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Citation for published version:

Chatterji, S & Heise, L 2021, 'Examining the bi-directional relationship between intimate partner violence and depression: Findings from a longitudinal study among women and men in rural Rwanda', *SSM - Mental Health*, vol. 1, 100038. <https://doi.org/10.1016/j.ssmmh.2021.100038>

Digital Object Identifier (DOI):

[10.1016/j.ssmmh.2021.100038](https://doi.org/10.1016/j.ssmmh.2021.100038)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

SSM - Mental Health

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Examining the bi-directional relationship between intimate partner violence and depression: Findings from a longitudinal study among women and men in rural Rwanda



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ARTICLE INFO

Keywords:

Depression
Intimate partner violence
Mental health and violence
Domestic violence
Rwanda

ABSTRACT

Several studies confirm that intimate partner violence (IPV) victimization is associated with symptoms of depression among women and men. Less recognized, is the potential role that depression symptoms may play in elevating the risk for IPV victimization and/or perpetration. While both phenomena deserve attention as global health issues in their own right, establishing the extent to which depression symptoms may be a risk factor for IPV as well as a consequence, holds promise to motivate greater attention to mental health issues as part of population-based violence prevention efforts. To advance this area of research and practice, we investigate the bidirectional association between IPV and depression symptoms in the context of a community randomized trial testing a couples based IPV prevention intervention in rural Rwanda. Results indicate that women's experience of depression symptoms at baseline were associated with physical, sexual, physical and/or sexual, or high intensity emotional IPV victimization at 24 months. Men's experience of depression symptoms at baseline were also associated with perpetration of physical, physical and/or sexual IPV, and severe physical and/or sexual IPV at 24 months. IPV victimization and perpetration, in turn, was also associated with a risk for future depression. At baseline, women who experienced any type of IPV and men who perpetrated physical or physical and/or sexual IPV were more likely to report depression symptoms at 24 months. Our findings highlight the need for trauma informed approaches for IPV prevention as well as access to proximate and affordable mental health services to reduce IPV and improve women and men's mental health.

1. Introduction

Intimate partner violence (IPV) refers to any behaviour within an intimate relationship that causes physical, psychological or sexual harm to those in the relationship (García-Moreno et al., 2012). IPV is a global public health issue. One-third of women worldwide have experienced at least one form of physical or sexual violence from their intimate partners in their lifetime (Devries, Mak, García-Moreno, et al., 2013). IPV has negative consequences on women's health including injury, hypertension, chronic pain, neurological issues, loss of a pregnancy, and substance use (Campbell, 2002; Stockman et al., 2014; Wu et al., 2010).

1.1. IPV-depression link

IPV also has detrimental impacts on mental health. IPV may lead to

traumatic stress which increases the risk for future symptoms of depression and other mental health disorders (Devries, Mak, Bacchus, et al., 2013). Several meta-analyses and reviews confirm that IPV victimization is associated with symptoms of depression among women (Bacchus et al., 2018; Beydoun et al., 2012; Devries, Mak, Bacchus, et al., 2013; Golding, 1999; Lagdon et al., 2014; Trevillion et al., 2012) and adolescent boys and adult men (Devries, Mak, Bacchus, et al., 2013; Spencer et al., 2019). IPV perpetration is also linked to depression symptoms among men (Oram et al., 2014; Spencer et al., 2019; Sandra M.; Stith et al., 2004). Both women and men who experience IPV are likewise at higher risk for experiencing other mental health disorders including PTSD, suicidality, and anxiety disorder (Devries, Mak, Bacchus, et al., 2013; Misca & Forgey, 2017; Spencer et al., 2019). The IPV-depression link has been examined in both clinical and non-clinical samples with similar results (Bacchus et al., 2018; Beydoun et al., 2012).

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<https://doi.org/10.1016/j.ssmmh.2021.100038>

Received 27 March 2021; Received in revised form 27 October 2021; Accepted 27 October 2021

Available online 30 October 2021

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1.2. Depression-IPV link

Research has also identified an increased risk of IPV victimization and/or perpetration among individuals experiencing recent depression symptoms (Oram et al., 2014; Spencer et al., 2019). Four meta-analyses found that depression symptoms are associated with IPV victimization among women (Devries, Mak, Bacchus, et al., 2013; Trevillion et al., 2012) and men (Devries, Mak, Bacchus, et al., 2013) and with IPV perpetration among women and men (Oram et al., 2014; Spencer et al., 2019). Two other reviews examined multisystemic risk factors for IPV and identified depression symptoms as a risk factor for male-to-female IPV perpetration (Schumacher et al., 2001; Sandra M. Stith et al., 2004). Smaller country-specific studies have explored this relationship using longitudinal data in Sweden (Yu et al., 2019) and cross-sectional data in South Africa (Breet et al., 2019).

There are several theories that explain why depression may be linked with future IPV victimization/perpetration. Depression has been associated with lower intimacy and relationship satisfaction (Birkley & Eckhardt, 2015; Lambert et al., 2012; Tuthill et al., 2019) which in turn are risk factors for IPV victimization and perpetration (Sandra M Stith et al., 2008; Sandra M. Stith et al., 2004). A partner's depression can add stress to an already troubled relationship which may also lead to IPV perpetration (Sandra M Stith et al., 2008). Symptoms of depression such as feeling worthless, unmotivated, hopeless and sad may impact an individual's ability to detect potentially abusive relationships, negotiate disagreements, manage triggers, or leave an abusive relationship (Gilbar et al., 2020; Iverson et al., 2011; Yu, Pepler, et al., 2018). Anger, agitation, irritability, and other symptoms of depression, have also been identified as risk factors for IPV perpetration (Orth & Wieland, 2006; Taft et al., 2011). Women with depression may also partner with individuals who themselves are experiencing mental health issues and are more likely to perpetrate IPV (Sandra M. Stith et al., 2004). Women who are depressed may be less open to or interested in sex which may make them vulnerable to sexual coercion or forced sex (Montejo et al., 2018). Depressed women may also find it difficult to perform household tasks and take care of their children, factors that are advanced by men to justify abuse (Capaldi et al., 2012).

