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Complex Solutions for a Complex Problem: A Meta-Analysis of the Efficacy of Multiple-Behavior Interventions on Change in Outcomes Related to HIV

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Abstract

Objective: The purpose of this meta-analysis was to examine the success of multiple-behavior interventions and to identify whether the efficacy of such programs depends on the number of recommendations prescribed and the type of outcomes measured.

Methods: We conducted a synthesis of 136 research reports (N = 59,330) using a robust variance estimate model (Tanner-Smith et al., 2016) to study change between baseline and the first follow-up across multiple-behavior interventions, single-behavior interventions, and passive controls.

Results: Multiple-behavior interventions were more efficacious than their single-behavior counterparts (multiple-behaviors: d = 0.44 [95% CI = 0.27, 0.60]; single-behavior: d = 0.21 [95% CI = 0.00, 0.43]), with efficacy varying based on the type of outcomes measured. Publication bias analysis revealed a small asymmetry but controlling for it did not eliminate these effects. There was a strong linear relation between the number of recommendations prescribed by an intervention and intervention efficacy (B = 0.07, SE = 0.01, p < .001), with strongest improvements observed for interventions making five or more recommendations. These patterns remained when controlling for other intervention and population characteristics.

Conclusions: Multiple-behavior interventions are successful in the HIV domain and increasing the number of recommendations made in the intervention generally maximizes improvements. These findings provide insights that may guide the design and implementation of integrated interventions.

Keywords

HIV; multiple-behavior intervention; integrated intervention; multi-domain; prevention

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According to syndemics theory, HIV does not occur in isolation but, rather, interacts with complex factors that jointly affect health outcomes (Singer et al., 2006). HIV can therefore be characterized as a consequence of other prevalent problems, such as unsafe sexual practices, substance use, mental health, and adverse social conditions that interact with one another and contribute to HIV transmission (e.g., Kalichman et al., 2007; Robinson et al., 2016; van den Berg et al., 2017). An integrative intervention approach, such as the use of interventions targeting change in multiple behaviors, is thus required to properly address HIV. This meta-analysis synthesizes the available literature on multiple-behavior interventions in the area of HIV to ascertain whether such integrated approaches live up to their promise and identify their optimal implementation.

Ideal Number of Recommendations

Multiple-behavior intervention models, which we define as programs that target change in two or more behaviors in either a simultaneous or sequential manner (Prochaska et al., 2008), have been implemented with the notion that these types of interventions are necessary to adequately tackle the complexity of HIV (Prochaska et al., 2008; Rotheram-Borus et al., 2009). Although all multiple-behavior interventions target more than one behavior, addressing prevention, testing, and/or treatment together, they often vary in terms of how many recommendations they prescribe. A critical implementation question thus concerns the optimal number of recommendations and involves understanding the shape of the relation between recommendation number and actual gains obtained from the intervention. On the one hand, interventions may be more relevant to potential recipients when they include more recommendations, as this provides at least some that appear useful to each recipient (Brehm & Self, 1989). On the other hand, a higher number of recommendations may make the overall goal of the intervention seem unattainable, resulting in reduced effort or disengagement (Albarracín et al., 2018; Brehm & Self, 1989). The two linear associations of opposite direction, however, can combine to produce an inverted U relation between recommendation number and intervention efficacy, suggesting that number of recommendations may need to be high enough to motivate individuals to attain their goals while being low enough to prevent disengagement.

A meta-analysis conducted by Wilson and colleagues (2015) addressed this very question by summarizing the results of interventions in the domains of diet, exercise, and smoking. Their results revealed that the most efficacious interventions were those that made a moderate (two to three) number of recommendations, relative to those that made a single recommendation and those that made four or more. Although these results are important, it is unclear whether similar models will apply to HIV-related interventions. It is thus necessary to examine the efficacy of multiple-behavior interventions and particularly, the ideal recommendation number, in the HIV domain.

Variability in Outcomes Measured

Interventions in the HIV domain not only measure outcomes concerning HIV-behaviors but also measure outcomes related to sexual risk, substance use, psychosocial health, as well as testing and treatment more generally. Although these outcomes are often correlated

with each other, there is some evidence to suggest that the efficacy of multiple-behavior interventions varies as a function of outcome type (Crepaz et al., 2015). For instance, a meta-analytic review of 15 randomized controlled trials found that multiple-behavior interventions, which simultaneously targeted at least two behaviors related to transmission risk, care management, or medication adherence, significantly reduced unprotected sexual intercourse, but only led to statistically marginal improvements in outcomes related to medication adherence and undetectable viral loads (Crepaz et al., 2015). To better understand the efficacy of multiple-behavior interventions in the HIV domain, it is thus crucial to consider variability in the outcomes they measure.

