models predicting women's percentage of the population living with HIV.

Unlike the findings for contraceptive use and female secondary schooling, results for the healthcare resource measures were fairly consistent across the two HIV outcome measures. While the results suggest that countries with a larger

number of trained medical staff are likely to have a lower proportion of women with HIV and lower rates of HIV prevalence, importantly, we find no significant relationships involving health expenditures. Comparing these findings suggests that using health funding for actual health workers, rather than specialty equipment or expensive interventions for complicated diseases, is most important in mitigating HIV in less-developed nations.

We also find a number of non-significant relationships involving other common indicators, such as GDP per capita, percent urban, and democracy. In many ways, our findings fit with prior research which finds inconsistent results for conventional development measures, such as GDP per capita. As an increasing number of studies find that, despite overall gains in economic growth, urbanization, and voting rights, gains in human well-being in less-developed nations, especially among the most vulnerable, remain modest. Thus, economic growth and development are not automatic in improving health; gains must be channeled into appropriate public resources and opportunities for women, including into increasing the number of medical workers, reproductive health resources, and education access, to be effective in mitigating disease vulnerabilities.

We acknowledge that our study has limitations. Overall, our sample size is relatively small. Our sample includes the maximum number of cases possible given the data available, but this still provided some notable constraints. A second limitation of our research strategy is the potential of multicollinearity, involving high correlations among many of the control variables. To address this, when conducting the regressions, we paid close attention to the VIFs and constructed the models carefully by adding one additional control variable at a time to the baseline predictors. However, we also included a more saturated model for each outcome to demonstrate that our results involving drought and HIV vulnerabilities are not driven by these strategies.

Another limitation involves our inability to test the mechanisms we speculate underlie the positive association between drought and the proportion of women living with HIV in less-developed nations. Indeed, a common weakness in all cross-national studies is a lack of attention to or explanation of the exact mechanisms by which many of the larger relationships take place. For example, risky sexual behaviors cannot be controlled for in a cross-national analysis of this type but are likely to be an implicit mechanism linking drought to women's HIV vulnerability. At a comparative level, factors such as hunger or lack of access to clean water represent some mechanisms that could be captured to speak to some motivations for risky sexual behaviors. However, constraints in sample size and modeling prevented the use of relevant interaction terms involving these measures. We maintain that the goal of our research is to represent an important introductory-level exploration into these phenomena which we hope will be further expanded on with more sophisticated, complicated methods and data that are better suited to test for potential mediating relationships, whether at the individual or country-level.

Despite not being able to test for specific mechanisms linking droughts to HIV vulnerability, it is still useful to draw on the rich evidence emerging from qualitative,

ethnographic, and case-study research in this vein to inform our understanding of the potential connection between suffering from drought and women's distinct vulnerability to HIV. A strength in our approach is in identifying the environment as an upstream cause or structural condition that could foster risky circumstances or coping strategies across populations. While several individual-level studies suggest the importance of disasters and environmental decline in creating vulnerabilities for women, here we demonstrate that linkages between drought and women's HIV have generalizability across less-developed nations.

Finally, our study lacks in intersectional dimensions inherent in contemporary ecofeminist approaches. The difficulty in methodologically incorporating intersectionality, particularly in quantitative, cross-national studies, is well-acknowledged (Hankivsky 2012; McCall 2005). In this study, we have made an initial step towards intersectionality in emphasizing how the impact of drought is especially prominent in relation to women's HIV burden in less-developed countries. We acknowledge, however, that women in less-developed nations are not a monolithic group, as evidenced in existing intersectional research (Denton 2002; Harlan et al. 2015). Future qualitative research has the capacity to further examine the relationship between drought and women's health that we have established here, highlighting the multiplicity of experiences by poverty, race, age, religious status, and/or disability.

Currently, there are large-scale efforts to address and mitigate the increasing frequency and severity of droughts in less-developed countries. For example, the United Nations Development Programme (UNDP) is conducting efforts to build resilience in the wake of climate change and increased disaster risk (2016). The UNDP has invested $1.7 billion in disaster risk reduction and recovery in less-developed nations (UNDP 2016). This organization incorporates gender equality into their disaster mitigation and resilience efforts (UNDP 2016). Through this program, women are involved in key disaster risk reduction initiatives, including contingency planning and long-term recovery. The UNDP also cites women's access to land, water, forests, housing, and other assets as critical to their efforts (UNDP 2016). Nevertheless, climate-related disasters are still increasing over time, and women remain most vulnerable to their effects. Because women in less-developed nations generally hold the ascribed expectation of family caretaker, other policy recommendations must be focused on promoting gender equality inside and outside of the home.