1.3. Bidirectional relationship between IPV depression

A growing body of literature also documents a reciprocal relationship between IPV and depression in Asia and Africa. Using longitudinal data on married women with four time points in Korea, Kim and Lee (2013) found that baseline physical IPV victimization is associated with future experience of depression and that depression in turn was also associated with future experience of physical IPV (Kim & Lee, 2013). Similarly, a reciprocal relationship between physical IPV intensity and depression symptom severity was documented in South Africa (Tsai et al., 2016). However, in another study with a smaller sample of 173 HIV-positive women in Uganda, forced sex victimization was associated with future depression symptom severity but depression symptoms were not associated with future risk of experiencing forced sex (Tsai et al., 2015).

Despite this growing wealth of research, there are important gaps in our understanding of the relationship between IPV and depression. While research establishes an association between depression symptoms and IPV victimization and perpetration (Oram et al., 2014; Spencer et al., 2019; Trevillion et al., 2012), the temporal relationship between these two experiences remains unclear. Studies have also largely focused on physical IPV, with few studies including sexual or emotional IPV as outcomes (Golding, 1999; Trevillion et al., 2012). Similarly, although studies have examined the bidirectional relationship between IPV and depression, most have focused on physical IPV and forced sex among female victims of partner violence. In addition, studies have focused on IPV victimization and have not examined the reciprocal relationship between depression and IPV perpetration. In part, this reflects the lack of availability of longitudinal studies including measurement of different

types of IPV victimization and/or prepertration to establish the relative ordering of victimization/perpetration versus depression symptoms, especially outside of the United States. While both phenomena deserve attention as global health issues in their own right, establishing the extent to which depression symptoms may be a risk factor for IPV as well as a consequence, holds promise to inspire greater attention to mental health issues as part of population-based violence prevention efforts.

2. Present study

To advance this area of research and practice, we investigate the bidirectional association between IPV and depression symptoms among a cohort of couples followed longitudinally over three time points as part of a cluster randomized controlled trial of *Indashyikirwa*, an IPV prevention intervention implemented in rural Rwanda between 2015 and 2018. This trial was part of What Works to Prevent Violence Against Women and Girls, an 8-year research collaboration funded by the UK government. Based on the literature, we hypothesized that women who experienced various types of IPV at baseline (physical, sexual, high intensity emotional, severe physical and/or sexual) and men who reported perpetrating these types of violence at baseline would be at increased risk of experiencing depression symptoms at 24 months. We further hypothesized that both women and men reporting symptoms of depression at baseline would be more likely to report future IPV victimization (women) and IPV perpetration (men).

3. Rwandan setting

For this paper, we conducted secondary analysis of data from the *Indashyikirwa* trial which was implemented in rural Rwanda. Rwanda is a small, densely-populated country located in Africa's Rift Valley where the Great Lakes Region and East Africa converge. The 1994 genocide, during which 800,000 people were killed and many others displaced, has profoundly impacted the mental health of the Rwandan population. Although Rwanda was one of the first countries in Africa to implement a mental health policy in 1995, access to mental health services remains low due to a lack of mental health professionals, inadequate government expenditure on mental health, fear of stigma, and the high cost of healthcare (Ng & Harerimana, 2016; Rugema et al., 2015; Umubyeyi et al., 2014). The 2018 updated strategic plan for the Rwandan health sector hopes to expand access to mental health services and increase the integration of mental health services into primary care. A representative sample survey of 917 men and women aged 20–35 published in 2014, found that 12% men and 27% of women reported major depressive episodes in the past two weeks and 16% (8% men, 23% women) reported experiencing a major depressive episode prior to the past two weeks (Umubyeyi et al., 2014).

Violence against women is likewise a public health issue in Rwanda. In response, the government enacted the Prevention and Punishment of Gender Based Violence Law in 2018 and criminalized marital rape in 2012. IPV nonetheless remains a persistent problem with 34% of women aged 15 to 49 in the general population reporting physical and/or sexual violence by a husband/partner in the past 12 months ((NISR), 2016). In two other studies, rates for physical IPV victimization ranged from 18.8 to 29.7% among women (Umubyeyi et al., 2014; Verduin et al., 2012) and 17% of women reported experiencing sexual IPV and 21.4% psychological IPV in the past 12 months (Umubyeyi et al., 2014).

4. Methods

4.1. Data

This study presents secondary analysis of data from the *Indashyikirwa* trial, a community-randomized controlled trial implemented in Rwanda. The *Indashyikirwa* intervention included four interlocking components: a 21 session couples' curriculum; training and support to community

activists; opinion leader training; and the creation of women's safe spaces. The couples' curriculum, an intensive gender transformative and relationship strengthening intervention, addressed positive and negative types of power, key triggers of IPV (i.e., jealousy, alcohol abuse, economic stress), and taught communication and conflict resolution skills. To be eligible, at least one partner had to be an active member of a local village saving and loan association (VSLA); they had to live together or be married; and be 18–49 years old ($n = 1660$ women and 1651 men). The couple's curriculum was evaluated by interviewing participants at three time points: baseline (before the intervention), and 12- and 24-months post-intervention. Although couples were recruited into the trial and individuals can be linked to their partners, primary trial analysis was conducted at the individual level. Similarly, this secondary analysis also presents individual level data. At 24 months, 97% of women and 93% of men were retained and the sample for the primary trial analysis comprised of 1647 women and 1622 men. All interviews were conducted in Kinyarwanda using Audio Computer-Assisted Self-Interview (ACASI). Respondents who were not literate or who preferred an in-person interview were interviewed face-to-face by a gender-matched interviewer. In the original trial 24% ($n = 395$) of women and 15% ($n = 240$) of men at baseline and 19% (306) of women and 6% ($n = 90$) of men at endline chose this option. Further details on the study rationale, setting, methods, and intervention are available elsewhere (Dunkle et al., 2020).

The sample for this study is restricted to the 1536 women and 1467 men who had complete information on all study variables at both baseline and 24 months. The primary trial analysis included individuals who provided information at one or two follow up points. The secondary analysis presented in this paper uses data from individuals who provided complete information at baseline and 24 months. The majority of missing responses were due to respondents' incomplete information at 24 months. We checked for differences between individuals who provided complete information and those who had missing responses by baseline demographic characteristics and respondents only differed on asset ownership which has been included as covariate in this secondary analysis (results not shown).

