AIDS and Behavior (2020) 24:2091–2100
https://doi.org/10.1007/s10461-019-02774-4

ORIGINAL PAPER

Pathways for HIV Prevention Behaviors Following a Home-Based Couples Intervention for Pregnant Women and Male Partners in Kenya

Abigail M. Hatcher[1,2] · Lynae Darbes[3] · Zachary Kwena[4] · Pamela L. Musoke[5] · Anna Joy Rogers[5] · George Owino[4] · Anna Helova[7,8] · Jami L. Anderson[8] · Patrick Oyaro[9] · Elizabeth A. Bukusi[4,5,6] · Janet M. Turan[7,8]

Published online: 1 January 2020

Abstract

Pregnancy is a time of heightened HIV risk, but also a phase when a couple can prioritize family health. We conducted secondary analysis of a home-based intervention in rural Kenya to explore couple-level adherence to HIV prevention behaviors. The intervention included health education, relationship-building skills, and Couples HIV Testing and Counseling. Pregnant women were randomized to the intervention (n = 64) or standard care (n = 63) along with male partners. Of 96 couples, 82 (85.0%) were followed to 3 months postpartum, when 31.0% of couples reported perfect adherence to HIV prevention. In logistic regression, intervention condition couples had three-fold higher odds of perfect adherence (AOR = 3.07, 95% CI = 1.01–9.32). A structural equation model found the intervention had moderate effects on couple communication, large effects on couple efficacy to take action around HIV, which in turn improved HIV prevention behaviors (CFI = 0.969; TLI = 0.955; RMSEA = 0.049). Strengthening couple communication and efficacy may help prevent the spread of HIV to infants or partners around the time of pregnancy.

Keywords HIV prevention · Couples · Home-based intervention · Pregnancy · Maternal child health · Kenya

Introduction

Prevention of mother-to-child transmission (PMTCT) of HIV requires multiple health behaviors by both pregnant women and their male partners. Couple relationship dynamics influence HIV prevention and treatment adherence [1], and when male partners are involved in HIV testing and antenatal care, women are more likely to accept antiretroviral treatment (ART), deliver in a health facility, and adhere to recommended care [2–4]. Yet, most antenatal HIV testing strategies have not been successful in engaging men [5, 6], making it challenging for men to become involved or for pregnant women to learn their partner's status [7]. In Kenya, while the majority of pregnant women receive HIV

✉ Abigail M. Hatcher
hatchera@globalhealth.ucsf.edu

1 Division of HIV/AIDS, Department of Medicine, University of California, 995 Potrero Avenue, Building 80, San Francisco, CA 94110, USA

2 School of Public Health, University of Witwatersrand, Johannesburg, South Africa

3 Department of Health Behavior and Biological Sciences, School of Nursing, University of Michigan, Ann Arbor, MI, USA

4 Centre for Microbiology Research, Kenya Medical Research Institute, Nairobi, Kenya

5 Department of Global Health and Obstetrics and Gynecology, University of Washington, Seattle, WA, USA

6 Department of Reproductive Health Sciences, University of California San Francisco, San Francisco, CA, USA

7 Department of Health Care Organization and Policy, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

8 Sparkman Center for Global Health, School of Public Health, University of Alabama at Birmingham, Birmingham, AL, USA

9 Research Care and Training Programme, Family AIDS Care and Educational Services, Kisumu, Kenya

testing (92%), less than 5% of male partners of pregnant women underwent HIV testing within the past year [8].

Couple-focused interventions have been found to be beneficial in a range of HIV treatment and prevention programs [9, 10]. A recent meta-analysis found that couples interventions were more effective than individually-based approaches for both HIV testing and ART uptake [11]. Couples HIV testing and counseling (CHTC), an evidence-based intervention, offers potential to engage men and women, but has been underutilized in the PMTCT context.

Men themselves desire more involvement in PMTCT and antenatal services, but are unlikely to use traditional clinic-based services [12–15]. Gender norms often limit men's ability to involve themselves in pregnancy and label antenatal clinics and health facilities as "female spaces" [7, 16, 17]. Innovative approaches that do not require men to visit health facilities could ensure that male partner involvement occurs in a safe and supportive way. Participating in home-based CHTC with partners could offer a safe, confidential environment for serostatus disclosure, combined with tailored counseling and solution-building for the couple [15].

Around the time of pregnancy, it is essential to conceptualize HIV prevention more broadly than the traditional definition of PMTCT. This is because women who initially test HIV-negative, and their male partners, often feel "safe" after the test result during antenatal care [18]. Yet, studies have identified a 3% seroconversion rate during and after pregnancy among previously HIV-negative pregnant women in sub-Saharan African settings [19, 20]. These women tend to seroconvert in late pregnancy, receive no counseling on infant feeding, have little access to PMTCT services, and have an increased risk of MTCT [19, 21, 22]. Since horizontal HIV transmission increases by more than two-fold during pregnancy, uninfected women and their male partners are at heightened risk of incident infection and, in turn, may contribute to new vertical infections among infants [19–21, 23, 24].

We conducted a randomized controlled pilot study of a three-session, home-based intervention for couples. Couples were randomized 1:1 to either control (standard of care) or intervention conditions. The intervention arm comprised couple-focused skills building, information pertaining to PMTCT and pregnancy, and the offer of home-based CHTC. Using data from pregnant women and their male partners, we sought to assess whether this home-based intervention influenced HIV prevention behaviors. We further aimed to explore pathways through which the intervention may improve HIV prevention behaviors using structural equation modeling.

