



A Daily Digital Mindfulness Meditation to Reduce Stress from Discrimination Among Racially Diverse Sexual and Gender Minorities: Preparation Phase of the Multi-Phase Optimization Strategy (MOST)

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Abstract

Objectives Young sexual and gender minorities (YSGM) experience disproportionate stress and poor mental health compared to young cisgender heterosexual individuals which may, in part, be due to exposure to discrimination. An app-based mindfulness meditation program may be an easily accessible intervention through which to improve mental health and well-being among this population.

Method We utilized the preparation phase of the Multiphase Optimization Strategy (MOST) process to guide this work. We used a 23 (8- condition) factorial intervention to examine the acceptability, feasibility, and preliminary efficacy of three meditation components: Awareness, Connection, and Purpose. Participants ($n = 72$ YSGM; 95.65% people of color) were enrolled and randomized to one of the eight conditions, engaged in meditation exercises via a smartphone app, and completed daily surveys that assessed stress and well-being over 5 days. Post-intervention, participants completed a survey and were interviewed about their experiences with the app and study protocol. Qualitative analyses explored the feasibility and acceptability of the study protocol, and factorial ANOVAs examined preliminary signals from each component and their interactions in reducing perceived stress and improving well-being.

Results The findings point toward the feasibility and acceptability of the intervention among YSGM participants; participants assigned to all three meditation components had the highest proportion of lost to follow-up. The omnibus test of the factorial model for perceived stress was not statistically significant, $F(7, 64) = 1.44, p = 0.20, \eta^2 p = 0.136$. The omnibus test for satisfaction with life was also non-significant, $F(7, 64) = 0.98, p = 0.45, \eta^2 p = 0.097$. Given non-significant omnibus tests, individual component effects should be interpreted with caution as preliminary signals rather than confirmed effects. Among individual components, the Connection component showed a potential signal for stress reduction ($b = -5.21, p = 0.04, \eta^2 p = 0.064$). Research with larger sample sizes is needed to evaluate the effects of the intervention components more fully.

Conclusions Quantitative findings were largely non-significant, consistent with this study's preparation-phase design. However, this study points to areas for further inquiry, including future work with larger, more diverse SGM samples, greater inclusion of instructors from diverse backgrounds in meditation apps, and the identification of engagement strategies for diverse populations.

Preregistration <https://clinicaltrials.gov/ct2/show/NCT05131360>.

Keywords MHealth · Sexual and gender minorities · Mindfulness meditation · Stress

Individuals who identify as a sexual (e.g., bisexual, lesbian, gay) and/or gender (e.g., transgender, non-binary) minority (i.e., sexual and gender minority [SGM]) experience disproportionately poorer mental health outcomes compared

to their cisgender, heterosexual counterparts (Henderson et al., 2022). In the United States, the prevalence of DSM-5 psychiatric disorders, including alcohol use disorder, major depressive disorder, and panic disorder, is significantly higher among sexual minorities, specifically gay men and lesbian women, compared to their heterosexual counterparts

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(Kerridge et al., 2017). Further, according to the 2015 United States Transgender Survey, 40% of transgender women and 45% of transgender men attempt suicide in their lifetime (Herman et al., 2019). Moreover, young SGM are at a particularly heightened risk of poor mental health compared to their cisgender and heterosexual counterparts (Plöderl & Tremblay, 2015). Thus, there is a critical need to address factors such as stress, which contributes to poorer mental health outcomes for SGM.

The minority stress framework helps to situate how minority stress is associated with poor mental health among SGM. According to Meyer's (2003) minority stress framework, SGM experience a disproportionate burden of stress compared to their non-SGM counterparts. SGM are exposed to this excess stress, called "minority stress", via both distal and proximal stress processes. Distal stress processes refer to external discrimination events (e.g., homophobia and/or transphobia), whereas proximal stress processes refer to the internalization of negative social attitudes, including expectations of rejection and internalized heterosexism (i.e., the internalization of negative societal attitudes about sexual minorities into one's self-concept). Over time, SGM's exposure to minority stress may lead to negative changes in various psychosocial processes, including emotion regulation, interpersonal relationships, and patterns of thought (Hatzenbuehler, 2009). These psychosocial changes, in turn, may have negative psychological consequences, including increased depressive/anxiety symptoms and suicidality, and unhealthy coping behaviors. Indeed, one study examining discrimination and mental health among 354 lesbian, gay, and bisexual individuals found that alcohol use mediated the association between exposure to perceived discrimination and mental health, such that discriminatory experiences were positively associated with alcohol use, which, in turn, was positively related to psychological distress (Ngamake et al., 2016). To reduce mental health disparities for SGM individuals, interventions aimed at improving mental health among SGM individuals must account for the role of stress.

Mindfulness-based meditation practices are effective in alleviating stress and improving mental health among individuals who experience discrimination (Zapolski et al., 2019). Broadly, mindfulness refers to practices in which individuals attempt to focus on the present moment and practice acceptance of the range of emotions and processes that their mind and body experience (Bishop et al., 2004). Emerging evidence suggests that mindfulness practice may reduce perceived stress among SGM individuals (Jabson Tree & Patterson, 2019; Sun et al., 2021; Toomey & Anhalt, 2016). For instance, a pilot study examining the impact of 8 weeks of mindfulness practice on mental health among SGM individuals found that perceived stress was reduced by approximately 20% and 40% for women and men, respectively, over the study period (Jabson Tree & Patterson, 2019). Although

there is a growing number of observational and intervention studies showing the effectiveness of mindfulness in reducing stress from discrimination and promoting well-being (Tomlinson et al., 2018), the key features of mindfulness interventions that are the most effective, efficient, and scalable remain unclear. Thus, an approach to empirically examine the key features of mindfulness that are effective in reducing stress from discrimination among SGM is imperative for creating culturally relevant and impactful well-being interventions for diverse populations of SGMs. There are three specific mindfulness-based practices (Awareness, Connection, and Purpose) that may reduce stress and increase well-being. Each of these is described in detail in our previous work (Cook et al., 2022), but is also briefly described below.