4.2. Measures

IPV. *Indashyikirwa* used a version of the WHO instrument for assessing IPV, adapted for administration by ACASI (García-Moreno, Jansen, Ellsberg, Heise, & Watts, 2005). The original study included measures of physical IPV (5 acts), sexual IPV (3 acts), and emotional IPV (4 acts). All scales used behaviorally specific questions to inquire about women's victimization and men's perpetration of specific acts of IPV (e.g., in the past 12 months how many times has a current husband or boyfriend ever slapped you or thrown something at you which could hurt you?). Responses were: '0 = never', '1 = once', '2 = a few times', or '3 = many times.' Outcome measures were created for each type of violence (physical, sexual, emotional, severe physical and/or sexual). Each outcome was coded as a binary variable where a participant was coded as a "case of IPV" if they endorsed at least one act on the scale. When constructing our binary IPV variables, we included only women who had not experienced any type of IPV within the past 12 months in the reference group. Best practice in IPV measurement recommends using a "clean" reference group when constructing IPV exposure variables to avoid diluting any association between IPV and the outcome of interest (Heise & Hossain, 2017).

The What Works program adopted the following coding for severe physical and/or sexual IPV: experience/perpetration of any of the 5 physical IPV acts or 3 sexual IPV acts more than once (few time or many times) or endorsement of more than one type of act of physical and/or sexual IPV. Emotional IPV was only assessed for female participants. In this study, we recoded the emotional IPV questions as high intensity emotional abuse (1 = experienced at least one or more acts of emotional IPV 'many times'; 0 = did not experience any type of IPV) (Heise et al., 2019).

Depression. We used the short version of the Centre for Epidemiologic Studies Depression self-report measure (CESD-10) to measure depression symptoms (Andresen et al., 1994). The scale includes 10 items such as: "During the past week, I felt that everything I did was an effort." Responses ranged from 0 (*rarely or none of the time*) to 3 (*most or all of the time*) on a 4-point Likert scale. Cronbach's alpha was 0.75 for women and 0.73 in this study. A continuous depressive symptom score was obtained by summing responses to items (range 0–30). This score was recoded to create a binary variable (0 = none to mild symptoms, 1 = moderate to severe symptoms) using a cutoff of a score of 10 or higher which is indicative of more severe depressive symptoms (Andresen et al., 1994). This threshold is the most commonly used cutoff in studies conducted in South Africa, Kenya, Malawi, Tanzania, Zambia, and Zimbabwe (Folb et al., 2015; Kilburn et al., 2018).

Weighted asset score. This variable was constructed by weighting each listed asset (bicycle, cell phone, radio, electricity, livestock, land, home ownership) with its inverse frequency among participants and then summing weights for assets owned (i.e. something owned by 50% of participants was weighted at 2.0 and something owned by 25% of participants weighted at 4.0; these weights were then summed for each asset owned).

4.3. Analysis

We first described the baseline characteristics of both women and men and examined their associations with depression symptoms. All tests took into account the complex sampling nature of the data, treating sectors as cluster and districts as sampling strata in the computation of standard errors. After testing for bivariate associations, we used multi-level poisson models with robust error variance for our main models to estimate relative risk ratios. Although depression and IPV were measured as binary variables, both IPV and depression were not rare outcomes in our dataset and logistic regression would have produced inconsistent estimates of risk ratios (Zou, 2004).

First, we estimated the association between depression symptoms at baseline and IPV victimization (women) and perpetration (men) at 24 months. These models also included a covariate for baseline measurement of IPV victimization/perpetration. Second, we tested the association between IPV victimization (women) and perpetration (men) at baseline and depression symptoms at 24 months. We included baseline measurement of depression symptoms as a covariate in these models. The district in which the data were collected was treated as a fixed effect to account for possible geographic variation. Sector (the unit of randomization for the trial) was added as a random effect term to account for variation in the outcome between sectors. Models for outcomes among women were adjusted for the experience of physical or sexual IPV from a previous partner and prior experience of sexual violence. Models for outcomes among men were adjusted for being beaten often or very often as a child, witnessing mother's abuse in childhood, and perpetration of physical or sexual IPV against a previous partner. All models were further adjusted for age, education, weighted asset score, and treatment assignment.

We also conducted sensitivity analyses with stratified samples to provide a more robust test of the bidirectional association between IPV and depression. Models with the outcome of recent IPV at 24 months were restricted to individuals who had not reported IPV victimization/perpetration in the past 12 months at baseline. Models with the outcome of depression symptoms at 24 months were restricted to individuals who did not report moderate/severe symptoms of depression at baseline. This strategy helps eliminate any possible confounding from earlier forms of violence or trauma that could increase likelihood of IPV or depression symptoms at baseline.

4.4. Ethical approval

Ethical approval for the Indashyikirwa study was obtained from the Rwandan National Ethics Committee (340/RNEC/2015) and the

National Institute of Statistics Rwanda (0738/2015/10/NISR). Secondary ethics approval was also obtained from the South Africa Medical Research Council (EC033-10/2015). Written consent was obtained from all participants; illiterate participants could have the form read to them by study personnel or a trusted person of their choosing. A female professional counselor, organized by the study, was available to support participants who experienced any distress, with services offered either in person, over the phone, or via referral at a later time (Dunkle et al., 2020).

5. Results

5.1. Sample characteristics

Demographic characteristics for all participants are presented in Table 1. The mean age of female participants was 33 years and 36 years for male participants. Approximately, two thirds of both female (68%) and male (67%) participants had completed primary education. Most participants were married (66% women, 67% men). At baseline, 39% of women and 25% of men reported moderate to severe symptoms of depression.

At baseline, 48% of women reported experiencing physical IPV in the past 12 months, 50% reported sexual IPV, 57% physical and/or sexual IPV, 47% severe physical and/or sexual IPV, and 31% high intensity emotional IPV. Among men, 27% reported perpetrating physical IPV, 24% sexual IPV, 35% physical and/or sexual IPV, 25% severe physical and/or sexual IPV in the past 12 months at baseline. Thirteen percent of women reported experiencing physical and/or sexual IPV in a prior intimate relationship whereas 13% of men reported perpetrating physical and/or sexual IPV with a prior partner. Among women, 49% had experienced some form of sexual violence in their lifetime. This included forced first sex, forced sex by a non-partner at any age, and/or unwanted sexual touching when they were less than 15 years of age. Among men, 43% had witnessed their mother being beaten by their father or some other man, and 28% reported receiving harsh physical punishment in their childhood.

5.2. Bivariate results

Table 2 presents bivariate associations between IPV and depression symptoms at baseline. Women with moderate to severe symptoms of depression at baseline were more likely to report experiencing physical, sexual, physical and/or sexual, and high intensity emotional IPV as compared to women who were not experiencing depression symptoms. Women reporting depression symptoms were also more likely to have experienced physical and/or sexual IPV from a prior partner and prior sexual violence in their lifetime. Men reporting moderate to severe symptoms of depression at baseline were also more likely to have perpetrated all types of IPV. Men who reported baseline symptoms of depression were also more likely to have experienced harsh physical punishment as a child and to have witnessed their mother's abuse.