Methods

Setting

This study was conducted in the Nyanza region of Kenya, an area with the highest HIV prevalence nationally (approximately 16%) [25]. Maternal mortality in the region is 669 per 100,000 live births [26], or more than four times the national target [27]. The research took place in southern part of Nyanza, in Migori County, which borders Tanzania and Lake Victoria. This setting has several characteristics that make it a priority area for interventions among pregnant women and male partners. In addition to high HIV prevalence among pregnant women (18%) and high rates of MTCT (7–10%) [28], our team's preliminary data at baseline indicated that only 50% of HIV-positive pregnant women enrolled in HIV care and treatment [29, 30].

Conceptual Framework

We adapted the Interdependence Model of Health Behavior Change (Fig. 1) to explore mechanisms through which a novel, home-based couples intervention may impact HIV-related health outcomes [31, 32]. This model proposes pathways by which couples choose to engage in positive health behavior outcomes, and accounts for several aspects of the couple context (e.g., relationship quality, communal coping). The conceptual framework posits that both partners influence each others' decisions around HIV prevention,

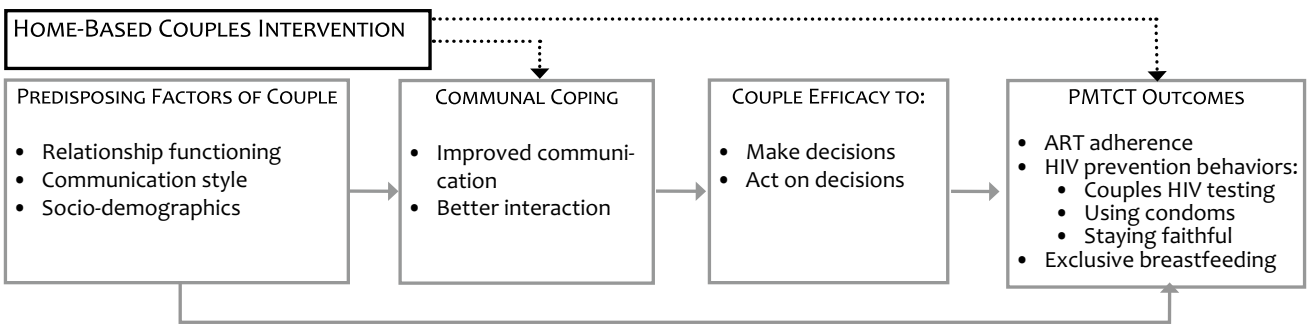

Fig. 1 Conceptual framework for home-based couples intervention based on Interdependence Model

and that this influence is determined by several relationship aspects [33]. Predisposing factors of couples include both intrinsic qualities (e.g., socio-demographic such as age, education, marital status) and traits that can be modified through intervention: relationship quality and couple communication. Communal coping results when couples create a shared vision for managing health [34]. Communal coping includes enhanced communication, joint decision making, and working together to try new behaviors. Achieving communal coping can lead to outcome efficacy, or the couple's belief that a solution can be found to the health challenge (in this case, HIV prevention behaviors around the time of pregnancy). Our qualitative work in this setting suggests that this model has relevance for understanding HIV-related decisions for pregnant couples in rural southwestern Kenya [32]. As described more fully elsewhere [35], we conducted formative research with 69 community members to refine an intervention strategy that mapped onto this conceptual framework.

Intervention

In the Jamii Bora (Kiswahili for "better family") pilot intervention, pairs of lay health workers (one man and one woman) delivered three counseling sessions via home visits. Couples received two visits during pregnancy and one visit 2 months postpartum. The lay health workers were persons with basic counseling skills who were hired locally and trained for 5 days. At each home visit, the lay health workers met with the woman and her male partner together for approximately 45 min. Key elements of the intervention included:

a. *Couple HIV Testing and Counseling (CHTC)* modules for mutual HIV serostatus disclosure, tailored prevention based on couple serostatus, and treatment strategies for discordant and concordant couples [36]. Disclosure assistance allows a couple to discuss HIV test results and strategies in a safe and supportive setting Pregnant couples are encouraged to test together, even if one or both partners have tested individually previously, given that women often engage in CHTC to facilitate partner disclosure. Couples have the opportunity to engage in CHTC at any of the couple home visits.
b. *Linkage to HIV care and adherence.* Lay health workers actively link couples to HIV prevention and treatment services, as well as other health services based at the local clinic. Couples in which one or more members are living with HIV are encouraged to take medication and to support each other's ART adherence goals.
c. *Maternal, child, and family health information* focuses on general family health promotion (e.g., benefits of health facility delivery, child immunizations during first 24 months, safe infant feeding, and family planning). This is also an opportunity for couples to ask questions about pregnancy, labor, and delivery. Lay health workers help couples develop strategies for service utilization.
d. *Couple communication exercises* create space for the pregnant woman and male partner to test out models of healthy communication and include communication skills such as active listening. Exercises give practical examples of how to communicate clearly, and ask couples to test out the approach with facilitation by lay health workers.

Data Collection

Trained researchers screened 252 pregnant women at four antenatal clinics, and identified 137 eligible for the study. To be eligible, pregnant women were 18 years of age or older, had been offered HIV testing at antenatal care, were in a stable relationship with a male partner for at least 6 months, had not yet engaged in CHTC or disclosed her HIV status to her male partner. Those women who were already aware that their male partner was living with HIV were excluded.

Male partners were the person identified by the pregnant woman as her primary partner and needed to be 18 years of age or older. We recruited HIV-negative women in roughly equal numbers to HIV-positive women each month, to ensure that these two groups were balanced over time. Pregnant women who met study inclusion criteria were asked if they would like to participate in a study about approaches for supporting pregnant couples on family health issues (including HIV). If interested, an initial informed consent process and a baseline questionnaire were administered by an interviewer of the same gender, followed by a separate consent process for the randomization.