From 2001 to 2010, droughts only represented 13% of African climate-related disasters (Guha-Sapir 2012); however, 80% of populations affected by climate-related disasters, overall, in Africa were affected by droughts. Thus, despite being more infrequent, droughts affect larger populations for longer periods of time. Women of reproductive age in developing nations most vulnerable to climate-related disasters are the fastest-growing population becoming infected with HIV (WHO 2018). Accordingly, there is an obvious need to explore the crucial link between climate change, disasters, and women's acute vulnerability to disease. Environment and disaster-related dimensions of women's health are often overlooked in research. It is our hope that this work contributes to efforts exposing the link between global environmental change and women's health in less-developed countries.

Appendix

Table 5 OLS regression results with additional control variables

	Model 1A HIV prev (ln)	Model 1B Women's percent	Model 2A HIV prev (ln)	Model 2B Women's Percent	Model 3A HIV prev (ln)	Model 3B Women's percent	Model 4A HIV prev (ln)	Model 4B Women's percent
Percent affected by drought	0.269* (0.035) *0.012* [1.20]	0.231* (1.15) *0.471* [1.20]	0.204 (0.019) *0.012* [1.30]	0.196* (0.776) *0.361* [1.30]	0.254* (0.024) *0.012* [1.19]	0.248** (1.23) *0.463* [1.19]	0.358** (0.042) *0.014* [1.11]	0.305** (1.80) *0.570* [1.11]
GDP p/c PPP	−0.123 (0.001) *0.001* [2.45]	−0.121 (0.001) *0.001* [2.45]	−0.124 (0.001) *0.001* [2.52]	−0.026 (−0.001) *0.001* [2.52]	−0.217 (−0.001) *0.001* [2.67]	−0.196 (−0.001) *0.001* [2.67]	−0.055 (−0.001) *0.001* [2.84]	−0.046 (−0.001) *0.001* [2.84]
Percent Muslim	−0.327* (−0.002) *0.001* [1.36]	−0.280** (−0.093) *0.034* [1.36]	−0.338* (−0.002) *0.001* [1.34]	−0.258** (−0.086) *0.032* [1.34]	−0.343* (−0.002) *0.001* [1.34]	−0.267** (−0.089) *0.033* [1.34]	−0.391** (−0.002) *0.001* [1.37]	−0.343** (−0.118) *0.037* [1.37]
Percent contractive use	−0.122 (−0.001) *0.002* [3.02]	−0.595*** (−0.343) *0.087* [3.02]	0.078 (0.001) *0.002* [3.89]	−0.368* (−0.212) *0.095* [3.89]	−0.057 (−0.001) *0.002* [2.67]	−0.615*** (−0.354) *0.081* [2.67]	0.089 (0.001) *0.002* [3.24]	−0.482** (−0.283) *0.097* [3.24]
Female primary education	−0.123 (−0.001) *0.002* [1.41]	0.014 (0.011) *0.074* [1.41]						
Fertility rate			0.207 (0.033) *0.036* [3.81]	0.374* (3.20) *1.39* [3.81]				
Births attended by medical staff					0.079 (0.001) *0.002*	0.150 (0.083) *0.067*		

Table 5 (continued)

	Model 1A HIV prev (ln)	Model 1B Women's percent	Model 2A HIV prev (ln)	Model 2B Women's Percent	Model 3A HIV prev (ln)	Model 3B Women's percent	Model 4A HIV prev (ln)	Model 4B Women's percent
					[1.95]	[1.95]		
Gender inequality index							0.192	0.204
							(0.719)	(26.14)
							0.486	*15.50*
							[2.01]	[2.01]
Mean VIF	1.89	1.89	2.57	2.57	1.96	1.76	2.11	2.13
N	69	69	69	69	69	69	58	58
R^2	0.20	0.52	0.20	0.56	0.19	0.53	0.20	0.54