5.3. Depression-IPV link

We first examined the multivariable associations between depression symptoms at baseline and IPV victimization/perpetration at 24 months. Depression symptoms at baseline were significantly associated with different forms of recent IPV victimization at 24 months. Women reporting moderate to severe symptoms of depression at baseline were more likely to experience past year physical, sexual, physical and/or sexual, or high intensity emotional IPV at 24 months as compared to women who reported none to mild symptoms of depression (Table 3, Models 1–5). Coefficients for different kinds of IPV ranged from 1.30 to 1.56 and were significant at the $p < 0.001$ and $p < 0.01$ levels. Women who reported moderate/severe symptoms of depression at baseline were more likely to experience recent physical and/or sexual IPV (aRR = 1.27,

Table 1
Sociodemographic characteristics of sample at baseline.

Variable	Women (N = 1536)		Men (N = 1467)	
	N or mean	% or (SE)	N or mean	% or (SE)
Age of respondents				
Mean age	32.73	0.23	35.62	0.23
Education				
No school	276	17.97%	234	15.95%
Primary (complete)	1050	68.36%	988	67.35%
Secondary (complete)	156	10.16%	159	10.84%
Other schooling	54	3.52%	86	5.86%
Relationship status				
Married	1018	66.28%	982	66.94%
Living as if married	518	33.72%	485	33.06%
Household assets				
Bicycle	508	33.07%	486	33.13%
Cell phone	1242	80.86%	1185	80.78%
Radio	1005	65.43%	972	66.26%
Electricity	308	20.05%	305	20.79%
HH has livestock	902	58.72%	872	59.44%
HH owns land	988	64.32%	1002	68.30%
HH owns home	1334	86.85%	1315	89.64%
Weighted assets score (range 0–15.2)	7.03	0.18	7.07	0.18
Who earns more				
Husband more	693	45.15%	378	25.80%
About the same	116	7.56%	118	8.05%
Wife more	141	9.19%	135	9.22%
Do all work together	585	38.11%	834	56.93%
Depression symptoms				
Moderate to severe	598	38.93%	368	25.09%
Victimization/perpetration of violence in the past 12 months				
Physical IPV	587	47.65%	360	27.05%
Sexual IPV	645	50.00%	306	24.38%
Physical and/or sexual IPV	860	57.14%	518	35.31%
Severe physical and/or sexual IPV	705	47.16%	361	24.61%
High intensity emotional IPV	296	31.46%	not assessed	
Previous experience of violence				
Experienced physical or sexual IPV with a past partner (prior to current relationship)	199	12.96%	186	12.68%
Any prior sexual violence	745	48.50%	not assessed	
Witnessed mother being beaten by father or another man	not assessed		637	43.45%
Beaten often or very often as a child	not assessed		407	27.74%

CI: 1.13–1.42) and recent high intensity emotional IPV (aRR = 1.56, CI: 1.15–2.10) at 24 months.

Men reporting moderate to severe symptoms of depression at baseline were more likely to perpetrate past year physical IPV at 24 months as compared to men who reported none to mild symptoms of depression (aRR = 1.48, CI: 1.15–1.91) at baseline. Depression symptoms were also associated with the perpetration of recent physical and/or sexual IPV (aRR = 1.28, CI: 1.07–1.53) and severe physical and/or sexual IPV at 24 months (aRR = 1.52, CI: 1.20–1.92). Men who perpetrated physical and/or sexual IPV in a prior relationship were more likely to perpetrate physical IPV (aRR = 1.41, CI: 1.14–1.75) and physical and/or sexual IPV (aRR = 1.29, CI: 1.09–1.52) in the past year against their current partner at 24 months.

5.4. Multivariable IPV-depression link

Results presented in Table 4 indicate that women who reported experiencing physical, sexual, physical and/or sexual, or high intensity emotional IPV within the last 12 months at baseline, were more likely to report moderate to severe symptoms of depression at 24 months. Coefficients ranged from 1.27 to 1.36 and were significant at the $p < 0.01$

Table 2
Bivariate association between depression symptoms and IPV at baseline.

	Women (n = 1536)					Men (n = 1467)				
	Yes (n = 598)		No (n = 938)		p value	Yes (n = 368)		No (n = 1099)		p value
	N or mean	% or (SE)	N or mean	% or (SE)		N or mean	% or (SE)	N or mean	% or (SE)	
Physical IPV	304	64.5%	283	37.2%	0.00	151	47.8%	209	21.1%	0.00
Sexual IPV	331	66.5%	314	39.7%	0.00	139	45.7%	167	17.6%	0.00
Physical and/or sexual IPV	413	71.2%	447	48.3%	0.00	203	55.2%	315	28.7%	0.00
Severe physical and/or sexual IPV	367	63.9%	338	36.7%	0.00	163	44.3%	198	18.0%	0.00
High intensity emotional IPV	206	55.2%	90	15.9%	0.00					
Phy/sex IPV from prior partner	105	17.6%	94	10.0%	0.00	75	20.4%	111	10.1%	0.00
Prior sexual violence	369	61.7%	376	40.1%	0.00					
Witnessed mother's abuse						177	48.2%	460	41.9%	0.03
Beaten often in childhood						140	38.0%	267	24.3%	0.01

Table 3
Multivariable association between depression symptoms at baseline and IPV at 24 months.