We did not randomize women reporting severe intimate partner violence (IPV) in the past 6 months (indicated by responding yes to any one of six items on severe physical or sexual IPV measured through the WHO multi-country study instrument [37]). Instead of randomization, this sub-group was referred directly to local services (n = 10), though they were still able to take part in the study endline assessments. There is limited empirical evidence that couples-based interventions could exacerbate violence, but we opted to err on the conservative side (i.e. excluding high-risk women) since we had yet to complete safety or acceptability assessments of the home-based intervention.

Once a woman was randomized, a lay health worker gave the woman a letter for her male partner to inform him about the study and any upcoming visits. Men completed a separate informed consent followed by a baseline questionnaire. A total of 31 male partners were not enrolled in the study because they refused, had moved, were unable to be contacted, or the woman felt uncomfortable inviting them. Full

reasons for lack of participation and a study flow chart can be found in previous publications [35]. Study assessments took place during antenatal visits (less than 36 weeks gestation) and at 3 months postpartum.

For this analysis, we assessed outcomes among pregnant women whose male partners were willing to participate in the study. A total of 96 eligible women were randomized to the intervention arm (home visits) or control arm (standard care) and had male partners who consented to participate in the study and completed baseline questionnaires. Of these, 82 couples (85.0%) were followed up successfully at three months postpartum—with both women and men completing follow-up questionnaires. As published elsewhere, intervention and control arm participants were not statistically different on any baseline socio-demographics measured [35].

The control arm offered standard clinic-based services. At the time of the study, this included free antenatal care, universal HIV testing, and the option for women and partners to return to the clinic for male partner HIV testing or CHTC. The last service was offered through letters to invite male partners to the clinic, with faster access to clinic services for women who returned to the clinic with male partners (they are not required to wait in a queue).

As described above, the intervention arm consisted of three couple home visits conducted by lay health workers. Home visits were arranged after communicating with the couples beforehand to find an appropriate time for the visit. All questionnaires were completed independently by the pregnant woman and her male partner in separate private locations.

Measures. The primary outcome measure was a latent construct of HIV prevention behaviors comprised of three measured variables. The first was a composite index of horizontal HIV prevention behaviors, coded on a five-point Likert scale. Participants were asked to confidentially self-report responses to a number of items regarding HIV testing, whether they had ever tested for HIV together as a couple, and the methods used for horizontal prevention in the past year ("What are you doing to prevent HIV transmission in your relationship: using condoms, staying faithful to one partner, taking ART, other"). For horizontal HIV prevention, 0 meant that no preventive measures were taken while 4 meant that they were fully engaged in HIV prevention through both recent CHTC and using condoms. For HIV-positive participants, a second measured variable assessed ART adherence using a single item from a validated ART adherence scale [38], which ranged from 0 indicating "poor" self-reported adherence to ART to 4 for "excellent" ART adherence. Lastly, exclusive breastfeeding was measured using a dichotomous self-report of exclusive breastfeeding [1] or any mixed feeding (0).

This latent construct of HIV prevention behaviors was dichotomized as "perfect adherence" to all HIV prevention behaviors vs. any other set of behaviors for use in logistic regression. Perfect adherence was defined as both partners reporting the best adherence to ART (if applicable), engaging in all horizontal HIV prevention options, and exclusively breastfeeding (if the mother was HIV-positive).

The primary predictor for logistic regression was randomization to the home-based intervention condition. The group assignment was made at the point of enrolment in the study and recorded in the data. For structural equation modeling, the primary predictor was number of intervention sessions received (since STATA can only estimate models using continuous variables).

We measured couple communication using the positive interaction sub-scale of a communication scale [39]. This scale has been used previously among rural, sub-Saharan African couples [40], and had adequate reliability in this sample (cronbach's alpha = 0.72). In confirmatory factor analysis, the communication sub-scale items were unidimensional and the scale held together as a construct. An example item was: "During a discussion of an issue or problem, both of us suggest possible solutions and compromises," with responses ranging from 1 = very unlikely to 8 = very likely.

We measured 'couple efficacy to take action' around HIV through a modified version of the Couple Communal Coping Scale [41]. In our modified version, we adapted items to reflect PMTCT behaviors, for example: "How confident are you that you and your partner can act together to prevent HIV transmission to your children," with 1 = not at all confident and 5 = very confident. Again, the scale had adequate reliability (cronbach's alpha = 0.70) and was a unidemensional as a latent construct with strong fit characteristics.

Socio-demographics collected through questionnaires included age of both men and women (assessed individually and combined into a single covariate of age difference), number of living children, education level, and living in a polygamous relationship. Household hunger was assessed using the 3-item Household Hunger Scale which asks about going to bed hungry, lacking enough food, and going an entire day without food [42]. Wealth was measured by asking whether participants had various household items on an index (e.g. electricity, radio) and summing the responses. These socio-demographics were chosen based on previous research that suggests family composition and socio-economic status influence engagement in HIV prevention and care around the time of pregnancy [43–45]. Weeks gestation at first antenatal clinic visit was abstracted from the pregnant woman's medical records.

Questionnaires were translated and back-translated into Kiswahili and Dhuluo by trained research assistants.

They were administered by gender-matched researchers using hand-held tablet computers using the Open Data Kit software.