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, $^+$ $p < 0.10$ (two-tailed tests); standardized regression coefficients are flagged for statistical significance; the unstandardized regression coefficient are labeled in parentheses; standard errors are reported in italics; and the VIFs are labeled in brackets. Variable definitions for those not explained in the main text are as follows:

Female primary education—the ratio of female educational enrollment regardless of age, to the female population of the age group corresponding to primary level education (World Bank 2018)

Fertility rate—the number of children that a woman would be expected to have if she were to live to the end of her childbearing years (World Bank 2018)

Births attended by trained medical staff—the percentage of deliveries attended by personnel trained to give the necessary supervision, care, and advice to women during pregnancy, labor, and the postpartum period, to conduct deliveries on their own, and to care for newborns (World Bank 2018)

Gender Inequality Index—a composite measure reflecting inequality in achievements between women and men in three dimensions: reproductive health, empowerment, and the labor market. The GII varies between 0 (when women and men fare equally) and 1 (when men or women fare poorly compared to the other in all dimensions). The health dimension is measured by the maternal mortality ratio and the adolescent fertility rate. The empowerment dimension is measured by the share of parliamentary seats held by each gender and by secondary and higher education attainment levels. The labor dimension is measured by women's participation in the workforce (UNDP 2019)

References

Allison, P. (1999). *Multiple regression: a primer*. Thousand Oaks: Pine Forge Press.

Allison, P. (2012). When can you safely ignore multicollinearity? Statistical Horizons. Retrieved from https://statisticalhorizons.com/multicollinearity.

Arku, F. S., & Arku, C. (2010). I cannot drink water on an empty stomach: a gender perspective on living with drought. *Gend Dev, 18*(1), 115–124.

Austin, K. F., & Noble, M. D. (2014). Measuring gender disparity in the HIV pandemic: a cross-national investigation of female empowerment, inequality, and disease in less-developed nations. *Sociol Inq, 84*(1), 102–130.

Austin, K. F., & McKinney, L. (2016). Disaster devastation in poor countries: the direct and indirect effects of ecological losses, gender inequality, and development. *Social Forces, 95*(1), 355–380.

Austin, K. F., Choi, M., & Berndt, V. (2017). Trading sex for security: unemployment and the unequal HIV burden among young women in developing nations. *Int Sociol, 32*(3), 343–368.

Austin, J., Guy, S., Lee-Jones, L., McGinn, T., & Schlecht, J. (2008). Reproductive health: a right for refugees and internally displaced persons. *Reproductive Health Matters, 16*(31), 10–21.

Bose, C. E. (2011). Eastern sociological society presidential address: globalizing gender issues: many voices, different choices. *Sociol Forum, 26*(4), 739–753.

Braun, Y. A. (2011). Drought. In M. Z. Strange, C. K. Oyster, & J. E. Sloan (Eds.), *The multimedia encyclopedia of women in today's world* (pp. 427–428). Thousand Oaks: Sage Publications.

Burroway, R. (2010). Schools against AIDS: secondary school enrollment and cross-national disparities in AIDS death rates. *Soc Probl, 57*(3), 398–420.

Burroway, R. (2012). A cross-national analysis of sex-specific HIV prevalence rates and women's access to property, land, and loans in developing countries. *Int J Sociol, 42*(2), 47–67.

Campbell, J. C., Baty, M. L., Ghandour, R. M., Stockman, J. K., Francisco, L., & Wagman, J. (2008). The intersection of intimate partner violence against women and HIV/AIDS: a review. *Int J Inj Control Saf Promot, 15*(4), 221–231.

Cook, B. I., Mankin, J. S., & Anchukaitis, K. J. (2018). Climate change and drought: from past to future. *Current Climate Change Reports, 4*(2), 164–170.

CRED (Centre for the Research on the Epidemiology of Disasters). (2019). Disasters in Africa: 20 year review (2000-2019). *CRED Crunch, 56*, 1–2.

Denton, F. (2002). Climate change vulnerability, impacts, and adaptation: why does gender matter? *Gend Dev, 10*(2), 10–20.

Dunaway, W. A., & Macabuac, M. C. (2007). "The shrimp eat better than we do": Philippine subsistence fishing households sacrificed for the global food chain. *Review, 30*(4), 313–327.

Dunkle, K. L., Jewkes, R. K., Brown, H. C., Gray, G. E., McIntryre, J. A., & Harlow, S. D. (2004). Transactional sex among women in Soweto, South Africa: prevalence, risk factors and association with HIV infection. *Soc Sci Med, 59*(8), 1581–1592.

