

Trajectories of intimate partner violence and their relationship to stress among young women in South Africa: An HPTN 068 study

International Journal of
Social Psychiatry
2024, Vol. 70(5) 904–914
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DOI: 10.1177/00207640241239535
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Abstract

Background: One in four South African women will experience intimate partner violence (IPV) in their lifetime, potentially increasing their biological stress. In South Africa, limited IPV and stress research has utilized multiple timepoints or examined modifying factors. Cash transfers (CTs) are associated with reduced IPV and stress and may be an intervention target.

Aims: We used data-driven methods to identify longitudinal IPV trajectory groups among South African adolescent girls and young women (AGYW), estimate each group's association with stress, and assess modification by a CT.

Methods: A total of 2,183 South African AGYW ages 13 to 24 years from the HIV Prevention Trials Network 068 study were randomized to a CT or control group. Physical IPV was measured five times (2011–2017), and stress was captured once (2018–2019). Stress measures included the Cohen Stress Scale and stress biomarkers (C-reactive protein (CRP), cytomegalovirus (CMV), herpes simplex virus type-1 (HSV-1)). Group-based trajectory modeling identified IPV trajectories; ordinal logistic regression estimated the association between trajectory group and stress.

Results: A two-group quadratic trajectory model was identified (higher trajectory group = 26.7% of AGYW; lower trajectory group = 73.3%). In both groups, the probability of IPV increased from ages 13 to 17 years before declining in early adulthood. However, the higher group's probability peaked later and declined gradually. The higher trajectory group was associated with an increased odds of elevated CRP (OR: 1.41, 95% CI [1.11, 1.80]), but not with other stress measures. The CT modified the relationship with CMV: a positive association was observed among the usual care arm (OR: 1.59, 95% CI [1.11, 2.28]) but not the CT arm (OR: 0.85, 95% CI [0.61, 1.19]).

Conclusions: Sustained IPV risk during adolescence was associated with elevated CRP in young adulthood. The relationship between IPV and elevated CMV was attenuated among those receiving a CT, suggesting that CTs could possibly reduce biological stress due to IPV.

Keywords

Intimate partner violence, stress, group-based trajectory models, cash transfers, adolescent girls and young women, South Africa

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Introduction

Intimate partner violence (IPV), or violence perpetuated by a male intimate partner, contributes substantially to the global burden of disease and disproportionately affects the health and well-being of adolescent girls and young women (AGYW; Sardinha et al., 2022; World Health Organization, 2021). Globally, one in four married or partnered AGYW will experience physical or sexual IPV by age 19, highlighting the need for early intervention (World Health Organization, 2021). In South Africa, the World Health Organization has estimated a lifetime IPV prevalence of 24% (World Health Organization, 2021). These staggering estimates correspond to millions of South African AGYW who already have or will encounter life-threatening violence with potentially long-lasting implications (Campbell, 2002; Coker et al., 2000).

Beyond contributing to physical injury, perpetuating harmful gender roles (Cislaghi & Heise, 2020), and threatening human rights, there are well-documented health effects of IPV. Violence increases the risk of depression, HIV, chronic pain, gastrointestinal disorders, and substance abuse, among a myriad of other health conditions (Campbell, 2002; Coker et al., 2000; Plichta, 2004; Reyes et al., 2023). There are many hypothesized pathways from violence to poor health outcomes, including through elevated levels of biological and perceived stress due to violence. In particular, evidence is mounting that violence can impair the physiological stress response in adults and subsequently have negative effects on health, such as increased susceptibility to chronic disease (Agorastos & Chrousos, 2022; Brown, 2004; Capitanio et al., 1998; Catalano, 1991; Clark et al., 1999; Cohen et al., 2007; Cole et al., 2003; Djuric et al., 2008; Jackson et al., 2010; Kessler, 1979; Kiecolt-Glaser et al., 2002; Leserman, 2008; Leserman et al., 2002; Pereira et al., 2003; Peters, 2004; Turner & Avison, 2003) and increased susceptibility to or progression of HIV (Cohen et al., 2007; Kiecolt-Glaser et al., 2002; Lupien et al., 2009; Segerstrom & Miller, 2004). Here, stress is defined as a state of threatened homeostasis due to extrinsic or intrinsic stimuli (e.g. stressors; Chrousos, 2009; Chrousos & Gold, 1992). These stressors may be real or perceived and emotional or physical. Stress is a multidimensional concept consisting of appraisal (i.e. assessing one's threat level), coping (i.e. assessing whether one can respond), and perseverative cognitions (e.g. rumination and worry; Lazarus & Folkman, 1984; Smyth et al., 2013).