The Present Meta-Analysis

Health promotion among people living with, or at risk for, HIV often necessitates targeting outcomes, including those related to risk reduction (separating sexual and substance-related risks), testing, treatment, and psychosocial health. Although such multiple-behavior interventions have gained prominence due to the potential for greater efficacy, improved patient satisfaction, and reductions in cost (Soto et al., 2004), questions regarding their efficacy remain. Particularly, although prior reviews suggest that promoting change in multiple behaviors is more effective than targeting a single behavior, this literature has not entertained the fundamental question of how many recommendations we can implement without overwhelming recipients or making the intervention impractical, whether there is distinct variability in the efficacy of interventions across different outcomes, and what the mechanisms are that are driving this effect. In this meta-analysis, we therefore reviewed 136 research reports summarizing the outcomes of interventions targeting change in HIV-specific behaviors related to sexual risk reduction, substance-related risk reduction, testing, treatment, and psychosocial health outcomes to answer these questions.

Methods

Literature Search

We conducted a computerized search of MEDLINE, PsychInfo, and EBSCO for reports published in English (see Appendix A for the list of keywords used). All reports published by August 2019 were considered. To supplement the database search, we searched for conference titles, emailed the most published authors in our database to request for their published and unpublished works, and examined the reference list of prior meta-analytic reviews and reports to identify other possible reports for inclusion.

Inclusion Criteria

Once our search was complete, we used the following criteria to determine the inclusion and exclusion of reports from our meta-analysis. This resulted in the inclusion of 136 reports (see Appendix B for the PRISMA chart; see Appendix C for the list of included reports).

1. Reports had to provide a description of the target intervention, so that it was possible to determine the number of distinct recommendations made by each intervention to promote healthy behavior. Reports that that did not provide a clear enough description to code for recommendation number were excluded.

2. Reports had to measure at least one behavioral or one clinical outcome. These included outcomes related to risk reduction (separated by sexual risk and substance-related risk), testing, treatment, and general psychosocial health outcomes. Reports that only measured factors, such as attitudes, self-efficacy, or intentions, were excluded.

3. Reports had to provide enough statistical information to calculate effect sizes representing change over time. Thus, reports had to include outcome values at both baseline and, at least, one follow-up. Reports that only provided information for one time point were excluded.

Coding Number of Recommendations

Recommendations were the distinct suggestions made by an intervention to promote healthy behavior. Similar to the coding procedure used by Wilson and colleagues (2015), we coded the number of recommendations made by each intervention by summing the total number of main and auxiliary suggestions described. Main recommendations were those that furthered the primary goals of the intervention, whereas auxiliary recommendations were those that helped participants achieve the primary goals of the intervention. For example, one of the intervention arms included in Go and colleagues (2015) was coded as presenting five recommendations because participants were encouraged to (a) reduce their sexual risk behaviors and (b) reduce their injection drug use, while also (c) looking for social support, (d) disclosing their HIV status, and (e) asking their partner to get tested. Among these recommendations, the first two were considered main recommendations, because they directly targeted behaviors related to sexual and substance-related risk, which were the primary focus of the intervention. The other three were coded as auxiliary recommendations because they were introduced to help participants achieve the primary goal of reducing risky behaviors. As passive controls represented no-intervention or waitlist groups, these were coded as having zero recommendations.[1,2]

Coding Outcome Measures

We also extracted effect sizes for HIV-specific outcomes related to risk reduction (separated by sexual risk and substance-related risk), testing, treatment, and psychosocial health (see Appendix D). Examples of outcomes related to sexual risk included measures of whether the participant had engaged in risky sexual behaviors, including not using a condom during sexual intercourse and having multiple sexual partners. Examples of outcomes related to substance-related risk included measures of the amount of alcohol or drug used in a specified period of time, as well as measures of the frequency with which syringes (or other equipment) were shared. Examples of outcomes related to testing included measures of whether participants were tested for HIV or an STI. Examples of outcomes related to treatment included measures of whether participants received treatment for HIV, STIs, or substance-related problems, as well as measures of their adherence to medications and

[1]Recommendation number was coded based on the level of granularity described in the research report. A description of “reducing sexual risk” in a report counted as one recommendation, whereas a description of “using condoms” and “reducing the number of sexual partners” counted as two.

[2]Overall, our focus was on the number of recommendations rather than the designation of conditions as interventions or comparisons.

changes in their biomedical indices related to anti-retroviral treatment. Finally, examples of outcomes related to psychosocial health included measures of gender violence, mental health, and quality of life.