Eaton, H., & Lorentzen, L. A. (2003). *Ecofeminism & globalization: exploring culture, context, and religion*. Lanham: Rowman & Littlefield Publishers.

Elmhirst, R. (2011). Introducing new feminist political ecologies. *Geoforum, 42*(2), 129–132.

EM-DAT. (2015). The International Disaster Database. Retrieved from http://www.emdat.be/database.

Enarson, E. (2000). Gender and Natural Disasters [PDF file]. Retrieved from https://www.ilo.org/wcmsp5/groups/public/%2D%2D-ed_emp/%2D%2D-emp_ent/%2D%2D-ifp_crisis/documents/publication/wcms_116391.pdf.

Enarson, E., Fothergill, A., & Peek, L. (2018). Gender and disaster: foundations and new direction for research and practice. In H. Rodriguez, W. Donner, & J. E. Trainor (Eds.), *Handbook of disaster research* (2nd ed., pp. 205–233). New York: Springer.

Ergas, C., & York, R. (2012). Women's status and carbon dioxide emissions: a quantitative cross-national analysis. *Soc Sci Res, 41*(4), 965–976.

FAO (Food and Agriculture Organization of the United Nations). (2011). Drought-related food insecurity: a focus on the horn of Africa. Retrieved from http://www.fao.org/3/mb738e/mb738e.pdf.

FAO (Food and Agriculture Organization of the United Nations). (2020). Drought. Retrieved from http://www.fao.org/land-water/water/drought/en/.

Fisher, M., & Carr, E. R. (2015). The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: the case of drought-tolerant maize seed in Eastern Uganda. *Glob Environ Chang, 35*, 82–92.