Although an association between stress and IPV has been established (Al-Modallal, 2012; Haight et al., 2022; Pakhomova et al., 2021; Richardson et al., 2020), there is still uncertainty about how to measure stress, including psychological and biological stress. To our knowledge, most violence and stress research has used measures from a single time point and focused on either psychological measures (Al-Modallal, 2012; Pakhomova et al., 2021;

Richardson et al., 2020; e.g. Sheldon Cohen Perceived Stress scale; Cohen et al., 1983) or hormonal forms of biological stress (e.g. cortisol; Boeckel et al., 2017; Halpern et al., 2016), but not both. Cortisol, a commonly used stress-responsive biomarker, is subject to diurnal variation, and a recent review reported mixed findings on the relationship between violence and cortisol (Yim & Kofman, 2019). This same review emphasized that limited work has examined the relationship between violence and stress using *immune* stress-responsive biomarkers as measures of biological stress, such as C-reactive protein (CRP), cytomegalovirus (CMV), and herpes simplex virus type-1 (HSV-1). CRP is a non-specific marker of inflammation that elevates from impaired immune function, such as infection, injury, and stressful situations (Danesh et al., 2004). CMV and HSV-1 are herpes viruses that can reactivate during stressful life events or chronic stress due to changes in immune function and stress hormones (Aiello et al., 2010; Sainz et al., 2001).

Several studies have observed an association between IPV and CRP (Fernandez-Botran et al., 2011; Newton et al., 2011; Out et al., 2012; Slopen et al., 2018); however, most were conducted among different populations that may not be generalizable to South African AGYW (e.g. middle-aged women in the U.S. (Fernandez-Botran et al., 2011; Newton et al., 2011; Out et al., 2012) or children in Tanzania (Slopen et al., 2018). In a separate analysis that our team conducted among AGYW in rural South Africa, we found that recent physical IPV was associated with increased levels of CMV cross-sectionally, providing further indication of a connection between violence and biological stress (Kelly et al., 2023). Yet, questions remain as to whether exposure to violence over time (i.e. a longitudinal trajectory of violence) is associated with increased perceived and biological stress, known risk factors for increased disease susceptibility (Cohen et al., 2007; Kiecolt-Glaser et al., 2002; Segerstrom & Miller, 2004).

Most IPV studies among AGYW rely on either a single concurrent IPV measure or ask older women to recount their experiences of violence during childhood or adolescence (Al-Modallal, 2012; Fernandez-Botran et al., 2011; Garbe, 2021; Pakhomova et al., 2021). Additionally, to our knowledge, few studies have examined factors that may modify the association between IPV and stress and could be used as intervention targets. Social protection programs, such as cash transfers, have been associated with reduced violence (Buller et al., 2018; Peterman & Roy, 2021) and stress (Fernald & Gunnar, 2009), and therefore may be an important target to disrupt the IPV to stress pathway. For example, in the HIV Prevention Network Trials (HPTN) 068 study (Pettifor et al., 2016), AGYW in rural Mpumalanga, South Africa were randomized to either a cash transfer conditional upon school attendance or the control arm. AGYW in the cash transfer arm experienced a 34% reduction in IPV (Pettifor et al., 2016). Several theories postulate as to how cash transfers reduce violence,

including that these programs increase women's decision-making power (Buller et al., 2018). Others propose that cash transfers reduce IPV (and improve other health-related outcomes) by lowering overall stress and improving mental health (Buller et al., 2018; Sun et al., 2021).