Coding Exploratory Study Characteristics

Relevant characteristics of the reports, as well as demographic and participant characteristics, and features of the intervention, were coded for by two independent raters (see Appendix E). Intercoder coefficients (kappas for categorical variables and simple correlations for continuous variables) were high (see Appendix F). Disagreements between coders were resolved by discussion, further examination of the reports, and consultation with a third coder.

Data Analytic Plan

Our synthesis involved measuring change in outcomes between baseline and the first follow-up in experimental and control groups separately. Effect sizes were calculated from means, proportions, and exact reports of t tests, F ratios, and p values (see Appendix G). For all effect sizes, we implemented Hedges and Olkin's (1985) correction for small sample size bias. For ease of interpretation, effect sizes were calculated so that positive scores represented health improvements (e.g., increase in treatment adherence, decrease in drug use) in all cases. For reports that included multiple outcomes or multiple measurements for one outcome, we kept all the effect sizes in the final analyses and used the robust variance estimate to deal with the dependency among correlated effect sizes obtained from the same study (Tanner-Smith et al., 2016). Given the variability in the methodology and sample characteristics of the reports included in this meta-analysis ($I^2 = 0.9841$), we obtained random-effect models for all cases.

Results

Description of Sample

We included 136 reports ($N = 59{,}330$), with 2 providing one group, 119 providing two groups, 9 providing three groups, 4 providing four groups, and 2 providing five groups. This included 205 intervention groups recommending multiple behaviors, 38 intervention groups recommending a single behavior, and 50 no-intervention control groups. The full dataset thus included 293 groups, providing a total of 610 effect sizes (see Appendix C for details about the reports included in this meta-analysis).

Ninety-nine percent of the reports included in this meta-analysis were published in journals and, on average, in North America in 2009. The sample included both males (58%) and females (41%) in their early thirties. Fifty-seven percent of participants were gay or bisexual, 36% were of African descent, and 40% completed high school. Interventions often targeted a specific population, either based on gender (42%), ethnicity (18%), or vulnerability (e.g., HIV-positive, 18%; intravenous drug user, 6%), with 82% of participants engaging voluntarily. Thirty-eight percent of interventions recruited participants from a hospital or clinic, 84% made use of random assignment procedures (at either the individual- or group-level), 38% were conducted at a health clinic, 79% were presented face-to-face,

36% used an individual delivery format, 20% used a public health educator, and 24% were described as culturally appropriate. On average, the time between intervention and post-test was 21.56 days (see Appendix F for a summary of the report, demographic, intervention, and participant characteristics).

Average Intervention Effect Size

We first obtained a weighted-mean average of overall change and examined the variability across all our effect sizes, including those from intervention groups recommending multiple behaviors, those from intervention groups recommending a single behavior, and those from control groups. Overall, the average affect size was $d = 0.35$ ($CI = [0.27, 0.42]$, $p < .001$, $k = 293$, $I^2 = 0.9841$), a small-to-medium effect.[3] For interventions recommending multiple behaviors, the average effect size was $d = 0.44$ ($CI = [0.27, 0.60]$, $p < .001$, $k = 205$). For interventions recommending a single behavior, the average effect size was $d = 0.21$ ($CI = [0.00, 0.43]$, $p = .22$, $k = 38$). Finally, for no-intervention control groups, the average effect size was $d = 0.08$ [$CI = [-0.06, 0.22]$, $p = .28$, $k = 50$). These results provide preliminary evidence to suggest that multiple-behavior interventions are more efficacious than their single behavior counterparts.

Analyses of Inclusion/Publication Bias

We addressed inclusion/publication bias in several ways. We first estimated potential biases in our sample by examining the funnel plot of effect sizes against the standard error. If the distribution of effect sizes is unbiased, the plot resembles a funnel, with effect sizes centered around the mean, and studies with smaller sample sizes displaying greater variability (Sterne et al., 2005). A visual inspection of the funnel plot of effect sizes included in this meta-analysis (see Appendix H) revealed a slight asymmetry, with studies missing on the left side. To empirically evaluate this bias in our data, our second step was to conduct Begg and Mazumdar's rank correlation test (Begg & Mazumdar, 1994). For the set of reports included in this meta-analysis, Begg and Mazumdar's rank correlation was 0.12 ($p < .001$), indicating evidence of bias. As Begg and Mazumdar's rank correlation test has been shown to have low power when the sample of studies included is small or the bias is not severe (Ruzni & Idris, 2012; Sterne et al., 2000), we supplemented this analysis by conducting Egger's regression (Egger et al., 1997). For the reports included in this meta-analysis, Egger's intercept was 6.68 ($p < .001$), suggesting an asymmetry in the distribution of effect sizes.