Data Analysis

We conducted all analyses in Stata 16 (StataCorp LLC, College Station, TX). We assessed internal consistency of all the scales by evaluating the Cronbach's alpha. We conducted bivariate analyses of the outcome variable (self-reported perfect PMTCT adherence) against the exposure variable (intervention condition) and other selected covariates. Bivariate analyses (*t* test, χ^2 test) were conducted to examine differences by HIV prevention for normally distributed variables. Nonparametric bivariate analyses (Mann–Whitney *U* test) were conducted for non-normally distributed study variables. To measure the association between the intervention condition and HIV prevention behaviors, we conducted univariate logistic regression analysis. We then adjusted for baseline socio-demographics that were theoretically important and associated with HIV prevention behaviors in univariate analysis at $p \leq 0.20$.

We next conducted Structural Equation Modeling (SEM) with maximum likelihood with missing values estimation to test pathways between the intervention, potential couple-focused mediators, and HIV prevention behaviors, based on our conceptual model. First, we used confirmatory factor analysis to determine the correct measurement model for the latent variables: couples communication and efficacy to act. We then used theory and bivariate regression data to guide preliminary model building. Model modifications were performed based on modification indices when theoretically justified. Once model fit was satisfactory, non-significant paths were trimmed. We defined significance at the $p < 0.05$ level.

The magnitude of standardized parameter estimates was assessed using Cohen's typology of small (≤ 0.10 or less), medium (0.30), and large (≥ 0.50) effect sizes [46]. Measures for model fit included a parsimonious measure (root-mean-square error of approximation (RMSEA)) and two incremental measures (Bentler's comparative fit index (CFI) and Tucker Lewis index (TLI)). Acceptable model fit assumed the model met the following criteria: RMSEA < 0.05; CFI ≥ 0.95; TLI ≥ 0.95 [47, 48].

Ethical Considerations

This study was conducted in the Migori County Kenya during the period 2014–2017 and was approved by the Institutional Review Boards of the University of Alabama at Birmingham and the Kenya Medical Research Institute. Participants provided signed informed consent in the language of their choice (Luo, English, or Swahili). Participants who reported IPV or major depression in questionnaires were provided with referrals. The study was supported by an independent Safety Monitoring Committee, composed of members from Kenyan and international organizations.

Table 1 Descriptive characteristics and bivariate associations between covariates and HIV prevention behaviors

	Total cohort	Adherent to HIV prevention behaviors		
	Median (IQR) or number (%)	Non-adherent n = 58 Mean or %	Perfectly adherent n = 26 Mean or %	p value (χ^2, Wilcoxon, or t-test)
Predisposing factors				
Age of women	23 (20–29)	25.0	24.7	0.782
Age difference between partners	7 (4–11)	8.3	8.4	0.865
Weeks gestation	26 (20–30)	25.5	23.6	0.113
Number of children	2 (1–3)	2.15	1.85	0.272
Polygamy	20 (20.8%)	24.1%	15.4%	0.366
Household hunger	13 (13.5%)	17.2%	3.8%	0.092
Wealth index items	6 (4–7)	4.4	5.6	0.005
At least primary education (both)	48 (50%)	39.7%	69.2%	0.012
Relationship mediators at baseline				
Communication	51 (49–54)	48.1	49.1	0.768
Efficacy to act	36 (34–38)	34.6	33.4	0.891

IQR inter-quartile range

Results

Sample Characteristics

The sample was comprised of 96 couples, of whom 82 couples (85%) participated in postpartum follow-up questionnaires (Table 1). Women were a median of 23 years old and male partners were an average of 7 years older than pregnant females. Prior to this pregnancy, families already had a median of 2 children. Household structure was typically married, with one in five households reporting polygamous marriage. Household hunger was rarely reported (13.5%), though other markers of household poverty were frequent, with 85% of the sample reporting cooking with firewood vs. stove. Only half of couples reported that both attended school to at least primary level.

Associations Between Predictors and HIV Behaviors

A total of 26 couples (31.0%) reported behaviors consistent with perfect HIV prevention adherence. The intervention condition was associated with a higher proportion of couples adhering to HIV prevention (69.2%) than the control condition (48.3%, p = 0.076). Non-adherent couples entered antenatal care at a later gestational stage (25.5 weeks vs. 23.6), had higher rates of household hunger (17.2% vs. 3.8%), had fewer wealth index items (median of 4.4 vs 5.6), and lower education levels (39.7% had primary education vs. 69.2%).

In multivariate analysis (Table 2, model 1), being randomized to the couples intervention was associated with a higher adjusted odds ratio (AOR) of good HIV prevention behaviors, even after controlling for weeks gestation, household hunger, wealth index, and education (AOR = 3.07, 95%CI = 1.01-9.32). In other words, couples randomized to the home-based intervention had three-fold greater odds of reporting perfect HIV prevention behaviors.

However, when couple mediators of communication and efficacy to act were included in the model (Table 2, model 2), communication fully mediated the relationship between the intervention and HIV prevention behaviors.