Awareness meditation practices train attentional regulation, specifically the capacity to direct and sustain attention on present-moment experience (e.g., breath, bodily sensations, thoughts) without judgment or reactivity (Cardaciotto et al., 2008). In the HMP app, Awareness sessions include practices such as mindful breathing, mindfulness of sensations, and open awareness, all focused on strengthening the ability to observe and regulate attention. *Connection* meditation practices are relational in focus, cultivating appreciation, kindness, and compassion toward oneself and others (Klussman et al., 2020). In the HMP app, Connection sessions progress from appreciation (noticing the positive, self-worth) to kindness (extending care to oneself and others) to compassion (responding to suffering in oneself and others). Whereas Awareness centers on how one attends to experience, Connection centers on how one relates to oneself and others, building prosocial emotions as a resource for coping with identity-based stressors and strengthening interpersonal bonds. Lastly, *Purpose* meditations allow for the construction of meaning in one's day-to-day life via goal setting and management of behaviors in alignment with one's values and goals (McKnight & Kashdan, 2009). The beneficial impact of Awareness (Killingsworth & Gilbert, 2010; Lutz et al., 2013), Connection (Gariépy et al., 2016; Klussman et al., 2020; Pace et al., 2009), and Purpose (Czekierda et al., 2017; Disabato et al., 2017) activities on mental health has been well supported in previous research.

The three components examined in this study (Awareness, Connection, and Purpose) are grounded in the Awareness, Connection, Insight, and Purpose (ACIP) framework developed by Dahl et al. (2020), which integrates classical mindfulness constructs with contemporary contemplative science. Awareness aligns with attention regulation and present-moment focus, core elements of traditional mindfulness practice (Lindsay & Creswell, 2019). Connection reflects loving-kindness and compassion meditation traditions that foster prosocial emotions and buffer against social isolation (Khouri et al., 2015). Purpose incorporates elements of values clarification that

enhance self-efficacy and meaning-making. Meta-analytic evidence demonstrates that mindfulness-based interventions reduce psychological distress with effect sizes of 0.35 to 0.45 (Goyal et al., 2014; Khoury et al., 2015), and neuroimaging research shows these practices produce durable changes in brain regions governing emotion regulation (Davidson & McEwen, 2012).

The framework used for this study highlights the multifaceted challenges faced by individuals with intersectional identities (i.e., individuals who hold multiple marginalized social identities, such as being both a racial/ethnic minority and a sexual minority). Overall, we posit that possessing multiple minoritized identities may lead to increased exposure to minority stress, which includes both external factors, such as discrimination, and internal ones, such as internalized stigma (Cook et al., 2022). This disproportionate burden of stress can, in turn, lead to poor mental health, including psychological distress, anxiety, and depressive symptoms (Hatzenbuehler, 2009). To mitigate the negative impacts of minority stress, we propose that potential intervention targets for reducing the impact of minority stress among SGM of color may focus on mindfulness strategies, including the components of *Awareness*, *Connection*, and *Purpose* (Fig. 1). As discussed previously, each component targets specific coping strategies to promote well-being through mindfulness meditation. For instance, *Awareness* emphasizes an increased focus on one's surroundings and internal signals (e.g., physical sensations, thoughts, and emotions) (Goldberg et al., 2020). By focusing on this component, individuals become

more aware of their coping mechanisms and appraisals in response to stressors, leading to healthier coping habits.

Additionally, the *Connection* component emphasizes nurturing a sense of compassion toward others, encouraging supportive relationships and interactions (Goldberg et al., 2020). Improved positive peer relationships would result from the Connection component, as community connectedness and perceived social support are known to buffer the negative impacts of stress (Dulai & Jaspal, 2024). Finally, the *Purpose* component involves having a clear grasp of one's values and motivations while incorporating them into everyday life (Goldberg et al., 2020). Clarifying and applying such mindfulness activities might enhance one's self-efficacy and self-worth, which can, in turn, buffer the effects of stress on an individual's mental health (Fürtjes et al., 2023).

Each component is hypothesized to reduce stress through distinct psychological mechanisms. Awareness targets stress reduction through improved emotion regulation: by increasing present-moment attention and reducing rumination, individuals develop a greater capacity to observe and respond to stressors adaptively rather than reactively (Lindsay & Creswell, 2019). Connection targets stress reduction through self-compassion and social connectedness: by cultivating kindness toward oneself and strengthening perceived social bonds, individuals develop a buffer against the internalization of discrimination (Khoury et al., 2015). Purpose targets stress reduction through enhanced meaning-making and self-efficacy: by clarifying personal values and aligning behavior with those values, individuals develop a stronger sense of coherence that reduces the psychological