Given the existing criticism that the above methods lack a statistical model and proper evaluation (McShane et al., 2016), we finally applied selection methods to further assess and adjust for publication bias. Selection methods assume that the probability of publication depends on the *p*-value of an effect size. Different *p*-values have different probabilities of getting published and, thus, included in meta-analyses (Vevea & Woods, 2005). Given that our dataset included both negative and positive effects, we ran a two-tailed sensitivity analysis. Assuming a moderate two-tailed selection bias, the adjusted effect dropped to 0.30, which represents an attenuation of the estimate by about 14% of the original value.

[3]According to Cohen's tradition (Cohen, 1992; Chen et al., 2010), $d = 0.2$ is considered a small effect, $d = 0.5$ is considered a moderate effect, and $d = 0.8$ is considered a large effect. Therefore, the effect we found in the current meta-analysis is a small-to-medium effect.

This sensitivity analysis indicates some bias, but this should have very little impact on our estimated effect sizes.[4]

Testing for the Ideal Number of Recommendations

We next examined intervention efficacy as a function of recommendation number, including mean-centered linear and quadratic terms in the model. These analyses included all recommendations as well as only the main recommendation/s in an intervention (see Appendix I). When considering all recommendations, the linear term was significant (B = 0.07, SE = 0.01, p < .001) but the quadratic term was not (B = −0.01, SE = 0.01, p = .32). We reran this model including only main recommendations to find a similar pattern of results (linear: B = 0.11, SE = 0.03, p < .001; quadratic: B = −0.02, SE = 0.01, p = .11). To better illustrate this effect, we also calculated the weighted-mean average of overall change for each recommendation number (see Appendix J). Due to small sample sizes, interventions recommending 6 to 14 recommendations were grouped together. These results show that the average effect size of interventions increased gradually with recommendation number, with interventions providing five or more recommendations producing the most change over time. This pattern is offered for descriptive purposes but does support a positive linear relation, with intervention efficacy improving along with the number of recommendations prescribed.

Intervention Efficacy for Different Outcomes

We also explored whether interventions were differentially efficacious across outcomes. We analyzed the sample of multiple- and single-behavior intervention groups, excluding control groups without any intervention, to compare the efficacy of interventions for (a) sexual risk reduction, (b) substance-related risk, (c) testing, (d) treatment, or (e) general psychosocial health outcomes. When looking at risk reduction, the average effect size for outcomes related to sexual risk was d = 0.35 (CI = [0.28, 0.42], p < .001, k = 208, I^2 = 0.9688) and the average effect size for outcomes related to substance-related risk was d = 0.51 (CI = [0.40, 0.62], p < .001, k = 87, I^2 = 0.9626). These results show that interventions were efficacious at improving outcomes related to risk reduction but were stronger for those related to substance use. The average effect size for outcomes related to testing was d = 0.60 (CI = [0.05, 1.15], p = .03, k = 14, I^2 = 0.9980) and the average effect size for outcomes related to treatment was d = 0.25 (CI = [0.04, 0.46], p = .02, k = 67, I^2 = 0.9630). These results show that interventions were efficacious at improving outcomes related to treatment but were stronger for those related to testing. Finally, the average effect size for outcomes related to psychosocial health outcomes was d = 0.16 (CI = [−0.16, 0.47], p = .31, k = 22, I^2 = 0.9526), showing no significant change over time. Given heterogeneity across outcomes, we further explored variability in different outcomes across different number of recommendations (see Appendix I). Although differences in the significance of the coefficient did emerge, the beta weights and their standard errors do not suggest that the impact of the number of recommendations differed across outcomes (see also Appendix K for means illustrating the amount of change for different numbers of recommendations).

[4]To be conservative, we also tested for one tailed selection biases. Assuming a moderate one-tailed selection bias, the adjusted effect dropped to 0.16, which represents an attenuation of the estimate by about 54% of the original value.

Moderator Analyses[5]

As interventions with different recommendation numbers may differ in other features, such as participants, intervention characteristics, or methodological characteristics, we lastly reran our analyses controlling for our significant moderators. After controlling for both recruitment context and random assignment, the linear term for recommendation number was still significant ($B = 0.07$, $SE = 0.02$, $p = .001$).[6] These findings thus provide further evidence that making multiple recommendations can maximize intervention efficacy, over and above characteristics of the intervention.