Structural Equation Model

The structural equation model aims to assess the impact of the intervention on the latent construct of HIV prevention behaviors while accounting for key couple relationship mediating pathways (Fig. 2, Table 3). The home-based intervention had a moderate effect on couple communication (standardized beta [*b*] = 0.22). Communication, in turn, had a large effect on couple efficacy to take action around HIV (*b* = 0.64). Couple efficacy to take action then had a moderate effect on HIV prevention behaviors (*b* = 0.33). There was no direct effect of intervention sessions on HIV prevention behaviors. Instead, the pathway of communication and couple efficacy seemed to predict the intervention's full influence on HIV prevention behaviors. The model controls for household hunger and education,

Table 2 Associations between intervention, couples mediators, and adherence to HIV prevention

	Model 1[a] Adjusted OR (95% CI)	p value	Model 2[a] Adjusted OR (95% CI)	p value
Couples intervention	3.07 (1.01 to 9.32)	0.048	2.25 (0.71 to 7.11)	0.170
Communication	–		1.29 (1.00 to 1.68)	0.049
Efficacy to act	–		1.04 (0.88 to 1.22)	0.72

OR odds ratio; *CI* confidence interval

[a]Adjusts for weeks gestation, education, household hunger, and wealth index

Table 3 Structural equation model measurement

	Standardized coef.	(95% Conf.		Interval)	P > |z|
HIV prevention behaviors ⇦					
Efficacy to act	0.33	0.02	–	0.64	0.036
Hunger	− 0.11	− 0.22	–	− 0.02	0.014
Education	0.04	0.01	–	0.08	0.023
Efficacy to act ⇦					
Communication	0.64	0.35	–	0.92	0.000
Communication ⇦					
Intervention sessions	0.22	0.03	–	0.42	0.024

Goodness of model fit Chi square = 176 (df = 143) p = 0.03; CFI = 0.969; TLI = 0.955 RMSEA = 0.049 (90% CI 0.015–0.072)

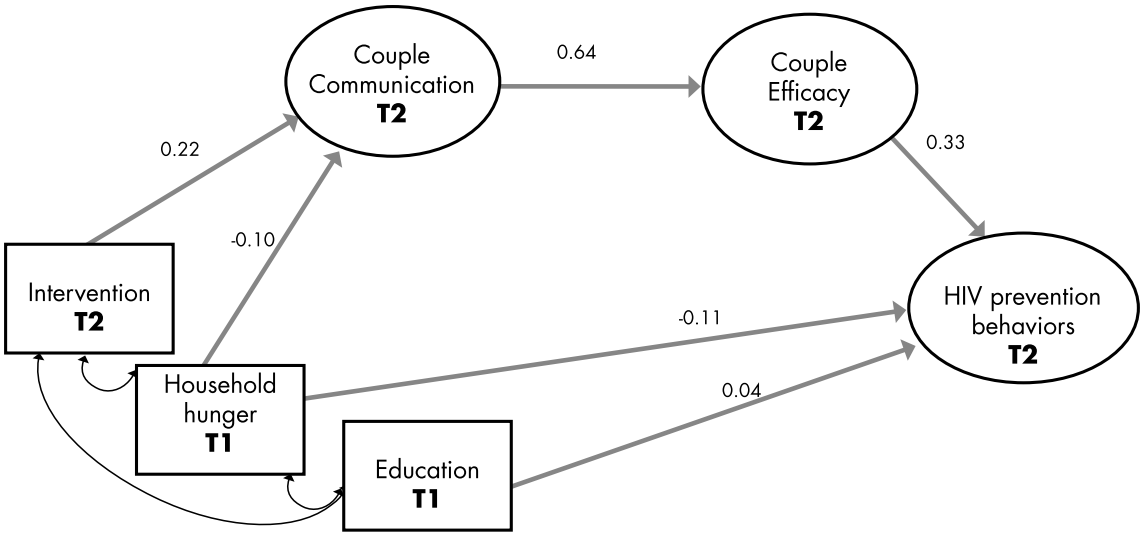

Fig. 2 Structural equation model of the relationship between intervention, couples moderators, and HIV prevention behaviors (n = 96 couples). Relationships represented by standardized parameter estimates, with boxes indicating measured variables and oval representing latent variable. All solid line relationships signifi cant at the $p < 0.05$ level. T1 = baseline, T2 = endline. Goodness of model fit Chi square = 176 (df = 143) p = 0.03; CFI = 0.969; TLI = 0.955 RMSEA = 0.049 (90% CI 0.015–0.072)

with both had small, but significant, effects on HIV prevention behaviors ($b = -0.11$ and 0.04, respectively). The model fit for these data was strong (CFI = 0.969; TLI = 0.955; RMSEA = 0.049 (90% CI 0.015 –0.072)).

Discussion

We learned that a home-based couples intervention implemented in a rural area improved couple relationship dynamics and impacted positively on HIV prevention behaviors. In a structural equation model controlling for education and household hunger, access to more intervention sessions led to improved couple communication and efficacy to take action around HIV. These couple dynamics, in turn, influenced better use of HIV preventive behaviors. Only 31% of couples self-reported implementing all available HIV preventive behaviors at follow-up 3 months postpartum. In multivariate analysis, the Jamii Bora intervention was associated with three-fold higher odds of couples reporting perfect adherence to these behaviors.

These findings suggest that home-based interventions hold promise for working with couples around the time of pregnancy to prevent vertical and horizontal HIV transmission. These data add to a growing literature of working with couples for HIV-related health. Another Kenyan study reported a two-fold increase in male partner HIV testing among those taking part in a home-based couples testing intervention [49]. Similarly, a couples-based intervention conducted in rural KwaZulu-Natal, South Africa significantly increased participation in CHTC, among a sample with low rates of ever testing for HIV in a high prevalence area [50]. Jamii Bora extends this work by using a home-based approach to target both HIV-negative and HIV-positive couples around the time of pregnancy. This is important given that all types of couples may benefit from assistance in order to practice the most effective HIV prevention behaviors that are appropriate for them.

New ways to assess couples health, regardless of their HIV status, are essential for HIV prevention [51] and may add value for the maternal and child health fields. Our use of a latent construct of HIV prevention behaviors (which can apply to HIV-positive, HIV-negative, or sero-discordant couples) is novel and may offer insights for future research. Recent literature and WHO guidance have called for a renewed emphasis on couples to enhance HIV prevention efforts [52–54], but to date few couple interventions have targeted pregnant women and male partners in low resource settings [55, 56].