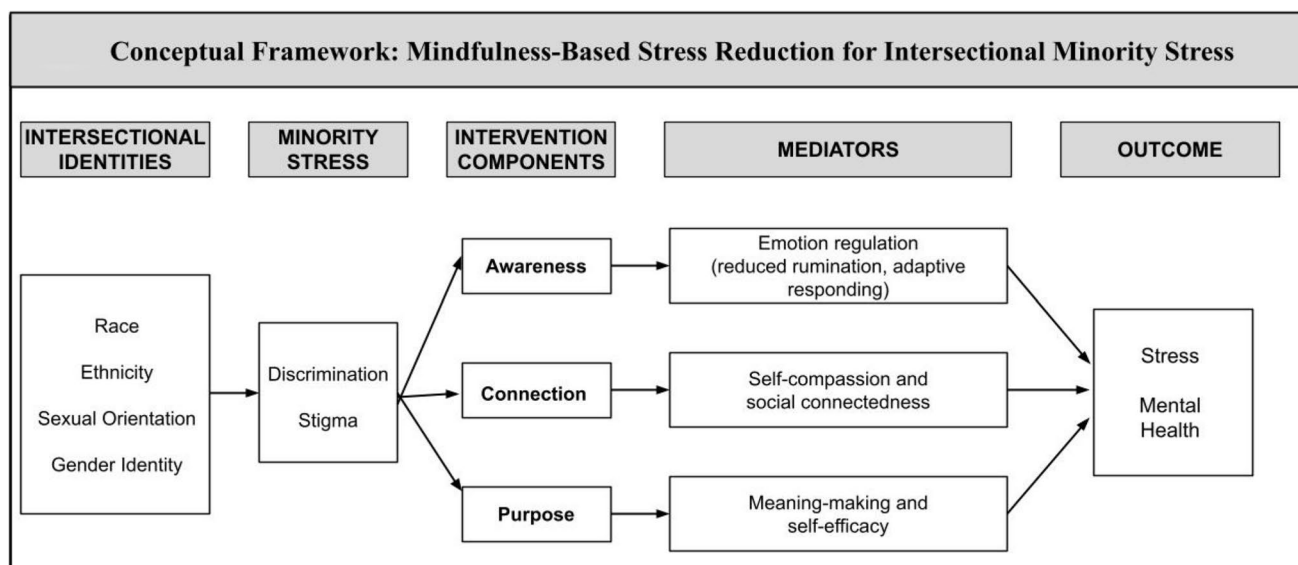


Fig. 1 The framework illustrates how intersectional minority stress leads to poor mental health outcomes. Mindfulness components (Awareness, Connection, Purpose) target distinct psychological mechanisms to buffer negative effects on mental health

impact of identity-based stressors (McKnight & Kashdan, 2009). These mechanisms were not directly measured in this preparation phase but will be assessed in future optimization trials.

MOST is an innovative, principled framework (Collins, 2018) that allows researchers to identify the intervention that produces the best expected outcome given constraints imposed by the need for affordability (cost to deliver), scalability (ability to reach large populations), and efficiency (achieving goals with minimal resources) (Collins et al., 2021), referred to as the optimized intervention. The framework has three phases: (1) preparation, (2) optimization, and (3) evaluation. In the preparation phase, a theoretically and empirically derived conceptual framework is developed, through which candidate intervention components are identified. Also, in this phase, pilot studies are conducted as needed, and the optimization objective (i.e., the way in which intervention effectiveness will be balanced against affordability, scalability, and/or efficiency) is specified. Then, in the optimization phase, an optimization randomized controlled trial (ORCT) is used to identify the most effective combination of intervention components, and component levels (i.e., variations in dosage or intensity of each component), that meet the a priori specified optimization objective. The RCT may use any number of experimental designs to address the optimization objective, most commonly a design from the efficient factorial experiment family. Factorial experiments allow for the simultaneous evaluation of multiple intervention components and their interactions. For example, a 2^3 factorial design tests all possible combinations of three two-level components (present/absent), resulting in eight experimental conditions. Finally, in the evaluation phase, an evaluation randomized controlled trial (ERCT) is conducted to evaluate the effectiveness of the optimized intervention against a suitable comparator.

The purpose of the preparation phase is to lay the groundwork for optimizing a multi-component intervention, with activities including revising the conceptual framework, identifying study components, conducting pilot work to assess feasibility and acceptability, and, finally, identifying optimization objectives (Collins et al., 2024). For this study, the preparation phase consisted of two parts. First, the research team conducted literature reviews to identify the key elements, conceptual framework, relevant findings, and underlying theories surrounding discrimination, stress, and poor mental health among YSGM to inform the development of the study components. During the first part, the research team had ongoing meetings with our collaborators from Healthy Minds Innovations, a nonprofit affiliated with the Center for Healthy Minds at the University of Wisconsin-Madison, a program that demonstrates effectiveness in previous research (Awareness, Connection, and Purpose). Each of the three components was delivered as pre-recorded

audio sessions via the app. Each session averaged 10 min in duration and included both didactic content and guided meditation practices. Participants could access sessions sequentially and replay them as desired. Awareness sessions included practices such as mindful breathing and mindfulness of sensations, with prompts directing participants to notice breath and bodily sensations without judgment. Connection sessions included appreciation and compassion practices, prompting participants to reflect on people they care about and cultivate feelings of kindness. Purpose sessions included practices focused on clarifying values and finding meaning in challenges, with prompts such as reflecting on moments of inspiration or viewing difficulties as opportunities for growth. All sessions were narrated by the same instructor, a White male. This demographic detail is noted because participant feedback indicated that narrator diversity influenced acceptability of the intervention among participants of color (see “Results”).

The meditation content was drawn from a general mindfulness program and was not culturally adapted for racially diverse YSGM beyond the inclusion of the intervention within a study protocol designed for this population. The exercises addressed universal mindfulness principles (present-moment awareness, compassion, values clarification) rather than incorporating culturally specific content (e.g., references to racial identity, intersectionality-specific stressors, or culturally grounded coping practices). This represents a limitation of the current preparation phase and informs future directions: cultural adaptation of meditation content, including the use of diverse narrators, culturally relevant examples, and content addressing intersectional experiences, is a priority for the optimization phase.

Second, aligned with MOST preparation principles (Collins, 2018), the research team conducted the pilot work to assess the feasibility, acceptability, and preliminary effectiveness of the developed components through a 2^3 factorial experiment (Collins, 2018; Cook et al., 2022). Change in perceived stress levels from before to after the intervention components was the primary outcome of interest in this study. Further, in exploratory analyses, we also measured changes in life satisfaction before and after the intervention period.