Given the gender-based violence epidemic in South Africa (World Health Organization, 2021), the myriad of adverse health outcomes associated with elevated stress and IPV (Cohen et al., 2007; Coker et al., 2000), and evidence of associations between IPV, biological stress, and cash transfers (Buller et al., 2018; Fernald & Gunnar, 2009; Yim & Kofman, 2019), we sought to extend our prior work in HPTN 068 (DeLong et al., 2020; Kelly et al., 2023; Stoner et al., 2022). In this current study, we examine how repeated or chronic experiences of physical IPV throughout adolescence and young adulthood (i.e. IPV trajectories) predict psychological *and* biological measures of stress. Based on prior work with this same cohort (DeLong et al., 2020), we examined the hypothesis that young women with higher, sustained trajectories of physical IPV are more likely to have elevated stress later in life than those with lower IPV trajectories. This may be one possible explanation for the association between IPV and poor health outcomes, such as an increased risk of HIV acquisition. As previous papers found that the conditional cash transfer was associated with reduced IPV in HPTN 068, we also assessed whether randomization to the cash transfer arm modified the relationship between IPV trajectory group and stress as a potential intervention target.

Methods

Original study

This study used data from HPTN 068 (NCT01233531; Pettifor et al., 2016), a randomized trial of the effect of a conditional cash transfer on HIV incidence among AGYW in South Africa. The trial was conducted within the rural Bushbuckridge subdistrict of Mpumalanga Province, South Africa within the Agincourt Health and Sociodemographic Surveillance System (Kahn et al., 2012). Young women were randomized at baseline in a 1:1 ratio to the control arm (no intervention) or to the intervention arm where the AGYW and her household received a monthly cash transfer (300 rand) conditional upon school attendance for up to 3 years. A total of 2,533 young women enrolled in the trial who were ages 13 to 20 years, in grades 8 to 11, attending school, not pregnant or married, willing to provide informed consent, and planning to stay in the study area during the study period (Pettifor et al., 2016).

In the main trial from 2011 to 2015, AGYW completed up to four annual study visits. After the trial ended in 2015, all participants completed two additional post-intervention visits: one in 2015 to 2017 and another in 2018 to 2019. At each visit, AGYW were asked about

sociodemographic information, sexual behaviors, IPV, and mental health and were tested for HIV and herpes simplex virus type 2 (HSV-2). At the final post-intervention visit (2018–2019), information was also collected on self-perceived stress and testing was done on stress-responsive biomarkers. All participants provided written informed consent (or assent if under age 18 years), and ethical approval was obtained from the University of Witwatersrand Human Research Ethics Committee and the University of North Carolina at Chapel Hill Institutional Review Board. All research procedures adhered to the tenets of the Declaration of Helsinki.

Current analysis

This analysis uses HPTN 068 data to examine longitudinal trajectories of IPV from 2011 to 2017 in relation to perceived and biological stress measured in 2018 to 2019. To be eligible for this analysis, AGYW needed available physical IPV data from at least three study visits out of the first five possible visits (including the four visits during the initial trial plus the first post-intervention visit) from before age 25 years. Twenty-five was used as a cut-off because adolescence and young adulthood is a critical developmental period, and the data was sparse at older ages. Participants were also required to have available stress measures (CRP, CMV, HSV-1, and perceived stress) from the final post-intervention visit. In addition to the parent study's ethical approvals, this analysis also obtained approval from the RTI Office of Research Protection (IRB ID# STUDY00021711).

Measures

Physical IPV was defined as an experience of physical violence perpetrated by a male partner in the past 12 months and was based on six questions from the World Health Organization's Multi-Country Study on Women's Health and Domestic Violence against Women Questionnaire (Pallitto et al., 2013).