	Women (n = 1536)					Men (n = 1467)			
	Models 1-5					Models 6-9			
	Physical	Sexual	High-intensity emotional	Phys/sexual	Severe phys/sexual	Physical	Sexual	Phys/sexual	Severe phys/sexual
	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR
Depression symptoms	1.39*** (1.20–1.61)	1.31** (1.11–1.54)	1.56** (1.15–2.10)	1.27*** (1.13–1.42)	1.30** (1.11–1.53)	1.48** (1.15–1.91)	1.24 (0.98–1.58)	1.28** (1.07–1.53)	1.52*** (1.20–1.92)
Phy/sex IPV from prior partner	1.03 (0.88–1.20)	1.07 (0.95–1.20)	1.32* (1.01–1.72)	1.01 (0.92–1.11)	1.07 (0.96–1.20)	1.41** (1.14–1.75)	1.32 (0.96–1.82)	1.29** (1.09–1.52)	1.23 (0.97–1.56)
Prior sexual violence	1.18 (0.99–1.40)	1.05 (0.91–1.20)	1.04 (0.80–1.35)	1.13 (0.99–1.28)	1.14* (1.02–1.28)				
Witnessed mother's abuse						0.89 (0.73–1.08)	1.45* (1.07–1.94)	1.08 (0.91–1.29)	1.08 (0.85–1.38)
Beaten often in childhood						0.86 (0.65–1.13)	1.04 (0.73–1.47)	0.99 (0.78–1.27)	1.07 (0.80–1.42)
Age	0.99 (0.99–1.00)	1.00 (1.00–1.01)	1.01 (0.99–1.03)	1.00 (0.99–1.01)	1.00 (0.99–1.01)	1.00 (0.98–1.01)	0.98 (0.97–1.00)	0.99 (0.98–1.00)	1.00 (0.98–1.01)
Education (omitted category: no education)									
Primary	0.85 (0.70–1.02)	0.83 (0.68–1.00)	0.70* (0.51–0.94)	0.90 (0.77–1.06)	0.84* (0.70–0.99)	0.72* (0.54–0.95)	0.79 (0.50–1.23)	0.78 (0.59–1.03)	0.79 (0.59–1.05)
Secondary	0.80* (0.66–0.96)	0.82 (0.62–1.08)	0.71 (0.47–1.07)	0.86 (0.72–1.03)	0.87 (0.73–1.02)	1.21 (0.83–1.76)	0.67 (0.41–1.09)	1.00 (0.73–1.36)	0.87 (0.60–1.26)
Above secondary/technical	0.62* (0.40–0.95)	0.64 (0.38–1.07)	0.25** (0.09–0.69)	0.71 (0.48–1.04)	0.57* (0.34–0.98)	0.42* (0.20–0.88)	0.79 (0.37–1.69)	0.63 (0.39–1.01)	1.04 (0.62–1.73)
Weighted asset score	1.00 (0.97–1.03)	0.99 (0.97–1.01)	1.00 (0.97–1.03)	0.99 (0.97–1.01)	1.01 (0.99–1.02)	1.02 (0.99–1.06)	1.03 (0.99–1.08)	1.03* (1.00–1.06)	1.01 (0.98–1.05)
Physical IPV (baseline)	2.92*** (2.43–3.52)					3.12*** (2.24–4.33)			
Sexual IPV (baseline)		2.47*** (2.01–3.05)					3.16*** (2.35–4.25)		
Emotional IPV (baseline)			5.06*** (3.53–7.24)						
Phys/sexual IPV (baseline)				1.94*** (1.66–2.27)				2.17*** (1.74–2.70)	
Severe phys/sexual IPV (baseline)					2.17*** (1.84–2.56)				2.64*** (2.03–3.42)
Treatment group	0.70*** (0.60–0.81)	0.81*** (0.73–0.91)	0.56*** (0.41–0.76)	0.81*** (0.75–0.88)	0.75*** (0.69–0.82)	0.94 (0.78–1.14)	0.69*** (0.59–0.82)	0.83** (0.73–0.94)	0.73*** (0.63–0.84)

95% Confidence intervals in parentheses ***p < 0.001, **p < 0.01, *p < 0.05.

and p < 0.05 levels. Women who experienced recent physical and/or sexual IPV (aRR = 1.33, CI: 1.10–1.61) or high intensity emotional abuse (aRR = 1.36, CI: 1.06–1.74) were more likely to report moderate/severe symptoms of depression at 24 months as compared to women who had not experienced partner violence in the past 12 months at baseline. In addition to recent IPV, prior experience of sexual violence was also

associated with depression symptoms at 24 months in models for sexual, physical and/or sexual, or high intensity emotional IPV.

Among men, those who perpetrated physical IPV had a higher likelihood of being at risk for depression at 24 months (aRR = 1.32, CI: 1.11–1.57) as compared to men who did not perpetrate any IPV in the past 12 months at baseline (Table 4, Models 6–9). Similarly, men who

Table 4
Multivariable association between IPV at baseline and depression symptoms at 24 months.

	Women (n = 1536)					Men (n = 1467)			
	Models 1-5					Models 6-9			
	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR
Physical IPV	1.35** (1.09–1.67)					1.32** (1.11–1.57)			
Sexual IPV		1.27* (1.05–1.55)					1.13 (0.92–1.40)		
High-intensity emotional IPV			1.36* (1.06–1.74)						
Physical and/or sexual IPV				1.33** (1.10–1.61)				1.21* (1.01–1.46)	
Severe physical and/or sexual IPV					1.27** (1.07–1.50)				1.19 (0.98–1.44)
Phy/sex IPV from prior partner	0.99 (0.80–1.23)	1.04 (0.83–1.31)	1.00 (0.78–1.27)	0.98 (0.81–1.17)	1.00 (0.83–1.21)	0.90 (0.71–1.14)	0.88 (0.67–1.14)	0.85 (0.67–1.07)	0.85 (0.67–1.06)
Prior sexual violence	1.18 (0.97–1.44)	1.23** (1.05–1.44)	1.25* (1.03–1.52)	1.24* (1.05–1.45)	1.25** (1.06–1.47)				
Witnessed mother's abuse						0.96 (0.79–1.17)	1.00 (0.78–1.29)	1.00 (0.81–1.24)	1.02 (0.82–1.25)
Beaten often in childhood						1.10 (0.92–1.32)	1.02 (0.80–1.29)	1.04 (0.86–1.25)	1.04 (0.87–1.26)
Age	1.01 (1.00–1.02)	1.01* (1.00–1.02)	1.01 (0.99–1.03)	1.01** (1.00–1.02)	1.01** (1.00–1.02)	1.00 (0.99–1.01)	0.99 (0.98–1.00)	1.00 (0.99–1.01)	1.00 (0.99–1.01)
Education (omitted category: no education)									
Primary	0.77** (0.65–0.92)	0.79* (0.65–0.97)	0.74** (0.61–0.91)	0.81** (0.69–0.95)	0.81* (0.69–0.95)	0.69*** (0.56–0.86)	0.70** (0.55–0.89)	0.73** (0.59–0.90)	0.73** (0.59–0.89)
Secondary	0.80 (0.61–1.06)	0.78 (0.56–1.08)	0.77 (0.56–1.05)	0.77 (0.58–1.01)	0.77 (0.59–1.02)	0.59** (0.40–0.87)	0.60* (0.37–0.99)	0.63* (0.41–0.97)	0.63* (0.41–0.97)
Above secondary/technical	0.69 (0.41–1.18)	0.91 (0.57–1.44)	0.66 (0.38–1.16)	0.85 (0.55–1.31)	0.89 (0.59–1.33)	0.37*** (0.21–0.67)	0.42** (0.23–0.77)	0.40** (0.22–0.72)	0.40** (0.22–0.72)
Weighted asset score	1.00 (0.97–1.03)	1.00 (0.97–1.02)	1.00 (0.98–1.03)	0.99 (0.97–1.02)	0.99 (0.97–1.02)	0.99 (0.97–1.02)	0.99 (0.96–1.02)	0.99 (0.97–1.02)	0.99 (0.97–1.02)
Baseline depression symptoms	2.29*** (1.88–2.80)	2.17*** (1.87–2.53)	2.13*** (1.76–2.59)	2.14*** (1.85–2.48)	2.14*** (1.85–2.47)	2.45*** (1.93–3.12)	2.58*** (1.96–3.38)	2.55*** (2.00–3.25)	2.56*** (1.99–3.28)
Treatment group	0.64*** (0.56–0.74)	0.68*** (0.58–0.78)	0.65*** (0.55–0.77)	0.64*** (0.57–0.73)	0.64*** (0.57–0.73)	0.85 (0.71–1.02)	0.81* (0.69–0.95)	0.81** (0.70–0.94)	0.82** (0.71–0.95)