Finally, as proposed by the MOST continual optimization principles (Collins, 2018), findings of this pilot study were used to identify an *optimization objective* (i.e., the desired outcome(s) of the intervention and its possible constraints). Using the preparation phase of MOST, this pilot study aimed to identify potential intervention components and preferences for the incorporation of mindfulness-based practice within the lives of YSGM in order to reduce stress (Landoll et al., 2022). Overall, our overarching goal is to develop effective, affordable, scalable, efficient (Collins et al., 2024), and culturally tailored interventions to alleviate stress among

YSGM using MOST. Because the intervention is delivered through a smartphone app, identifying which components are effective allows developers to exclude unnecessary content, reducing production costs and session length. A shorter, empirically optimized app is less burdensome for users and more feasible to distribute at scale across diverse SGM populations.

Method

Preparation Study

The preparation project, entitled the “Daily Mindfulness Intervention to Reduce Stress from Discrimination among Young Sexual and Gender Minorities (REDUCE)” consisted of a 2^3 factorial experiment in which participants were randomized to one of eight intervention conditions (Supplementary Table S1, which summarizes the factorial design and all eight experimental conditions) representing all possible combinations of the three candidate components (i.e., Awareness, Connection, and Purpose). Those assigned to Condition 8 (None/Introduction Only) were assigned to complete a 5-min introductory exercise into meditation via the HMP app on Day 1 of the study and were not randomized to any other condition and thus did not complete any other meditation practices over the 5-day study period. The intervention components and all assessments were administered via the HMP app. A CONSORT diagram, as seen in Supplement 2, is provided to show the flow of participants through each stage of the study and randomization processes.

Power analysis was conducted using the FactorialPowerPlan package in R (Dziak et al., 2012). For the primary outcome of stress reduction, assuming a pretest-posttest correlation of 0.6, a medium effect size (Cohen $d=0.50$), and $\alpha=0.05$, a sample size of 80 was estimated to provide 78% power to detect individual main effects of intervention components. The medium effect size assumption was informed by meta-analytic evidence showing that mindfulness-based interventions produce effects in the range of $d=0.35$ to 0.45 for stress reduction among general populations (Goyal et al., 2014; Khoury et al., 2015). We selected a slightly larger effect ($d=0.50$) based on the expectation that a population experiencing elevated minority stress may show greater responsiveness to a stress-targeted intervention. We acknowledge this was an optimistic assumption, particularly for a brief 5-day digital intervention. With 72 completers rather than the target 80, the achieved power was approximately 72% for detecting main effects of this size. Smaller but clinically meaningful effects (e.g., $d=0.30$) would require substantially larger samples (approximately $n=200$) to detect reliably, which underscores the importance of the forthcoming optimization trial. The largely

non-significant findings here are consistent with either true null effects or effects that were too small for this sample to detect. Due to feasibility constraints typical of preparation-phase studies, 72 participants completed the study protocol (90% of the target), providing sufficient data to assess feasibility and acceptability and to obtain preliminary effect estimates, though the study remained modestly underpowered for detecting hypothesized effects.

Procedure and Participants

YSGM participants ($n=72$) were recruited via a variety of online (e.g., email blasts to LGBTQ+ listservs) and offline (e.g., flyer postings with study information around various NYC-based campuses) recruitment techniques. Initial inclusion criteria included being between the ages of 18 and 29 at the time of screening, residing in the New York tristate area (i.e., New York, New Jersey, and Connecticut), and identifying as SGM. Interested persons were directed to an online screening survey. If participants met the aforementioned inclusion criteria, they were then contacted via email by a research assistant (RA) to schedule an informed consent meeting via video conferencing. Those who provided written informed consent completed an online baseline questionnaire. Upon completion, participants were randomized using the REDCap Randomization Module and began the 5-day study period. Participation ranged from 5 to 10 min per day. On the first day, each participant completed a 5-min, self-guided introduction to mindfulness. On days 2–5, participants completed the assigned mindfulness-based audio sessions on the app specific to the condition to which they were randomized. Within 1 week after the 5-day study period, participants completed an online follow-up questionnaire and a 15-min debrief interview via video conferencing.

During the 5-day intervention period, participants were asked to complete a survey each night that assessed mood via a modified version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), adapted to reflect mood states over the current day, and exposure to stressful events via the Daily Inventory of Stressful Events (DISE; Almeida et al., 2002). A 5-day diary procedure was selected based on prior research demonstrating that mindfulness-based practice is effective at reducing stress over these brief periods (Zeidan et al., 2010), and to allow for sufficient variability in mood and stress to better capture any impact of the mindfulness activities on mood and stress over the study period. At the end of the study period, participants completed an online post-intervention survey to assess changes in perceived stress and life satisfaction post-intervention. Measures are described below.

Perceived stress. Participants were given the Perceived Stress Scale (PSS; Cohen et al., 1983) at baseline and follow-up. The 14-item PSS measures perceptions of stress

over the past month. PSS responses fall on a 5-point Likert scale ranging from 0 = *Never* to 4 = *Very often*. An example item includes “*In the last month, how often have you felt nervous and stressed?*” Due to an error in the programming of the PSS on REDCap, the PSS included in this study contained 13 of the 14 items (item 10 of the PSS was omitted). Thus, the remaining 13 PSS items were summed to create a total perceived stress score, which could range from 0 to 52, with higher scores denoting greater perceived stress. The PSS had acceptable reliability in this sample: Cronbach’s alpha for the baseline and follow-up PSS was 0.83 and 0.69, respectively.

Although the PSS assesses general perceived stress rather than discrimination-specific stress, we selected this measure for several reasons. First, the minority stress framework posits that discrimination contributes to overall perceived stress burden (Meyer, 2003). Second, a general stress measure captures the cumulative impact of discrimination alongside other stressors, reflecting the lived reality of individuals with intersectional marginalized identities. Third, validated discrimination-specific stress measures for YSGM with intersectional identities were limited at the time of study design. Future optimization phases should incorporate discrimination-specific stress measures alongside general stress measures to more precisely assess intervention mechanisms.