Our findings contribute to a better understanding of mechanisms by which interventions may improve HIV prevention behaviors in couples. We learned that couple communication increased efficacy to act together around HIV. In turn, couple efficacy influenced HIV prevention behaviors. This finding reflects back to Lewis et al. model for interdependence theory, which posits that couples who cope better together will have greater ability to take joint action around health challenges [31]. This aligns with our team's qualitative findings that home-based couples visits can aid the couple in developing efficacy to engage in key health services for maximum impact on the entire family [32].

There are several limitations of these analyses. The relatively small sample size requires additional research in a larger cohort. The sample size precluded inclusion of key relationships covariates in the analysis, since all but three couples were married, and we did not assess relationship duration. The fact that this study was conducted in a rural area where couples may be more likely to be found at home is a limitation, since results may not apply to urban settings where finding a man at home during the day may be more challenging. Omission of couples for whom the man was never invited or where severe IPV took place may bias the results towards a greater proportion of couples with supportive relationship dynamics.

Self-reported HIV prevention measures are weaker than biomarkers or other measures, like clinic records. The latent construct for HIV prevention behaviors has not been used previously, and should be validated in larger samples. This is the first sub-Saharan African study to use the Couple Communal Coping Scale. While the internal consistency of this measure was strong, it is possible that coping takes distinct forms in heterosexual Kenyan relationships compared to the US setting where the measure was developed. More work could be done to validate these measures and ensure translation and response items align with local understanding of communication and efficacy. As the study only assessed couples at two time-points, directionality of the pathways cannot be assumed. We tested the structural equation model with reversed arrows (i.e. HIV behaviors leading to communication and efficacy, or communication and efficacy leading to increased exposure to intervention sessions) and these models did not converge. Nevertheless, future longitudinal studies with three or more timepoints are needed to lend causal arguments to these preliminary findings.

Conclusion

A home-based couples intervention had significant effects on use of HIV prevention behaviors by HIV-positive and HIV-negative couples. Primary pathways for intervention effect on HIV prevention behaviors were couple communication and efficacy to take action around HIV. If we are to halt the spread of HIV within heterosexual couples in sub-Saharan Africa, couples-based approaches are essential. Home-based couples strategies around the time of pregnancy may offer important benefits for the health of infants and their parents.

Acknowledgements The authors thank the dedicated staff of FACES who contributed their time and logistical support to this project. The authors acknowledge the important role of the KEMRI-UCSF Collaborative group, the Director of KEMRI, the Director of KEMRI's Centre for Microbiology, and the Nyanza Provincial Ministries for their support in conducting this research. The research described in this manuscript was supported by the U.S. National Institute of Mental Health (NIMH), though Grant R34MH102103. This work was also supported in part by the University of Alabama at Birmingham Center for AIDS Research (P30 AI027767). The content is solely the responsibility of the authors and does not necessarily represent the official views of the U.S. National Institutes of Health.

References

1. Ware NC, Wyatt MA, Haberer JE, Baeten JM, Kintu A, Psaros C, et al. What's love got to do with it? Explaining adherence to oral antiretroviral pre-exposure prophylaxis for HIV-serodiscordant couples. J Acquir Immune Defic Syndr. 2012;59(5):463–8.
2. Besada D, Rohde S, Goga A, Raphaely N, Daviaud E, Ramokolo V, et al. Strategies to improve male involvement in PMTCT Option B + in four African countries: a qualitative rapid appraisal. Glob Health Action. 2016;9(1):33507.
3. Ezeanolue E, Obiefune M, Yang W, Ezeanolue C, Pharr J, Osuji A, et al. What do you need to get male partners of pregnant women tested for HIV in reourse limited settings? The baby shower cluster randomized trial. AIDS Behavior. 2017;21(2):587–96.
4. Yargawa J, Leonardi-Bee J. Male involvment and maternal heatlh outcomes: systematic review and meta-analysis. J Epidemiol Community Health. 2015;69(6):604–12.
5. Yende N, Rie AV, West N, Bassett J, Schwartz S. Acceptability and preferences among men and women for male involvement in antenatal care. J Pregnancy. 2017;2017:4758017.
6. Brusamento S, Ghanotakis E, Car LT, van Velthoven M, Majeed A, Car J. Male involvement for increasing the effectiveness of prevention of mother-to-child HIV transmission (PMTCT) programmes. Cochrane Database Syst Rev. 2012;10:CD009468.
7. Theuring S, Jefferys L, Nchimbi P, Mbezi P, Sewangi J. Increasing partner attendance in antenatal care and HIV testing services: comparable outcomes using written versus verbal invitations in an urban facility-based controlled intervetnion trial in Mbeya, Tanzania. PLoS ONE. 2016;11(4):e0152734.
8. UNAIDS. Kenya AIDS response progress report. Available at: http://www.unaids.org/sites/default/files/country/documents/KEN_narrative_report_2014.pdf. 2014; Accessed April 1, 2017.
9. El-Bassel N, Remien RH. Couple-based HIV prevention and treatment: state of science, gaps, and future directions. Family and HIV/AIDS: Springer; 2012. p. 153–72.
10. Medley A, Baggaley R, Bachanas P, Cohen M, Shaffer N, Lo YR. Maximizing the impact of HIV prevention efforts: interventions for couples. AIDS Care. 2013;25:1569–80.
11. Crepaz N, Tungol-Ashmon MV, Vosburgh HW, Baack BN, Mullins MM. Are couple-based interventions more effective than interventions delivered to individuals in promoting HIV protective behaviors? A meta-analysis. AIDS Care. 2015;27(11):1361–6.
12. Koo K, Makin J, Forsyth B. Where are the men? Targeting male partners in preventing mother-to-child HIV transmission. AIDS Care. 2013;25(1):43–8.
13. Manjate Cuco R, Munguambe K, Bique Osman N, Degomme O, Temmerman M, Sidat M. Male partners' involvement in prevention of mother-to-child HIV transmission in sub-Saharan Africa: a systematic review. SAHARA J. 2015;12:87–105.
14. Musoke P, Hatcher A, Rogers AJ, Achiro L, Bukusi E, Darbes L, et al. Men's hopes, fears and challenges in engagement in perinatal health and the prevention of mother-to-child transmission of HIV in rural Kenya. Cult, Health Sex. 2018;10:1–14.
15. Walcott M, Hatcher A, Kwena Z, Turan J. Facilitating HIV status disclosure for pregnant women and partners in rural Kenya: a qualitative study. BMC Public Health. 2013;13(1):1115.