The primary outcome was stress, measured at the final visit in 2018 to 2019 using both self-perceived stress and stress-responsive biomarkers (CRP, CMV, and HSV-1). Perceived stress was measured using the Sheldon Cohen Perceived Stress Scale (Cohen et al., 1983) and was dichotomized using existing cut-points to provide ease of comparison with other studies (low stress (0–13, ref.) vs. moderate/high stress (14–40, index); Cohen & Janicki-Deverts, 2012). Moderate and high levels were combined due to sparse data at higher stress levels. The Cohen scale has been validated for use on the African continent (Ben Loubir et al., 2014; Makhubela, 2022; Manzar et al., 2019).

Biomarkers (CRP, CMV, and HSV-1) were collected via dried blood spots (DBS) and were processed using enzyme-linked immunosorbent assays (ELISA). CMV and

HSV-1 variables were categorized using four ordinal levels, similar to prior analyses of these data (Kelly et al., 2023; Stoner et al., 2022): seronegative (0), and seropositive optical density (OD) levels divided into tertiles (1=low, 2=medium, and 3=high). Equivocal serostatus was re-classified as seropositive to provide more conservative estimates. CRP (in mg/L) was divided into quartiles (lowest values=first quartile; highest values=fourth quartile) because the CRP distribution was heavily right skewed and to be consistent with previous studies.

Study arm was examined as a potential modifier (cash transfer vs. control; described above). Covariates were identified from a directed acyclic graph and included: baseline socioeconomic status (using a household asset index), any food insecurity during the first five study visits (defined as worrying about having enough food), positive HIV status identified during the first five study visits, and positive HSV-2 serostatus, also identified during the first five study visits. Incident HIV was measured using two rapid tests (Determine HIV-1/2 test; Uni-gold Recombigen HIV test) and confirmatory testing as needed (GS HIV-1 western blot assay).

Statistical analysis

Group-based trajectory modeling (GBTM) was used to identify IPV trajectories during the first five study visits (from 2011 to 2017). GBTM is a data-driven approach which uses study data to identify latent groups of individuals whose values follow a homogenous trajectory or pattern over time (Jones & Nagin, 2013; Nagin, 2014; Nagin et al., 2018). We first fit unconditional trajectory models with a Bernoulli response distribution to identify the best trajectory shape using age as the unit of time. The best-fitting trajectory shape (linear, quadratic, or cubic) was determined by holistically considering: (1) the sample-size adjusted Bayesian Information Criteria (BIC; least negative values indicating better fit); (2) Akaike Information Criteria (AIC); and (3) visual assessment of the trajectory curves (Nagin et al., 2018). We then compared two-, three-, and four-class solutions by considering the above criteria, as well as latent class sizes (<5% considered unstable). Following a ‘classify and analyze’ approach (Lanza & Rhoades, 2013), we then ran ordinal logistic regression models using the covariates previously specified to estimate the association between IPV trajectory group and each stress measure (the lowest IPV trajectory was the referent group for all models). Modification by the cash transfer was assessed by comparing stratum-specific odds ratios (ORs) and corresponding 95% confidence intervals (CIs). Analyses were conducted using Stata version 16 (StataCorp LLC, College Station, Texas, USA); trajectory models used the *traj* command (Jones & Nagin, 2013).

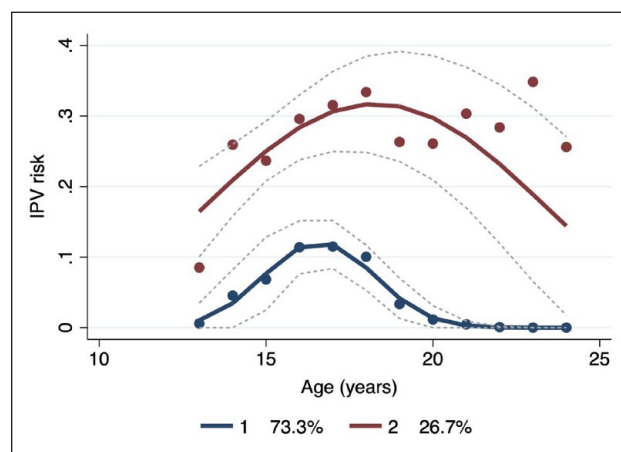


Figure 1. Trajectories of physical intimate partner violence (IPV) among adolescent girls and young women (ages 13–24 years) in rural South Africa¹.