Participants were given the Satisfaction with Life Scale (SLS; Diener et al., 1985), a 5-item scale ranging on a Likert scale from 1 = *Strongly disagree* to 7 = *Strongly agree*, to measure their overall life satisfaction. An example item includes, “*The conditions of my life are excellent.*” SLS items were summed, resulting in a score ranging from 7 to 35, with higher scores denoting greater life satisfaction. Cronbach’s alpha for the baseline and follow-up assessments of SLS was 0.85 and 0.73, respectively.

At the end of the 5 days, each participant engaged in a debrief interview whose guide was structured to garner information pertaining to the feasibility and acceptability of the intervention content and protocol. RAs asked questions about the following themes: (1) feasibility of implementing the protocol, including recruitment, and (2) acceptability of the protocol as administered. RAs also used prompts to get participants to reflect on their experiences in the study and to highlight any barriers that they may have had with the intervention (e.g., prompting a participant to discuss why their experiences with the app were good or bad or neutral). Lastly, RAs captured information on the usability of the HMP app and mindfulness exercises by asking participants to reflect on their opinions of the app and exercises. The interview invited participants to reflect on their experiences with the study and daily mindfulness practices and was not recorded for pragmatic reasons, and, as such, RAs took copious notes on participant responses. The full set of interview questions can be found in Supplement 3. After the debrief

interview, participants were provided with compensation. A financial incentive structure was utilized to increase retention in the study; participants were paid US\$10 each for completing baseline and follow-up surveys. Additionally, participants were provided US\$3 for each nightly diary completed for a total of US\$15. If they completed at least 4 of the nightly diaries, they were given an additional US\$12. Thus, participants could earn up to US\$47 for participation. The New York University Institutional Review Board approved the procedures for this study. Full study details of the study protocol are published in detail elsewhere (Cook et al., 2022).

Data Analyses

Because we were interested specifically in the feasibility and acceptability of the intervention, we used a directed content analytical approach to analyze the qualitative debrief interview data. The directed content approach is a deductive approach to analysis and coding of data that takes prior research and theory as a framework for the initial coding (Hsieh & Shannon, 2005). To this end, we specified a coding schematic with predetermined key themes of feasibility and acceptability of meditation practice. Subthemes were deduced from the interview responses and an initial coding scheme was created for each of the overarching themes of feasibility, acceptability, and barriers. Two RAs trained in qualitative methodology created the initial coding schematic and consulted with each other to discuss discrepancies and adjust where necessary to create a final version. Once the final coding scheme was created, the interview notes were coded for the different themes and subthemes to enrich our understanding of the feasibility and acceptability of an app-based meditation intervention for racially and ethnically diverse SGM, as well as pinpointing areas for future improvement. Lastly, we explored the usability of the HMP app and intervention (e.g., ease of use, understandability, user interface, thoughts on its use for mental health) (Zapata et al., 2015) by asking participants to reflect on their opinions of the HMP app and mindfulness exercises (see Supplement 3). Debrief notes were analyzed using Dedoose qualitative software (SocioCultural Research Consultants LLC, 2023).

For quantitative analyses, we examined sociodemographics of the sample and whether participants who were lost to follow-up were different from those who completed the study on key demographics (e.g., race/ethnicity, gender identity). Because this study was focused on the preparation phase of MOST, only data from the baseline and follow-up surveys were analyzed here. Participants who did not complete both baseline and follow-up assessments were excluded from efficacy analyses (complete case analysis). We quantitatively explored the usability of the HMP app through

descriptive statistics of the number of days on which sessions were completed and the practice duration (in minutes) for each experimental condition. As a secondary goal, we explored preliminary efficacy using factorial linear modeling using effect coding as recommended by Collins (Collins, 2018; Kugler et al., 2018). With effect coding, each intervention component (i.e., Awareness, Connection, Purpose) is assigned a value of +1 or −1 depending on whether or not it was assigned to the condition. The coefficients in Table 4 represent each component's main effect (i.e., the average contrast between conditions where that component is present versus absent across all combinations of the remaining components) as well as pairwise interactions between components. These are estimated simultaneously via ordinary least squares regression. For each of our study outcomes of perceived stress and mental well-being, we ran a factorial ANOVA to estimate the main effects and the interactions between factors (i.e., components). In this framework, each coefficient represents the estimated main effect of a given component averaged across levels of the other components, linking the factorial ANOVA to a regression-based estimation approach common in MOST designs (Collins, 2018). To enhance interpretability, we report partial eta-squared (η^2p) as a measure of effect size for each component and interaction term, along with 95% confidence intervals (CIs) for unstandardized coefficients. Following Cohen's (1988) benchmarks, partial η^2p values of 0.01, 0.06, and 0.14 correspond to small, medium, and large effects, respectively. Percent change was selected as the outcome metric to enhance clinical interpretability and maintain consistency with prior MOST factorial studies (Cook et al., 2016; Thomas et al., 2021).

Results

Overall, 72 participants completed the 5-day intervention as well as the post-intervention survey. Table 1 displays the sociodemographic characteristics of the sample. The majority of the participants (55.6%) were between the ages of 25 and 29; the remaining were between the ages of 18 and 24. The majority (71%) identified as non-Hispanic. Over one-third (38%) of the sample identified as Black, 17% identified as multi-racial, 41% identified as 'other', and 4.3% identified as White. The "other" category predominantly comprised Asian/Pacific Islander participants (31% of the total sample). With respect to gender identity, half (50%) of the sample identified as cisgender male, while the remaining identified as cisgender female (28%) or transgender, non-binary, or another gender identity (22%). With respect to sexual identity, the majority (58%) identified as gay or lesbian, whereas 35% identified as bisexual and 7% identified as other. A large proportion of the sample had a college

Table 1 Sociodemographic characteristics of the study sample ($N=72$)

	%(n)
Age	
18–24	44.44 (32)
25–29	55.56 (40)
Race ^a	
White	4.35 (3)
Black	37.68 (26)
Multi-racial	17.39 (12)
Other	40.58 (28)
Ethnicity ^b	
Non-Hispanic	71.43 (50)
Hispanic	28.57 (20)
Gender identity	
Cisgender male	50.00 (36)
Cisgender female	27.78 (20)
Transgender, non-binary, or other	22.22 (16)
Sexual orientation	
Gay or lesbian	58.33 (42)
Bisexual	34.72 (25)
Other	6.94 (5)
Education	
High school diploma/GED	12.50 (9)
Some college	26.39 (19)
College degree	40.28 (29)
Graduate degree	20.83 (15)

^a3 participants did not report their race

^b2 participants did not report their ethnicity

degree (40%). At baseline, participants reported moderately elevated perceived stress ($M=27.01$, $SD=7.27$) compared to normative samples of young adults ($M=25.6$; Cohen & Williamson, 1988).