95% Confidence intervals in parentheses ***p < 0.001, **p < 0.01, *p < 0.05.

perpetrated physical and/or sexual IPV were also more likely to report depression symptoms at 24 months (aRR = 1.21, CI: 1.01–1.46). Education was also associated with depression. Men who were educated were less likely to report depression symptoms at 24 months as compared to men without any formal education.

5.5. Sensitivity analyses

We conducted sensitivity analyses to test the robustness of our findings by restricting the sample for each model to individuals who had not experienced the outcome at baseline.

Depression-IPV link. First, we examined the association between depression symptoms at baseline and IPV victimization (women) and perpetration (men) at 24 months among individuals who did not report IPV victimization/perpetration at baseline (Table 5). For all models, results were similar to models with the full sample. Among women who did not report recent IPV victimization at baseline, depression symptoms at baseline were associated with past year physical, sexual, physical and/or sexual, or high intensity emotional IPV at 24 months. For example, among women who did not report any IPV victimization in the past 12 months at baseline, depression symptoms at baseline were associated with higher likelihood of physical and/or sexual IPV victimization at 24 months (aRR = 1.41, CI: 1.07–1.85). Among men who did not report perpetrating any IPV at baseline, men who reported depression symptoms at baseline were more likely to perpetrate physical IPV (aRR = 1.99, CI: 1.32–3.01), physical and/or sexual IPV (aRR = 1.49, CI: 1.12–1.98), and severe physical and/or sexual IPV (aRR = 1.63, CI: 1.06–2.51) at 24 months.

IPV-depression link. The second set of sensitivity models tested the association between IPV victimization (women) and perpetration (men) at baseline and depression at 24 months among individuals who did not report moderate/severe symptoms of depression at baseline (Table 6). In these restricted samples, all models yielded findings similar to those with the full sample, with one exception. There was no significant association between baseline perpetration of physical and/or sexual IPV and depression at 24 months among men who did not report depression symptoms at baseline at baseline.

Across all types of IPV in the restricted samples, there was a significant association between women's experience of IPV victimization and their increased likelihood of reporting depression symptoms at 24 months. For example, among the subset of women who did not report moderate to severe symptoms of depression at baseline, those who reported physical and/or sexual IPV victimization in the past year at baseline were more likely to report moderate to severe symptoms of depression at 24 months (aRR = 1.49, CI: 1.13–1.96). Among the subset of men who did not report depression symptoms at baseline, men who perpetrated physical IPV had higher likelihood of experiencing depression at 24 months (aRR = 1.41, CI: 1.06–1.87).

6. Discussion

Using longitudinal data from rural Rwanda, this study examined the bi-directional relationship between IPV victimization (women) and perpetration (men) and depression. The results confirm that the relationship between IPV victimization/perpetration and depression is bi-directional among both women and men. Specifically, depression was

Table 5

Multivariable association between depression at baseline and IPV at 24 months among individuals with no recent exposure to IPV victimization/perpetration at baseline.

	Women					Men			
	Models 1-5					Models 6-9			
	Physical	Sexual	High-intensity emotional	Phys/sexual	Severe phys/sexual	Physical	Sexual	Phys/sexual	Severe phys/sexual
	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR
Depression symptoms	1.54* (1.07–2.21)	1.54* (1.08–2.20)	1.84* (1.14–2.97)	1.41* (1.07–1.85)	1.63*** (1.22–2.18)	1.99** (1.32–3.01)	1.37 (0.81–2.33)	1.49** (1.12–1.98)	1.63* (1.06–2.51)
Phy/sex IPV from prior partner	1.73 (0.87–3.46)	1.38 (0.71–2.69)	2.75** (1.47–5.14)	1.38 (0.84–2.27)	1.39 (0.83–2.34)	1.39 (0.82–2.36)	1.21 (0.60–2.45)	1.23 (0.83–1.81)	1.28 (0.82–2.02)
Prior sexual violence	1.19 (0.80–1.75)	1.02 (0.78–1.32)	1.00 (0.55–1.81)	1.10 (0.88–1.38)	1.20 (0.96–1.50)				
Witnessed mother's abuse						1.10 (0.79–1.52)	1.39 (0.86–2.23)	1.17 (0.87–1.57)	1.36 (0.94–1.98)
Beaten often in childhood						0.68 (0.37–1.25)	1.20 (0.71–2.04)	0.97 (0.61–1.55)	0.96 (0.60–1.53)
Age	0.98 (0.95–1.01)	1.01 (0.98–1.03)	1.03 (0.98–1.07)	1.00 (0.98–1.02)	1.00 (0.98–1.01)	0.98 (0.95–1.01)	0.99 (0.96–1.01)	0.99 (0.96–1.01)	0.99 (0.97–1.02)
Education (omitted category: no education)									
Primary	0.66* (0.44–0.99)	0.66* (0.46–0.95)	0.73 (0.37–1.45)	0.72* (0.54–0.96)	0.63** (0.45–0.89)	0.42*** (0.25–0.69)	0.73 (0.42–1.27)	0.57** (0.40–0.80)	0.65 (0.42–1.00)
Secondary	0.69 (0.42–1.13)	0.42* (0.20–0.89)	0.34 (0.07–1.67)	0.64* (0.42–0.96)	0.69* (0.48–1.00)	1.05 (0.59–1.86)	0.57 (0.22–1.49)	0.96 (0.61–1.52)	0.98 (0.56–1.70)
Above secondary/technical	0.50 (0.12–2.06)	0.55 (0.20–1.55)	0.00*** (0.00–0.00)	0.67 (0.31–1.43)	0.53 (0.21–1.30)	0.29 (0.07–1.18)	0.51 (0.15–1.74)	0.38 (0.13–1.06)	0.94 (0.39–2.22)
Weighted asset score	1.00 (0.94–1.06)	1.00 (0.95–1.04)	0.99 (0.90–1.08)	0.99 (0.96–1.02)	1.00 (0.97–1.04)	1.04 (1.00–1.08)	1.05 (0.98–1.11)	1.04* (1.01–1.08)	1.03 (0.98–1.07)
Treatment group	0.69** (0.52–0.90)	0.95 (0.73–1.23)	0.47*** (0.31–0.73)	0.90 (0.74–1.10)	0.79 (0.62–1.01)	1.02 (0.68–1.51)	0.80* (0.66–0.98)	0.93 (0.74–1.17)	0.83 (0.63–1.09)
Observations	645	645	645	645	790	949	949	949	1106