¹Each point corresponds to the observed probability of physical IPV at each age; dashed lines are the 95% confidence intervals for the trajectory curve.

Missing data

Missingness was differential with respect to several demographic variables, including food insecurity (observed: 33.0% vs. censored: 40.6%), initial IPV (observed: 9.8% vs. censored: 15.4%), positive HSV-2 serostatus (observed: 3.8% vs. censored: 10.3%), and intervention study arm (observed: 53.0% vs. censored: 29.7%). We created inverse probability of observation weights (Robins & Finkelstein, 2000) using baseline demographic information (age, food insecurity status, recent physical IPV, HSV-2 serostatus, study arm, SES, and being sexually active) to reweight the final analytical sample ($N=2,183$) to the original HPTN 068 cohort ($N=2,533$) and account for missingness. These weights were applied to the trajectory models; there was also differential missingness of the biological stress data, so a second set of inverse probability of observation weights were applied to the regression models to account for AGYW with missing biomarker data.

Results

Trajectory model selection

A total of 2,533 AGYW enrolled in HPTN 068, and 2,183 (86%) met the inclusion criteria for this trajectory analysis. A two-group quadratic model was selected as the final GBTM model (Figure 1). This model had a low BIC (−3,643.73), high average posterior probabilities (0.775, 0.786), and visually fit the data well (Table 1). The two-group cubic model was also considered because it had the most favorable BIC (−3,641.85) and a slightly higher entropy (0.73); however, there were concerns that the cubic model would overfit the data (DeLong et al., 2020).

Table 1. Model fit statistics for group-based model trajectories of intimate partner violence among young South African women (2011–2017).

Polynomial	Groups	BIC ^a	AIC	Entropy	Smallest group (%)	Average posterior probability ^b			
						Group 1	Group 2	Group 3	Group 4
Linear	2	-3,691.48	-3,677.26	0.77	47.1	0.788	0.682		
	3	-3,702.01	-3,679.25	0.53	0.8	0.840	0.547	0.626	
	4								
Quadratic	2	-3,643.73	-3,623.82	0.69	26.7	0.775	0.786		
	3	-3,645.82	-3,606.00	0.73	11.8	0.735	0.722	0.514	
	4								
Cubic	2	-3,641.85	-3,616.25	0.73	47.5	0.700	0.808		
	3								
	4								

^aAdjusted for sample size.^bGrey boxes indicate that there were <4 groups for that model; patterned boxes indicate a lack of convergence.

The three-group quadratic model was initially promising, but the third group's small size (11.8%) introduced stability concerns. Thus, the two-group quadratic model was selected as the final GBTM model.

Of the two trajectory groups identified, approximately one of four participants belonged to the higher group ($N=583/2,183$, 26.7%) and three of four belonged to the lower group ($N=1,600/2,183$, 73.3%; Figure 1; Table 2). In the lower group, the probability of IPV increased from ages 13 to 17 years before declining to 0 by age 21 years. In the higher group, the IPV probability increased from ages 13 to 18 years before slowly decreasing during ages 19 to 24 years, although this trend was imprecise and may reflect a leveling of risk.

Demographic characteristics

At baseline, the median age was 15 years (interquartile range (IQR): 14,16; Table 2). Most participants were HIV negative (2,123/2,183, 97.3%), a third were food insecure (720/2,183, 33.0%) and 18.2% (398/2,183) met the Children's Depression Inventory's criteria for depression (Kovacs, 1978). When dichotomizing by IPV trajectory group, those belonging to the higher group had lower levels of household assets, were more likely to be depressed, and were slightly older.