Table 2 displays the mean amount of time spent on the intervention each day and the mean number of days spent engaged in the intervention by experimental condition. Across all conditions, the average time spent on the intervention was 6.69 min per day ($SD=2.04$). The average minutes of practice duration fluctuated across experimental conditions. For example, those in Condition 6 (Connection Only) spent the most number of minutes per day on the intervention ($M=9.30$ min/day, $SD=1.10$), whereas those in Condition 5 (Awareness and Connection) spent the fewest minutes per day on the intervention ($M=5.41$ min/day, $SD=0.95$). The average number of days (out of five total days) spent engaged with the app was less dependent upon the experimental condition. Though 10 individuals were randomized to each experimental condition, there was differential retention across conditions. In particular, only 6 participants completed the Awareness, Connection, and Purpose condition.

Table 2 Average practice duration per day (in minutes) and average number of days engaged in mindfulness activities by experimental condition

Experimental Condition	<i>N</i>	Practice duration <i>M</i> (<i>SD</i>)	Days of sessions <i>M</i> (<i>SD</i>)
1 (“Awareness, Connection, and Purpose”)	6	5.75 (1.50) Range: 5, 10	2.70 (1.45) Range: 1, 5
2 (“Connection and Purpose”)	10	5.41 (0.95) Range: 5, 8	2.93 (1.42) Range: 1, 5
3 (“Awareness and Purpose”)	10	5.42 (0.97) Range: 5, 8	2.95 (1.41) Range: 1, 5
4 (“Purpose Only”)	10	9.23 (1.21) Range: 7, 10	2.93 (1.42) Range: 1, 5
5 (“Awareness and Connection”)	9	5.41 (0.95) Range: 5, 8	2.93 (1.41) Range: 1, 5
6 (“Connection Only”)	9	9.36 (1.10) Range: 7, 10	2.94 (1.44) Range: 1, 5
7 (“Awareness Only”)	8	9.30 (1.15) Range: 7, 10	3.00 (1.39) Range: 1, 5
8 (“None/Introduction Only”)	10	7.50 (0.51) Range: 7, 8	–
Overall	72	6.69 (2.04) Range: 5, 10	2.91 (1.41) Range: 1, 5

Themes, subcategories, and example excerpts are displayed in Table 3. For the theme of feasibility, three subcategories emerged: (1) the intervention being easily accessible; (2) an easy outreach process for reminders about intervention components and getting in contact with RAs; and (3) strong financial incentives to participate. In particular, many participants noted that the intervention was easily accessible and could be implemented in their day-to-day lives. Specifically, participants described the accessible interface of the HMP app and how the meditations could be integrated into their daily activities (e.g., there is an “active” version of the meditations one can use if they do not wish to be sitting down). Participants noted that they were able to learn from the meditations to be present in the current moment. In addition, participants described how the process of getting contacted by and being able to contact RAs was an easy process, wherein their questions or concerns were addressed promptly. Further, participants also noted that the text messages that they received with their daily survey links served as a helpful tool to keep them on track with the study protocol and to engage with the intervention. Lastly, most participants described increased willingness to participate and adhere to the study protocol due to the financial incentives. Several participants noted that the financial incentive is what initially drove them to participate in the study; however, at the same time, participants also mentioned that they enjoyed the meditations and were happy that they participated regardless of financial incentives in the end.

With respect to the acceptability of the intervention, four subcategories emerged: (1) becoming in tune with one’s daily emotions; (2) changed perceptions of discrimination; (3) desire to continue meditation practice; and (4) uplifted

mood following meditations. Many participants noted an increased ability to understand and accept the daily fluctuations in their mood each day. This, in turn, allowed for increased self-reflection and awareness during the day. Further, while many participants noted that the study protocol led to an increased sensitivity and awareness of discriminatory experiences throughout each day (e.g., microaggressions), some reported that the process of being aware of their experiences allowed them to stay focused in the present moment and calm themselves down. Some participants described a desire to continue meditation practice in their day-to-day lives, even without the financial incentive attached to it. Participants described how the practices allowed for increased self-awareness and reflection, which, in turn, improved their mood.

Although many participants reported positive experiences, some participants experienced barriers related to engaging with the intervention: (1) day-to-day stress unrelated to the intervention; (2) difficulty “sitting with” one’s daily emotions; and (3) a desire for greater diversity in the instructors within the HMP app. Most participants reported day-to-day stressors, which, for some, impacted their ability to fully focus on the content of the meditations. Others reported increased perceptions of stress due to the daily mood reflection. For some, it was hard (and stressful) to acknowledge and name their moods and emotions throughout the course of the day. Lastly, a few participants noted that the HMP app lacked diversity (the primary instructor in the app was a White male), noting that they would be more likely to continue with the meditation app if the meditation instructor were someone who shared cultural identities such as racial/ethnic identity.