95% Confidence intervals in parentheses ***p < 0.001, **p < 0.01, *p < 0.05.

found to be a risk factor for future IPV victimization (women) and perpetration (men). At baseline, women who reported symptoms of depression were more likely to report physical, sexual, physical and/or sexual, severe physical and/or sexual or high intensity emotional IPV victimization in the past year at 24 months. Our results align with findings from prior studies that have established a longitudinal relationship between depression symptoms and IPV victimization among women (Devries, Mak, Bacchus, et al., 2013; Spencer et al., 2019; Tsai et al., 2016). These findings also extend the understanding of these relationships by examining the longitudinal association between depression and high intensity emotional IPV.

Depression was also a risk factor for future perpetration of IPV. Among men, baseline depression symptoms were also associated with the perpetration of physical, physical and/or sexual, severe physical and/or sexual IPV in the past year at 24 months. These results extend findings from prior cross-sectional studies with men that identified depression as a correlate of IPV victimization and/or perpetration (Oram et al., 2014; Spencer et al., 2019; Trevillion et al., 2012).

IPV victimization and perpetration, in turn, was also associated with a risk for future depression. Women who experienced physical, sexual, physical and/or sexual, or high intensity emotional IPV in the past 12 months at baseline were more likely to experience moderate to severe symptoms of depression at 24 months. These results are consistent with findings from other studies that highlight the negative impact of IPV on women's mental health (Bacchus et al., 2018; Devries, Mak, Bacchus, et al., 2013; Trevillion et al., 2012). Prior experience of sexual violence was also associated with depression over time. These findings highlight the importance of including covariates such as childhood sexual abuse, forced first sex, and sexual assault in studies that investigate the IPV-depression link to rule out potential confounding.

The findings also emphasize the longitudinal risk of depression

among men who perpetrate physical IPV. Men who perpetrated physical IPV or physical and/or sexual IPV in the past year at baseline were more likely to report moderate to severe symptoms of depression at 24 months. These results extend findings from cross-sectional studies that have found that depression is a correlate of IPV perpetration among men (Sandra M. Stith et al., 2004; Spencer et al., 2019).

Our results align with prior studies that found a reciprocal relationship between IPV victimization and depression among women (Kim & Lee, 2013; Tsai et al., 2015, 2016). The findings of this study also extends this literature by examining the reciprocal relationship between male-to-female IPV perpetration and depression. While we found evidence of this bidirectional relationship between male-to-female IPV victimization and perpetration and depression, we did not investigate the mechanisms that underlie these associations. We used data from two time points two years apart. Future studies can use longitudinal data with multiple time points and detailed IPV and mental health history to examine the cyclical relationship between IPV and depression over the life course. Prior research from the United States found that the association between exposure to violence in adolescence and adult IPV perpetration, is mediated through depression symptoms (Heinze et al., 2021). Another study with Dutch adolescents found that victimization mediated the association between depression symptoms and future violent behaviors (Yu, Branje, et al., 2018).

6.1. Implications for research and practice

The impact of IPV victimization on women's risk of depression has long been recognized (Bacchus et al., 2018; Devries, Mak, Bacchus, et al., 2013). Less commonly acknowledged is that depression can put women at higher risk of IPV victimization and men at higher risk of perpetration. This suggests that efforts to improve mental health and reduce depression

Table 6

Multivariable association between IPV at baseline and depression at 24 months among individuals with low to mild symptoms of depression at baseline.