IPV and biomarkers

AGYW belonging to the higher IPV group had 1.41 times the odds of elevated CRP compared to those in the lower group, adjusting for confounders (OR: 1.41, 95% CI [1.11, 1.80]; Table 3). Neither self-perceived stress (OR: 1.07, 95% CI [0.81, 1.41]) nor the other stress-responsive biomarkers (CMV OR: 1.13, 95% CI [0.88, 1.44]; HSV OR: 1.01, 95% CI [0.80, 1.28]) were associated with IPV

trajectory group. The cash transfer modified the association between IPV trajectory group and CMV: among those randomized to the control arm, belonging to the higher IPV group was associated with higher levels of CMV compared to the lower IPV group (control OR: 1.59, 95% CI [1.11, 2.28]; cash transfer OR: 0.85, 95% CI [0.61, 1.19], Table 3). While the CRP stratum-specific 95% CIs overlapped, there was possible modification of the IPV-CRP relationship: among those randomized to the intervention, belonging to the higher trajectory group was associated with 1.5 times the odds of elevated CRP compared to the lower trajectory group (cash transfer OR: 1.51, 95% CI [1.09, 2.10]; control OR: 1.30, 95% CI [0.92, 1.85]). There was no evidence of modification for HSV-1 (cash transfer OR: 1.05, 95% CI [0.76, 1.45]; control OR: 0.96, 95% CI [0.76, 1.45]) or self-perceived stress (cash transfer OR: 0.97, 95% CI [0.66, 1.42]; control OR: 1.21, 95% CI [0.82, 1.79]).

Discussion

Among a cohort of AGYW in rural South Africa, a two-group quadratic trajectory model of physical IPV had the best model fit. In both groups, the probability of IPV increased throughout early adolescence before declining in later adolescence and early adulthood. However, the probability of IPV in the higher trajectory group peaked later and declined more slowly than the lower trajectory group. When examining the relationship between IPV and stress, belonging to the higher trajectory group was associated with elevated CRP levels but was not associated with other measures of biological (CMV and HSV-2) or perceived stress. Thus, high, sustained IPV during adolescence and early adulthood may increase CRP levels, possibly leading to alternations in the immune response; however, longitudinal stress measures are needed to further examine this

Table 2. Baseline demographic characteristics among young South African women in HPTN 068, stratified by IPV trajectory group^a.

	Lower IPV group (N=1,602)		Higher IPV group (N=581)		Overall (N=2,183)	
	N	%	N	%	N	%
Study arm						
Intervention	882	44.9	275	47.3	1,157	53.0
Control	729	55.1	306	52.7	1,026	47.0
Age						
Median, IQR	15	14,16	16	14,17	15	14,16
Household assets						
Q1 (lowest)	415	25.9	161	27.7	576	26.4
Q2	425	26.5	164	28.2	589	27.0
Q3	374	23.4	145	25.0	519	23.8
Q4 (highest)	387	24.2	110	18.9	497	22.8
Missing	1	0.1	1	0.2	2	0.1
Food insecurity ^b						
Yes	501	31.3	219	37.7	720	33.0
No	1,088	67.9	361	62.1	1,449	66.4
Missing	13	0.8	1	0.2	14	0.6
HIV status						
Positive	38	2.4	22	3.8	60	2.8
Negative	1,564	97.6	559	96.2	2,123	97.3
HSV-2 status						
Positive	55	3.4	29	5.0	84	3.9
Negative	1,544	96.4	552	95.0	2,096	96.0
Missing	3	0.2	0	0	3	0.1
Depressed ^c						
Yes	218	13.6	180	31.0	398	18.2
No	1,311	81.8	379	65.2	1,690	77.4
Missing	73	4.6	22	3.8	95	4.4
Alcohol use ^d						
Yes	26	1.6	19	3.3	45	2.1
No	1,575	98.3	560	96.4	2,135	97.8
Missing	1	0.1	2	0.3	3	0.1

^aPhysical intimate partner violence (IPV) trajectory group membership was identified from quadratic group-based trajectory models.

^bMeasured in the last month.

^cMeasured using the Child Depression Index (>7 = depressed).

^dDefined as more than one drink per month.

hypothesis. Randomization to the cash transfer modified the relationship between IPV trajectory group and CMV, possibly indicating an intervention area. This relationship was attenuated among those receiving the cash transfer.