16. Jefferys L, Nchimbi P, Mbezi P, Sewangi J, Theuring S. Official invitation letters to promote male partner attendance and couple voluntary HIV counseling and testing in antenatal care: an implementation study in Mbeya Region, Tanzania. Reprod Health. 2015;12:95.
17. Morfaw F, Mbuagbaw L, Thabane L, Rodrigues C, Wunderlich A, Nana P, et al. Male involvement in prevention programs of mother to child transmission of HIV: a systematic review to identify barriers and facilitators. Syst Rev. 2013;2:5.
18. Rujumba J, Neema S, Byamugisha R, Tylleskar T, Tumwine J, Heggenhougen H. "Telling my husband I have HIV is too heavy to come out of my mouth": pregnant women's disclosure experiences and support needs following antenatal HIV testing in eastern Uganda. J Int AIDS Soc. 2012;15(2):17429.
19. Nyoyoko N, Umoh A. The prevalence and determinants of HIV seroconversion among booked ante-natal clients in the University of Uyo teaching hospital, Uyo Akwa Ibom State, Nigeria. Pan Afr Med J. 2016;25:247.
20. Dinh T, Delaney K, Goga A, Jackson D, Lombard C, Woldesenbet S, et al. Impact of maternal HIV seroconversion during pregnancy on early mother to child transmission of HIV (MTCT) measured at 4–8 weeks postpartum in South Africa 2011–2012: a national population-based evaluation. PLoS ONE. 2015;10(5):e0125525.
21. Lawi J, Mirambo M, Magoma M, Mushi M, Jaka H, Gumodoka B, et al. Sero-conversion rate of Syphilis and HIV among pregnant women attending antenatal clnic in Tanzania: a need for re-screening at delivery. BMC Pregnancy Childbirth. 2015;15:3.
22. Rogers A, Weke E, Kwena Z, Bukusi E, Oyaro P, Cohen C, et al. Implementation of repeat HIV testing during pregnancy in Kenya: a qualitative study. BMC Pregnancy Childbirth. 2016;16:151.
23. Johnson L, Stinson K, Newell M, Bland R, Moultrie H, Davies M, et al. The contribution of maternal HIV seroconversion during late pregnancy and breastfeeding to mother-to-child transmission of HIV. J Acquir Immun Defic Syndr. 2012;59(4):417–25.
24. Kinuthia J, Kiarie J, Farquhar C, Richardson B, Nduati R, Mbori-Ngacha D, et al. Cofactors for HIV-1 incidence during pregnancy and postpartum period. Curr HIV Res. 2010;8(7):510–4.
25. Kimanga DO, Ogola S, Umuro M. Prevalence and incidence of HIV infection, trends, and risk factors among persons aged 15–64 years in Kenya: results from a nationally representative study. J Acquir Immun Defic Syndr. 1999;2014(66(Suppl 1)):S13.
26. Desai M, Phillips-Howard PA, Odhiambo FO, Katana A, Ouma P, Hamel MJ, et al. An analysis of pregnancy-related mortality in the KEMRI/CDC health and demographic surveillance system in Western Kenya. PLoS ONE. 2013;8(7):e68733.
27. Ministry of Public Health and Sanitation, Ministry of Medical Services. National Reproductive Health Strategy, 2009–2015. Nairobi: Republic of Kenya; 2009.
28. FACES. FACES—Family AIDS care and educational service AIDS research institute at UCSF, the Bixby center for global reproductive health, and the Kenya medical research institute 2012. Available from: http://www.faces-kenya.org.
29. Turan JM, Onono M, Cohen CR, Bukusi EA. Stigma and lack of disclosure as barriers to use of maternity and HIV services by HIV-positive pregnant women in rural Kenya: APHA 140th Annual Meeting, October 27–31, 2012; Oct 27–31, 2012; San Francisco, CA, USA.
30. Turan JM, Bukusi EA, Onono M, Steinfeld R, Washington S, Shade S, et al. Effects of antenatal care-HIV service integration on the prevention of mother-to-child transmission cascade: results from a cluster-randomized controlled trial in Kenya: integration for impact: reproductive health & HIV services in sub-Saharan Africa; September 12–14, 2012; Nairobi, Kenya, September 12–14, 2012.
31. Lewis MA, McBride CM, Pollak KI, Puleo E, Butterfield RM, Emmons KM. Understanding health behavior change among couples: an interdependence and communal coping approach. Soc Sci Med. 2006;62(6):1369–80.
32. Rogers AJ, Achiro L, Bukusi EA, Hatcher AM, Kwena Z, Musoke PL, et al. Couple interdependence impacts HIV-related health behaviours among pregnant couples in southwestern Kenya: a qualitative analysis. J Int AIDS Soc. 2016;19(1):21224.
33. Kelley HH, Thibaut JW. Interpersonal relations: a theory of interdependence. New York: Wiley; 1978.
34. Lyons RF, Mickelson KD, Sullivan MJL, Coyne JC. Coping as a communal process. J Soc Pers Relationsh. 1998;15(5):579–605.
35. Turan JM, Darbes LA, Musoke PL, Kwena Z, Rogers AJ, Hatcher AM, et al. Development and piloting of a home-based couples intervention during pregnancy and postpartum in Southwestern Kenya. AIDS Pat Care STDS. 2018;32(3):92–103.
36. Centers for Disease Control and Prevention: couples HIV counseling and testing intervention and curriculum. Atlanta, GA: centers for disease control and prevention, national center for STD HIV viral hepatitis and TB prevention, global AIDS program; 2007.
37. Garcia-Moreno C, Jansen HA, Ellsberg M, Heise L, Watts CH. Prevalence of intimate partner violence: findings from the WHO multi-country study on women's health and domestic violence. Lancet. 2006;368(9543):1260–9.
38. Wilson IB, Fowler FJ Jr, Cosenza CA, Michaud J, Bentkover J, Rana A, et al. Cognitive and field testing of a new set of medication adherence self-report items for HIV care. AIDS Behav. 2014;18(12):2349–58.
39. Futris TG, Campbell K, Nielsen RB, Burwell SR. The communication patterns questionnaire-short form: a review and assessment. Fam J. 2010;18(3):275–87.
40. Darbes LA, McGrath NM, Hosegood V, Johnson MO, Fritz K, Ngubane T, et al. Results of a couples-based randomized controlled trial aimed to increase testing for HIV. J Acquir Immun Defic Syndr. 2019;80(4):404–13.
41. Salazar LF, Stephenson RB, Sullivan PS, Tarver R. Development and validation of HIV-related dyadic measures for men who have sex with men. J Sex Res. 2013;50(2):164–77.
42. Deitchler M, Ballard T, Swindale A, Coates J. Validation of a measure of household hunger for cross-cultural use. Washington, DC: Food and Nurtrition Technical Assistance II Project (FANTA-2), Acedemy for Educational Development. 2010.
43. Awiti Ujiji O, Ekstrom AM, Ilako F, Indalo D, Wamalwa D, Rubenson B. Reasoning and deciding PMTCT-adherence during pregnancy among women living with HIV in Kenya. Cult Health Sex. 2011;13(7):829–40.
44. Kirsten I, Sewangi J, Kunz A, Dugange F, Ziske J, Jordan-Harder B, et al. Adherence to combination prophylaxis for prevention of mother-to-child-transmission of HIV in Tanzania. PLoS ONE. 2011;6(6):e21020.
45. Ayuo P, Musick B, Liu H, Braitstein P, Nyandiko W, Otieno-Nyunya B, et al. Frequency and factors associated with adherence to and completion of combination antiretroviral therapy for prevention of mother to child transmission in western Kenya. J Int AIDS Soc. 2013;16:17994.
46. Cohen J. Statistical power analysis for the behavioral sciences (revised ed.). New York: Academic Press; 1977.
47. Bentler PM. Comparative fit indexes in structural models. Psychol Bull. 1990;107(2):238.
48. Steiger JH. Structural model evaluation and modification: an interval estimation approach. Multivar Behav Res. 1990;25(2):173–80.
49. Krakowiak D, Kinuthia J, Osoti AO, Asila V, Gone MA, Mark J, et al. Home-based HIV testing among pregnant couples increases partner testing and identification of serodiscordant