Table 3 Qualitative themes and sub-codes

Theme	Description	Example quotes
Feasibility of intervention		
Easily accessible intervention	Descriptions related to the user friendliness of the app and meditations as well as their utility in everyday life	"[I] enjoyed how simple the app was. [I] liked that the meditations were split into quick 5 min chunks as this made it made it easy to focus on what was going on around [me] at the time of a meditation" — Asian male, gay, age 25–29, Awareness, Connection, and Purpose "I liked how you could pick an 'active' version for the meditation, so I didn't have to be sitting and meditating but I was able to be walking or cleaning my room while simultaneously meditating so that was convenient and I enjoyed that aspect" — Hispanic female, bisexual, age 18–24, Awareness and Purpose "The contact process was pretty smooth, with prompt responses, and no problem with communication. Only issue was Day 1 audio malfunction, which we resolved quickly" — Black male, gay, age 25–29, awareness "[The] daily reminders were very helpful. Communication [from RAs] was good amount, [I] knew what to do" — Asian transgender male, bisexual, age 18–24, Awareness
Easy outreach process	Easy and understandable protocol as well as easy communicate with research assistants (RAs), especially when a question about the study or protocol arose	
Financial incentives to participate	Increased willingness to participate and adhere to study protocol due to the financial incentive structure set-up	"The incentive is what got me started and the reason why I signed up. Incentive was the initial motivator, but I actually enjoyed participating in the study" — Asian female, bisexual, age 18–24, Awareness and Connection "[The financial incentive structure increased my willingness] because [I had] to record [my] mood and feedback on the daily app on [my] phone. [I] felt as if [my] actions were more than driven by incentive" — Asian male, gay, age 18–24, none/introduction only
Acceptability of intervention		
Becoming in tune with one's daily emotions	An increased ability to understand, name, and accept one's mood(s) throughout the day	"I was more aware of my mood throughout the day because I knew I had to think about it. I was also in a better mood because of all of the self-reflection and meditations" — Multi-racial female, gay, age 18–24, Connection "[The intervention] helped me to be a more insightful person with regards to just reflecting on myself on a daily basis. I will continue reflecting on myself on a daily basis even though the study is over" — Asian female, bisexual, age 25–29, none/introduction only
Changed perceptions of discrimination	Increased awareness of discriminatory experiences day-to-day	"I became more aware of [discrimination], certain things I don't think of as discrimination [or] microaggressions but doing the surveys made me more aware" — Multiracial transgender male, gay, age 25–29, Awareness and Purpose "[My] perceptions of discrimination have changed because the whole process of mindfulness, calming down, chilling out feelings, and being more relaxed allowed [me] to focus more and not see situations so negatively" — Black male, gay, age 18–24, Awareness and Purpose
Desire to continue meditations	Willingness and desire to implement meditation practices in one's day-to-day life	"[I] ventured to YouTube [after the study was over] looking for more real practice. [I] appreciated the app for helping [me] love meditation" — Afro-Caribbean Hispanic male, gay, age 25–29, none/introduction only "[I am] keeping the app because [I] have become accustomed to it and do not know what to do without it. It helped [me] guide my meditation and teach [me] what to do" — Asian male, gay, age 25–29, Purpose

Table 3 (continued)

Theme	Description	Example quotes
Uplifted mood following meditations	Improved mood and well-being as a result of the intervention and meditation practices	"My mood actually did change. I am always in a good mood, but it feels different now because I did the surveys every day and I would ask myself why I was doing it, but I did it. Listening to the meditations was also interesting because they made me feel good" — Hispanic male, gay, age 18–24, Connection "My mood did [change] because I was more aware of my mood throughout the day because I knew that I had to think about it. I was also in a better mood because of all of the self-reflection and meditations" — Multi-racial female, gay, age 18–24, Awareness and Connection
Intervention-related barriers		
Day-to-day stress unrelated to intervention	Daily stressors that interfere with one's ability to engage with intervention practices	"[I did not feel] stress related to the study, though I have been stressed due to the large amount of work I've had on my plate. I feel I couldn't turn off my brain for even a second in order to stay on top of things" — Asian male, gay, age 25–29, Connection and Purpose "[I was facing] something outside of the study, with school, and couldn't get work done because of anxiety [so I] ended up procrastinating" — Black female, bisexual, age 25–29, Purpose
Difficulty sitting with one's daily emotions	Stress pertaining to documenting and sitting with one's daily moods and emotions	"[Documenting my mood] was frustrating...because you are more hyperaware, and [my] mood was worse than [I] thought" — Afro-Caribbean Hispanic male, gay, age 25–29, none/introduction only "[Documenting mood] was not easy at all, actually hard. I compared it to my reflections in the original baseline survey and I kept feeling like I wasn't really assessing my mood but rather factors influencing my mood" — Multi-racial female, bisexual, age 25–29, Purpose
Desire for diversity in intervention-related components	Need for inclusivity and diversity in the intervention-related app	"I liked [the intervention], but I probably won't use it because I always feel a little uncomfortable when the guider is someone not from my tradition" — Asian female, bisexual, age 18–24, Connection "The 5-min meditations were easily accessible, but [I] would appreciate non-white voices for the meditations" — Multiracial and nonbinary, bisexual, age 25–29, Connection and Purpose "[I wish there were a] different narrator. [I wish] they had narrators of color" — Multi-racial Hispanic female, gay, age 25–29, Purpose

Note: To protect participant confidentiality, racial/ethnic identities, gender identity, sexual identity, age group, and intervention assignment are listed for each example quote

Table 4 Results of factorial ANOVA with effect coding ($N=72$)