	Women					Men			
	Models 1-5					Models 6-9			
	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR	aRR
Physical IPV	1.44*					1.41*			
	(1.05–1.98)					(1.06–1.87)			
Sexual IPV		1.45*					1.22		
		(1.08–1.96)					(0.80–1.87)		
High-intensity emotional IPV			1.82*						
			(1.15–2.89)						
Physical and/or sexual IPV				1.49**				1.27	
				(1.13–1.96)				(0.95–1.70)	
Severe physical and/or sexual IPV					1.29*				1.30
					(1.01–1.65)				(0.98–1.74)
Phy/sex IPV from prior partner	1.05	1.01	0.87	1.00	1.03	0.92	1.00	0.92	0.92
	(0.72–1.55)	(0.70–1.46)	(0.52–1.48)	(0.72–1.39)	(0.74–1.44)	(0.54–1.58)	(0.58–1.72)	(0.55–1.53)	(0.56–1.53)
Prior sexual violence	1.33	1.33	1.34	1.29	1.33				
	(0.93–1.91)	(0.95–1.87)	(0.90–1.99)	(0.95–1.75)	(0.98–1.81)				
Witnessed mother's abuse						0.89	0.98	0.96	0.97
						(0.64–1.25)	(0.70–1.37)	(0.68–1.36)	(0.69–1.37)
Beaten often in childhood						1.29	1.07	1.19	1.19
						(0.96–1.73)	(0.74–1.56)	(0.89–1.59)	(0.89–1.59)
Age	1.01	1.01	1.02	1.01	1.01	0.99	0.99	0.99	0.99
	(0.98–1.03)	(0.98–1.03)	(0.99–1.04)	(0.99–1.03)	(0.99–1.03)	(0.98–1.01)	(0.97–1.00)	(0.98–1.01)	(0.98–1.01)
Education (omitted category: no education)									
Primary	0.58**	0.61**	0.60**	0.64**	0.64**	0.65**	0.66*	0.67**	0.68**
	(0.42–0.81)	(0.44–0.85)	(0.43–0.83)	(0.48–0.84)	(0.48–0.84)	(0.48–0.86)	(0.47–0.92)	(0.51–0.90)	(0.51–0.90)
Secondary	0.52	0.45	0.47	0.49*	0.49*	0.53*	0.55	0.55*	0.55*
	(0.27–1.00)	(0.19–1.04)	(0.19–1.17)	(0.26–0.93)	(0.26–0.94)	(0.32–0.89)	(0.30–1.01)	(0.32–0.93)	(0.33–0.94)
Above secondary/technical	0.86	0.95	0.71	1.00	0.98	0.23**	0.28*	0.24**	0.24**
	(0.46–1.62)	(0.50–1.78)	(0.30–1.67)	(0.62–1.61)	(0.59–1.61)	(0.08–0.66)	(0.10–0.78)	(0.09–0.65)	(0.09–0.66)
Weighted asset score	1.02	1.02	1.03	1.01	1.01	0.99	0.99	0.99	0.99
	(0.97–1.07)	(0.98–1.07)	(0.98–1.08)	(0.97–1.05)	(0.97–1.05)	(0.94–1.04)	(0.94–1.03)	(0.95–1.03)	(0.95–1.03)
Treatment group	0.61***	0.69**	0.60***	0.62***	0.62***	0.83	0.82	0.79	0.79
	(0.48–0.76)	(0.53–0.89)	(0.45–0.80)	(0.51–0.75)	(0.51–0.75)	(0.61–1.11)	(0.62–1.09)	(0.61–1.03)	(0.61–1.03)
Observations	938	938	938	938	938	1099	1099	1099	1099

95% Confidence intervals in parentheses ***p < 0.001, **p < 0.01, *p < 0.05.

symptoms may reduce IPV and have wide-ranging implications for public health. There is an urgent need to identify and advocate for inexpensive mental health interventions that can be delivered by lay providers in low income settings. Such interventions hold the potential to both improve mental health and reduce future IPV victimization/perpetration. Recent impact evaluations offer several promising examples, including CETA (Common Elements Treatment Approach), a lay-led cognitive-behavioral counselling approach that achieved significant reductions in both depression symptoms, alcohol abuse and IPV among couples experiencing IPV in Zambia (Kane et al., 2021; Murray et al., 2020). Cognitive behavioral therapy also reduced the risk of PTSD and depression among US women with histories of past trauma, which in turn lowered risk for future IPV (Iverson et al., 2011).

Similarly, women and men who report symptoms of depression should be screened for victimization and perpetration of violence. Mental health service providers can involve family members and significant others in the treatment process to improve relationship quality. This approach has shown success in the field of IPV prevention where couples' and parenting interventions have improved relationship satisfaction and reduced IPV victimization and/or perpetration (Doyle et al., 2018; Hosain et al., 2014; Raj et al., 2016). Mental health interventions can also follow suit.

Although the Rwandan government has taken steps to address mental health services, there is much scope for improvement (Umubyeyi et al., 2014; Verduin et al., 2012). There is an urgent need to improve access and affordability of mental health services and to reduce the stigma around accessing them. The recent strategic plan for the Rwandan health sector sought to integrate mental health into primary care which is a welcome move. The government can also take steps to improve the mental health literacy of primary health care workers to improve access to mental health services as they are often the first point of contact in

rural areas (Shidhaye & Kermodé, 2013).

6.2. Limitations

This study has several limitations. First, all measures relied on self-reports which are subject to under-reporting and social desirability bias. The *Indashyikirwa* trial used anonymous reporting through ACASI data collection to mitigate such bias. Research suggests that ACASI encourages more truthful and forthcoming reporting compared to face-to-face interviews or self-administered methods for stigmatized topics (Fenton et al., 2001; Macalino et al., 2002). The trial also used field researchers who were external to the program and emphasized the confidentiality of all answers.

Second, the Rwandan genocide has been linked to depression (Umubyeyi et al., 2014) and we were unable to adequately control for this type of trauma. The original study included two items that asked participants if they had witnessed the war or were present in Rwanda during the genocide. But no item measured participants' direct experience of the genocide due to ethical and logistical issues. We did test for differences in depression at baseline by these two variables and did not find any significant difference as almost all participants in our sample had experienced the genocide. Future studies should ask questions on the Rwandan genocide and other potential forms of past trauma, to include them as covariates.

Finally, several aspects of the parent *Indashyikirwa* study limit the conclusions that we can draw from our analysis. The *Indashyikirwa* intervention recruited participants from existing Village Saving and Loan Associations (VSLAs) run by CARE Rwanda. While VSLA membership was not means tested, VSLA participants may have differed systematically from the general Rwandan population, thus limiting the generalizability of our findings. Additionally, the parent study focused on male-

to-female IPV. Future studies can measure IPV victimization and perpetration of both women and men.

This study also has several strengths. Our findings provide longitudinal evidence of a bi-directional relationship between depression symptoms and different types of IPV from Rwanda. By including measures of high intensity emotional IPV, severe physical and/or sexual IPV, we also extended the literature on depression symptomatology as a risk factor for subsequent IPV victimization/perpetration. Our sensitivity analysis allowed us to compare the results of two different approaches for testing a reciprocal relationship between two variables and found that both approaches produce similar results.

7. Conclusion

This study examined the bi-directional relationship between IPV victimization (women) and perpetration (men) and depression among women and men in rural Rwanda. Results indicate that women's experience of depression symptoms at baseline were associated with all types of IPV victimization at 24 months. Men's experience of depression symptoms at baseline were also associated with perpetration of physical, physical and/or sexual IPV, and severe physical and/or sexual IPV at 24 months. At baseline, women who experienced any type of IPV and men who perpetrated physical or physical and/or sexual IPV were more likely to report depression symptoms at 24 months. Our findings highlight the need for trauma-informed approaches for IPV prevention as well as access to proximate and affordable mental health services to reduce IPV and improve women and men's mental health.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors would like to thank the editor and the referees for valuable feedback on this paper.

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