partnerships. J Acquir Immune Defic Syndr. 2016;72(Suppl 2):S167–73.
50. Darbes LA, McGrath NM, Hosegood V, Johnson MO, Fritz K, Ngubane T, et al. Uthando Lwethu: results of a randomized controlled trial of a couples-based intervention to increase testing for HIV in rural KwaZulu-Natal, South Africa. Trials. 2014;15:64.
51. Gamarel KE, Chakravarty D, Neilands TB, Hoff CC, Lykens J, Darbes LA. Composite risk for HIV: a new approach towards integrating biomedical and behavioral strategies in couples-based HIV prevention research. AIDS Behav. 2019;23(1):283–8.
52. Montgomery CM, Watts C, Pool R. HIV and dyadic intervention: an interdependence and communal coping analysis. PLoS ONE. 2012;7(7):e40661.
53. Villar-Loubet OM, Bruscantini L, Shikwane ME, Weiss S, Peltzer K, Jones DL. HIV disclosure, sexual negotiation and male involvement in prevention-of-mother-to-child-transmission in South Africa. Cult Health Sex. 2012;15:253–68.
54. World Health Organization. Guidance on couples hiv testing and counselling including antiretroviral therapy for treatment and prevention in serodiscordant couples. Geneva: WHO; 2012.
55. Orne-Gliemann J, Balestre E, Darak S, Tchendjou PT, Miric M, Butsashvili M, et al. Couple communication about the prevention of sexual risks: the role of a prenatal HIV counselling intervention—Prenahtest ANRS 12127 trial. XIX International AIDS Conference; Washington, DC July 22-27, 2012.
56. Takah N, Kennedy I, Johnman C. The impact of approaches in improving male partner involvement in the Prevention of Mother-to-child Transmission of HIV on the uptake of maternal antiretroviral therapy among HIV seropositive pregnant women in sub Saharan Africa: a systematic review and meta-analysis. BMJ open. 2017:epub ahead of print.