This study provides novel information on how longitudinal IPV relates to different stress measures, including perceived and biological stress. Most biological stress studies use hormonal biomarkers (i.e. cortisol), but cortisol is unstable and known to fluctuate diurnally (Yim & Kofman, 2019). We used multiple biological stress measures that were valid, precise, and theory driven to fill this gap. We also chose biomarkers that could be collected using DBS, given that DBS is potentially more feasible in low-resource areas than venipuncture (Lin et al., 2021).

IPV trajectory group was only associated with elevated CRP, which aligns with previous studies that have

observed a relationship between violence and CRP at a single time point in different populations (Fernandez-Botran et al., 2011; Newton et al., 2011; Out et al., 2012; Slopen et al., 2018). Since CRP measures systemic inflammation, these findings suggest that violence may affect immune function which could potentially result in a high likelihood of sickness or increased susceptibility to infection (Danesh et al., 2004). It is important to note that CRP may elevate in response to other factors, such as physical health and other comorbidities (e.g. cardiovascular health; Aronson et al., 2004; Li & Fang, 2004), which could partially explain this association. However, the study population was young and relatively healthy, and the statistical models controlled for several other stressors (e.g. food insecurity) and health conditions (e.g. HIV and HSV-2), suggesting that CRP may elevate in response to IPV.

Table 3. Associations between intimate partner violence (IPV) trajectory group and stress among young South African women, overall and stratified by study arm^a.

Measure	Unadjusted		Adjusted	
	OR	95% CI	OR	95% CI
CRP ^b	1.45	[1.15, 1.83]	1.41	[1.11, 1.80]
CMV	1.14	[0.90, 1.46]	1.13	[0.88, 1.44]
HSV-I	1.02	[0.81, 1.28]	1.01	[0.80, 1.28]
Perceived stress	1.06	[0.81, 1.39]	1.07	[0.81, 1.41]
CRP				
CCT arm	1.53	[1.12, 2.09]	1.51	[1.09, 2.10]
Control arm	1.35	[0.96, 1.92]	1.30	[0.92, 1.85]
CMV				
CCT arm	0.88	[0.63, 1.23]	0.85	[0.61, 1.19]
Control arm	1.59	[1.12, 2.27]	1.59	[1.11, 2.28]
HSV-I				
CCT arm	1.07	[0.78, 1.46]	1.05	[0.76, 1.45]
Control arm	1.00	[0.71, 1.41]	0.96	[0.68, 1.37]
Perceived stress				
CCT arm	0.97	[0.67, 1.42]	0.97	[0.66, 1.42]
Control arm	1.19	[0.81, 1.76]	1.21	[0.82, 1.79]

^aThe first four estimates assume homogeneity with respect to study arm, while the following stratified estimates include an interaction term for study arm (conditional cash transfer (CCT) vs. control). For adjusted estimates, the following minimally sufficient covariate adjustment set was identified from a directed acyclic graph: study arm, baseline socioeconomic status, any food insecurity during the study, HIV diagnosis during the study, and HSV-2 diagnosis during the study. IPV trajectory groups (lower IPV risk (ref) vs. higher IPV risk) were identified from group group-based trajectory models.

^bCRP = C-reactive protein; CMV = cytomegalovirus; HSV-I = herpes simplex virus type-I; perceived stress was measured using the Sheldon Cohen Perceived Stress Scale.

IPV trajectory group was not associated with other measures of biological stress (CMV and HSV-1) or perceived stress. However, stress was only measured once this study, so future research should examine how IPV trajectories relate to longitudinal measures of stress. This study was also strengthened by using the Cohen Perceived Stress Scale to measure perceived stress (Cohen et al., 1983). The Cohen scale has been validated in a range of cross-cultural settings and populations (Lee, 2012; Yilmaz Koğar & Koğar, 2024); however, the majority of validation studies occurred outside of the African continent and among older populations (Lee, 2012; Yilmaz Koğar & Koğar, 2024). Importantly, the conceptualization of stress may differ across cultures (Kaiser & Weaver, 2019), so validation studies should be conducted among rural African AGYW to determine whether the Cohen scale aptly measures perceived stress in this population.