Fothergill, A., & Peek, L. (2004). Poverty and disasters in the United States: a review of recent sociological findings. *Nat Hazards, 32*, 89–110.
Frank, E., & Unruh, J. (2008). Demarcating forest, containing disease: land and HIV/AIDS in southern Zambia. *Popul Environ, 29*(3), 108–132.
Freedom House. (2011). Freedom in the World 2011. Retrieved from https://freedomhouse.org/report/freedom-world/freedom-world-2011.
Gaard, G. (2011). Ecofeminism revisited: rejecting essentialism and re-placing species in a material feminist environmentalism. *Fem Form, 23*(2), 26–53.
Gaard, G. (2015). Ecofeminism and climate change. *Women's Stud Int Forum, 49*, 20–33.
Gaard, G. (2017). *Critical ecofeminism*. NY: Lexington.
Gerber, N., & Mirzabaev, A. (2017). Benefits of action and costs of inaction: drought mitigation and preparedness – a literature review [PDF file]. World Meteorological Organization, Integrated Drought Management Programme Working Paper No. 1. Retrieved from http://www.droughtmanagement.info/literature/IDMP_BACI_WP.PDF.
Godfrey, P. C. (2012). Introduction: race, gender & class and climate change. *Race, Gender & Class, 19*(1/2), 3–11.
Gray, P. B. (2004). HIV and Islam: is HIV prevalence lower among Muslims? *Soc Sci Med, 58*(9), 1751–1756.
Guha-Sapir, D. (2012). Disaster data: a balanced perspective. *CRED Crunch, 28*, 1–2.
Hankivsky, O. (2012). Women's health, men's health, and gender and health: Implications of intersectionality. *Soc Sci Med, 74*, 1712–1720.
Harlan, S. L., Pellow, D. N., Roberts, J. T., Bell, S. E., Holt, W. G., & Nagel, J. (2015). Climate justice and inequality. In R. E. Dunlap & R. J. Brulle (Eds.), *Climate change and society: sociological perspectives* (pp. 127–163). Oxford: Oxford University Press.
Heimer, C. A. (2007). Old inequalities, new disease: HIV/AIDS in Sub-Saharan Africa. *Annu Rev Sociol, 33*, 551–577.
Horton, L. (2012). After the earthquake: gender inequality and transformation in post-disaster Haiti. *Gend Dev, 20*(2), 295–308.
Hunter, L. M., Reid-Hresko, J., & Dickinson, T. W. (2011). Environmental change, risky sexual behavior, and the HIV/AIDS pandemic: linkages through livelihoods in rural Haiti. *Popul Res Policy Rev, 30*(5), 729–750.
King, Y. (1999). Ecofeminism. In W. P. Mankiller, G. Mink, M. Navarro, B. Smith, & G. Steinem (Eds.), The reader's companion to U.S. women's history (p. 207). Boston, MA: Houghton Mifflin Company.
Leclerc-Madlala, S. (2008). Transactional sex and the pursuit of modernity. *Soc Dyn, 29*(2), 213–233.
Lungu, A., & Hüsken, S. M. C. (2010). Assessment of access to health services and vulnerabilities of female fish traders in the Kafue Flats, Zambia. Zambia: analysis report. Retrieved from http://aquaticcommons.org/4143/1/WF_2700.pdf.
Majid, N., & McDowell, S. (2012). Hidden dimensions of the Somalia famine. *Global Food Security, 1*(1), 36–42.
Maynard, G., & Ong, C. (2016). Economic dependency and HIV/AIDS prevalence in the developing world: a comparative, longitudinal analysis. *Sociol Inq, 86*(2), 189–216.
McCall, L. (2005). The complexity of intersectionality. *Signs, 30*(3), 1771–1900.
McCleary-Sills, J., Douglas, Z., Rwehumbiza, A., Hamisi, A., & Mabala, R. (2013). Gendered norms, sexual exploitation and adolescent pregnancy in rural Tanzania. *Reproductive Health Matters, 21*(41), 97–105.
McIntosh, W. A., & Thomas, J. K. (2004). Economic and other societal determinants of the prevalence of HIV: a testing of competing hypotheses. *Sociol Q, 45*(2), 303–324.
McKinney, L. (2014). Gender, democracy, development, and overshoot: a cross-national analysis. *Popul Environ, 36*(2), 193–218.
McKinney, L., & Austin, K. (2015). Ecological losses are harming women: a structural analysis of female HIV prevalence and life expectancy in less developed countries. *Soc Probl, 62*, 529–549.
Mies, M. (1998). *Patriarchy & accumulation on a world scale: women in the international division of labor*. New York: Zed Books.
Mies, M., & Shiva, V. (1993). *Ecofeminism*. New York: Zed Books.
Mojola, S. A. (2011). Fishing in dangerous waters: Ecology, gender and economy in HIV risk. *Soc Sci Med, 72*(2), 149–156.
Mojola, S. A. (2014). *Love, money, and HIV: becoming a modern African woman in the age of AIDS*. Oakland: University of California Press.
Mosavel, M., Ahmed, R., & Simon, C. (2012). Perceptions of gender-based violence among south African youth: implications for health promotion interventions. *Health Promot Int, 27*(3), 323–330.