Discussion

Due to an increasing interest in the use of multiple-behavior interventions in the HIV domain, understanding implementation is critical. The purpose of this meta-analysis was to contribute to research on the efficacy of intervention and identify factors that may contribute to intervention success. First, our results revealed differences between single- and multiple-behavior intervention groups. Particularly, the results showed that multiple-behavior interventions are successful at improving health in the HIV domain, producing small-to-medium effects (average: $d = 0.44$ [95% $CI = 0.27, 0.60$]). An assessment of bias revealed asymmetry in our meta-analysis. However, even assuming a moderate bias, the observed effect remained significant, suggesting that the asymmetry we found had very little impact on our estimated effect sizes.

Second, our meta-analysis showed that the impact of multiple-behavior interventions was greater for some outcomes than others. For example, interventions assessing outcomes related to risk reduction (including sexual risk and substance-related risk), testing and treatment were efficacious, whereas those assessing outcomes related to general psychosocial health outcomes showed little change. However, as outcomes related to psychosocial health are likely mediated by other outcomes, they may take longer to change, and thus, show little improvement at the end of the intervention.

Finally, our results found significant linear effects of recommendation number on overall change, with stronger improvements observed for interventions making five or more recommendations and little variability across different outcomes. The linear pattern observed in our meta-analysis differs from the curvilinear pattern found by Wilson and colleagues (2015) in the lifestyle domain, a difference that may be due to unique relations among the recommendations prescribed in each domain. On the one hand, the lifestyle domain is one in which the same goal can be achieved by different behaviors, including quitting smoking, increasing exercise, and improving one's diet, but each behavior is difficult in and of itself and performing one does not necessarily facilitate the others. Thus, when more recommendations are made, the combinations become more challenging and cease to improve efficacy beyond a point. On the other hand, in the case of HIV interventions, recommendations are often combined because one facilitates the other. For example,

[5]We also conducted moderator analyses to determine whether there were participant or intervention characteristics that influenced intervention efficacy. For details of our findings, see Appendix L.

[6]For outcome type, the linear and quadratic terms remained significant for sexual risk (linear: $B = 0.06$, $SE = 0.02$, $p = .01$; quadratic: $B = -0.01$, $SE = 0.01$, $p = .03$) and the linear term remained significant for substance-related risk ($B = 0.10$, $SE = 0.04$, $p = .02$).

reducing drug use facilitates adherence to treatment, and testing often provides a positive starting point to either treatment or prevention. Hence, receiving more recommendations should make at least some of the goals easier to execute and may lead to reinforcement of the larger, important goal (McDonald et al., 2017; Wilson et al., 2015). In this case, more recommendations may exert synergistic effects and linearly increase efficacy.[7]

Limitations

Although both behavioral and clinical outcomes are important in the HIV domain, interventions, including the ones we synthesized, often rely on behavioral outcomes as a measure of change. As behavioral outcomes are measured through self-report, issues related to social desirability (Newell et al., 1999) can reduce the validity of these results. Furthermore, under conditions where people lack knowledge about their health (e.g., whether they are HIV positive; Pedrana et al., 2012), corroborating self-report data with clinical outcomes becomes even more important. Therefore, it will be important to compare behavioral outcomes and biological estimates to inform and evaluate HIV prevention strategies

There has been a recent rise in interventions addressing multi-level change, concerning issues at the structural, social, behavioral, and biological levels. Such multi-level interventions have targeted issues related to HIV beyond the individual, emphasizing the importance of the relationship context (Albarracín, et al., 2010), or the intergenerational benefits of interventions for families coping with HIV (Rotheram-Borus et al., 2006). A potential next step could thus involve combining the results of meta-analytic reviews such as this into multi-level models, to understand the underlying mechanisms that may be similar or different on a larger scale.

Conclusion

This meta-analysis revealed that multiple-behavior interventions in the HIV domain are efficacious at promoting change, often varying depending on the type of outcome assessed. Additionally, we showed that the number of recommendations included in an intervention can have important implications on intervention efficacy. We hope that the results from this work will add to past theoretical and empirical studies advocating the use of multiple-behavior interventions and contribute to the development and implementation of more efficacious integrated HIV interventions in the future. However, the interventions designed to target HIV, and its related risk behaviors, are not static across time, but often change to reflect the growing complexity of this problem. Therefore, as new HIV domains accrue, results of these systematic reviews will need to be replicated.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

[7]For these linear effects to hold, recommendations cannot be arbitrary in nature and the main and auxiliary recommendations must cohere, with the latter facilitating the former.

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