Randomization to the cash transfer may have masked the overall association between IPV and CMV, either by lowering the risk of IPV, stress, or both. Future work should more deeply examine these pathways to pinpoint how social protection programs could disrupt the IPV-stress relationship. Compared to other social protection programs (e.g. in-kind transfers), cash transfers are attractive in that they can be easier to implement (e.g. using mobile money transfers) and they provide increased autonomy for recipients. The cash transfer in HPTN 068 was

conditional; however, future interventions should consider the use of unconditional cash transfers, such as government grants, given their success in many settings (Sun et al., 2021) and reduced recipient burden. Yet, the effects of cash transfers on IPV are heterogeneous regardless of conditionality (Buller et al., 2018; Sun et al., 2021), suggesting the need for more tailored, multipronged interventions (e.g. ‘cash plus’ interventions).

We previously identified trajectories of physical IPV in HPTN 068 (DeLong et al., 2020); however, this was prior to the completion of the two post-intervention visits (i.e. included fewer timepoints), included a younger population (eighth and ninth graders in 2011), and used years since enrollment as the unit of time rather than age. Notably, the IPV trajectories in this current analysis align with those from previous work, as both studies identified two-group trajectory models. Yet, the current study provides important evidence beyond replicating previous work. Here, we more fully capture the peak of IPV during adolescence and decline during early adulthood given the longer observation period, and we examine how high, sustained trajectories of physical IPV relate to stress given the known effects of stress on health, including HIV acquisition (Campbell, 2002; Coker et al., 2000; Plichta, 2004).

This study was limited in that only *physical* IPV was included given that physical violence was the only consistent, robust IPV measure collected during the study period.

However, other forms of IPV, such as emotional and sexual IPV, can have long-lasting effects on the health and well-being of young women and may result in varying forms or levels of stress (Spencer et al., 2022). Yet, a recent study observed the strongest relationship between physical IPV and stress compared to other forms of IPV (Haight et al., 2022). Our study only had stress measures at one timepoint, so we could not examine how stress changed longitudinally in relation to IPV trajectory group. Additionally, IPV may have been underreported by AGYW given the sensitive nature of this topic. Lastly, there was sparse data at older ages which likely resulted in imprecision of the higher IPV trajectory curve at older ages. Thus, this imprecise decline may reflect a leveling out of IPV in early adulthood, rather than a gradual decline. Sensitivity analyses were conducted excluding older ages due to sparse cells (restricting to ages <24 years and ages <23 years), but no meaningful changes were detected, so the full model (ages <25 years) was retained given its larger sample size.

Conclusion

In a sample of AGYW in rural South Africa, we identified two longitudinal trajectories of IPV: those with high, sustained IPV experiences that leveled off, and those with some experiences at younger ages but not in adulthood. Belonging to the higher IPV trajectory group was associated with elevated CRP in young adulthood but not with other measures of biological or perceived stress. Randomization to a conditional cash transfer attenuated the relationship between the high IPV trajectory group and CMV, suggesting that it may be an important target to reduce the effects of IPV on biological stress. Social protection programs may be a future area of intervention for AGYW at high risk of IPV, as this group is more likely to have reoccurring experiences of IPV, which may increase CRP and result in other adverse health outcomes. However, future work is needed to determine the causality and longitudinal nature of these relationships.

Acknowledgements

We thank the HPTN 068 study team and all trial participants. The MRC/Wits Rural Public Health and Health Transitions Research Unit and Agincourt Health and Socio-Demographic Surveillance System have been supported by the University of the Witwatersrand, the Medical Research Council, South Africa, and the Wellcome Trust, UK (grants 058893/Z/99/A; 069683/Z/02/Z; 085477/Z/08/Z; 085477/B/08/Z).

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article:

This study was funded by the National Institutes of Health (R21HD106583, R01 MH110186, R01MH087118, and T32 AI 070114) and by award numbers UM1 AI068619 (HPTN Leadership and Operations Center), UM1AI068617 (HPTN Statistical and Data Management Center), and UM1AI068613 (HPTN Laboratory Center). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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