Murray, A. F. (2013). *From outrage to courage: the unjust and unhealthy situation of women in poorer countries and what they are doing about it*. Menlo Park: Anne Firth Murray.
Neumayer, E., & Plümper, T. (2007). The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life expectancy, 1981-2002. *Ann Assoc Am Geogr, 97*(3), 551–566.
Norgaard, K., & York, R. (2005). Gender equality and state environmentalism. *Gend Soc, 19*(4), 506–522.
Ocello, C., Petrucci, A., Testa, M. R., & Vignoli, D. (2015). Environmental aspects of internal migration in Tanzania. *Popul Environ, 37*, 99–108.
Oglethorpe, J., & Gelman, N. (2008). AIDS, women, land, and natural resources in Africa: current challenges. *Gend Dev, 16*(1), 85–100.
Oyefara, J. L. (2007). Food insecurity, HIV/AIDS pandemic and sexual behaviour of female commercial sex workers in Lagos metropolis, Nigeria. *SAHARA-J: Journal of Social Aspects of HIV/AIDS, 4*(2), 626–635.
Pascoe, S. J. S., Langhaug, L. F., Mavhu, W., Hargreaves, J., Jaffar, S., Hayes, R., & Cowan, F. M. (2015). Poverty, food insufficiency and HIV infection and sexual behaviour among young rural Zimbabwean women. *PLoS One, 10*(1), e0115290.
Quinn, T. C., & Overbaugh, J. (2005). HIV/AIDS in women: an expanding epidemic. *Science, 308*(5728), 1582–1583.
Rocheleau, D., Thomas-Slayter, B., & Wangari, E. (1996). Feminist Political Ecology: Global issues and local experiences. New York: Routledge.
Sam, A. S., Abbas, A., Padmaja, S. S., Kaechele, H., Kumar, R., & Müller, K. (2019). Linking food security with household's adaptive capacity and drought risk: Implications for sustainable rural development. *Soc Indic Res, 142*, 363–385.
Shandra, J. M., Shandra, C. L., & London, B. (2008). Women, non-governmental organizations, and deforestation: a cross-national study. *Popul Environ, 30*(1/2), 48–72.
Shircliff, E. J., & Shandra, J. M. (2011). Non-governmental organizations, democracy, and HIV prevalence: a cross-national analysis. *Sociol Inq, 81*(2), 143–173.
Shukla, A. (2014). Drought + politics = famine in Somalia. *Int J Innov Appl Stud, 6*(4), 1104–1110.
Smith, M. K. (2002). Gender, poverty, and intergenerational vulnerability to HIV/AIDS. *Gend Dev, 10*(3), 63–70.
Steinberg, T. (2000). *Acts of god: the unnatural history of natural disaster in America*. Oxford: Oxford University Press.
Stoebenau, K., Heise, L., Wamoyi, J., & Bobrova, N. (2016). Revisiting the understanding of "transactional sex" in Sub-Saharan Africa: a review and synthesis of the literature. *Soc Sci Med, 168*, 186–197.
Terry, G. (2009). No climate justice without gender justice: an overview of the issues. *Gend Dev, 17*(1), 5–18.
Tierney, K. (2007). From the margins to the mainstream? Disaster research at the crossroads. *Annu Rev Sociol, 33*, 503–525.
Tschumi, E., & Zscheischler, J. (2020). Countrywide climate features during recorded climate-related disasters. *Clim Chang, 158*, 593–609.
UNAIDS. (2014). Methodology: understanding the HIV estimates in the OUTLOOK: Cities report. Retrieved from http://www.unaids.org/en/resources/documents/2014/UNAIDS_methodology_cities_report_2014.
UNAIDS. (2017). When women lead, change happens. Retrieved from https://www.unaids.org/sites/default/files/media_asset/when-women-lead-change-happens_en.pdf.
UNDP. (2016). Climate and disaster resilience. Retrieved from http://www.undp.org/content/undp/en/home/ourwork/climate-and-disaster-resilience/overview.html.
UNDP. (2019). Gender Inequality Index. Retrieved from http://hdr.undp.org/en/content/gender-inequality-index-gii#:~:text=The%20GII%20is%20an%20inequality%20index.&text=It%20measures%20the%20human%20development,more%20loss%20to%20human%20development.
Wamoyi, J., Wight, D., Plummer, M., Mshana, G. H., & Ross, D. (2010). Transactional sex amongst young people in rural northern Tanzania: an ethnography of young women's motivations and negotiation. *Reprod Health, 7*(2), 1–18.
Wamoyi, J., Ranganathan, M., Kyegombe, N., & Stoebenau, K. (2019). Improving the measurement of transactional sex in Sub-Saharan Africa: a critical review. *J Acquir Immune Defic Syndr, 80*(4), 367–374.
Warren, K. J. (1990). The power and the promise of ecological feminism. *Environmental Ethics, 12*(2), 125–146.
Weiser, S. D., Leiter, K., Bangsberg, D. R., Butler, L. M., Percy-de Korte, F., Hlanze, Z., Phaladze, N., Iacopino, V., & Heisle, M. (2007). Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. *PLoS Med, 4*(10), 1589–1598.
Williams, T. P., Binagwaho, A., & Betancourt, T. S. (2012). Transactional sex as a form of child sexual exploitation and abuse in Rwanda: implications for child security and protection. *Child Abuse Negl, 36*(4), 354–361.

Wisner, B. (2016). Vulnerability as a concept, model, metric, and tool. Oxford research encyclopedia of natural Hazard science. Retrieved from: https://oxfordre.com/naturalhazardscience/view/10.1093/acrefore/9780199389407.001.0001/acrefore-9780199389407-e-25

World Bank. (2018). World development indicators. Retrieved from https://databank.worldbank.org/data/source/world-development-indicators#.

World Health Organization (WHO). (2018). HIV/AIDS. Retrieved from https://www.who.int/news-room/fact-sheets/detail/hiv-aids.