Condition	Perceived stress				Satisfaction with life			
	<i>b</i>	<i>p</i>	95% CI	η^2p	<i>b</i>	<i>p</i>	95% CI	η^2p
1 (A + C + P)	0.89	0.72	[−4.05, 5.83]	0.002	0.51	0.90	[−7.57, 8.59]	0.000
2 (C + P)	−0.03	0.99	[−4.79, 4.73]	0.000	4.67	0.24	[−3.20, 12.54]	0.022
3 (A + P)	1.82	0.46	[−3.07, 6.71]	0.009	−2.85	0.47	[−10.68, 4.98]	0.008
4 (P)	4.23	0.09	[−0.68, 9.14]	0.044	−0.08	0.98	[−6.43, 6.27]	0.000
5 (A + C)	1.14	0.65	[−3.86, 6.14]	0.003	2.73	0.49	[−5.12, 10.58]	0.007
6 (C)	−5.21	0.04*	[−10.17, −0.25]	0.064	4.23	0.29	[−3.69, 12.15]	0.017
7 (A)	−2.49	0.32	[−7.45, 2.47]	0.015	7.70	0.06	[−0.33, 15.73]	0.054
8 (None)	−3.30	0.19	[−8.28, 1.68]	0.027	12.08	0.003**	[4.26, 19.90]	0.129
Omnibus <i>F</i>	<i>F</i> (7, 64) = 1.44, <i>p</i> = 0.20			0.136	<i>F</i> (7, 64) = 0.98, <i>p</i> = 0.45			0.097

Note. A, Awareness; C, Connection; P, Purpose. Coefficients are unstandardized. 95% CI, 95% confidence interval for *b*. η^2p = partial eta-squared. Percent change from baseline to follow-up served as the outcome metric

* $p < 0.05$. ** $p < 0.01$

With respect to feelings related to the accessibility of the intervention, those assigned to the Purpose and Connection as well as the Purpose and Awareness conditions had the highest proportion of individuals reporting that the HMP app was easily accessible (6 responses for each group, respectively). Further, the Purpose and Awareness and None/Introduction Only groups had high frequencies of individuals who reported that the application changed their perception of discrimination (9 responses and 5 responses, respectively). Lastly, the Connection Only and Awareness and Purpose groups had the highest frequency of individuals who reported having an uplifted mood after the meditation (6 responses and 5 responses, respectively). Other subcategories were applied consistently across groups. Supplement 4 displays the frequency of subcategories applied to the interview notes across each condition to qualitatively explore themes within each group.

Quantitative Results Related to the Preliminary Efficacy of Active Components

Table 4 displays the results of the factorial ANOVA examining the association between intervention assignment(s) and perceived stress and satisfaction with life, including unstandardized coefficients, 95% confidence intervals, and partial eta-squared (η^2p) effect sizes.

For perceived stress, the omnibus test did not reach statistical significance, $F(7, 64) = 1.44$, $p = 0.20$, $\eta^2p = 0.136$. Given this non-significant omnibus test, individual component estimates should be interpreted as exploratory signals. Among individual components, the Connection component showed a potential signal for stress reduction ($b = -5.21$, $p = 0.04$, 95% CI [−10.17, −0.25], $\eta^2p = 0.064$), representing a medium-sized effect estimate. Participants who received the Connection component reported a 5.21 percentage-point

greater reduction in perceived stress compared to those who did not. The Purpose Only condition approached significance ($b = 4.23$, $p = 0.09$, 95% CI [−0.68, 9.14], $\eta^2p = 0.044$), suggesting that Purpose alone, without Awareness or Connection, was associated with a small increase in stress, though the confidence interval included zero. All other conditions produced small, non-significant effects with wide confidence intervals crossing zero, reflecting the limited statistical power of this preparation-phase sample. For satisfaction with life, the omnibus test was also non-significant, $F(7, 64) = 0.98$, $p = 0.45$, $\eta^2p = 0.097$. The None/Introduction Only condition showed a positive exploratory estimate for life satisfaction ($b = 12.08$, $p = 0.003$, 95% CI [4.26, 19.90], $\eta^2p = 0.129$); given the non-significant omnibus test, this should not be interpreted as a confirmed effect. The Awareness Only condition approached significance ($b = 7.70$, $p = 0.06$, 95% CI [−0.33, 15.73], $\eta^2p = 0.054$). No other conditions reached statistical significance for satisfaction with life. Given the non-significant omnibus tests for both outcomes, individual component effects should be interpreted with caution. The wide confidence intervals observed across most conditions underscore the preliminary nature of these findings and the need for adequately powered optimization trials in subsequent MOST phases.

Discussion

This study used the preparation phase of MOST to assess the feasibility, acceptability, and preliminary efficacy of three app-based mindfulness meditation components (Awareness, Connection, and Purpose) for reducing perceived stress and improving well-being among racially diverse YSGM. Using a 2^3 factorial design, we examined signals from each component and their interactions to inform future optimization

trials. The omnibus tests for primary and secondary outcomes did not reach statistical significance. Several factors likely contribute to these null quantitative findings. First, the study was modestly underpowered relative to our a priori power analysis (see “[Method](#)”). Second, the brief 5-day intervention period, while sufficient to assess feasibility and consistent with prior mindfulness research (Zeidan et al., 2010), may have limited participants’ ability to fully internalize the practices. These findings are consistent with the preparation phase of MOST, where the primary goals are to assess feasibility and acceptability and obtain preliminary effect estimates rather than to detect definitive efficacy signals (Collins, 2018). The effect estimates obtained here will inform power calculations and design decisions for future optimization trials. Additionally, the PSS measures perceived stress over the past month, which creates two measurement limitations. First, this timeframe may not be sensitive to changes occurring over 5 days. Second, the PSS assesses general stress rather than discrimination-related stress specifically. While the intervention content addressed discrimination-related stress processes (e.g., reappraisal of discriminatory experiences, fostering self-compassion in response to identity-based stressors), the primary outcome captured general stress. Future studies should include discrimination-specific stress measures to strengthen the alignment between intervention content and assessment.

Overall, we found evidence that suggests the intervention was both feasible and acceptable among our sample of SGM. With respect to feasibility, participants noted that the HMP app was easy to use and also allowed them to incorporate mindfulness activities within their daily routines (e.g., with the “active” sessions, participants were able to move around rather than having to sit still during a meditation session). Further, participants noted that the process for communication with RAs was simple and that the financial incentive structure tied to the study promoted their engagement with the protocol. Participants also described feelings of acceptability with respect to the intervention. A limitation is that financial incentives may not be available in real-world implementation, which could affect engagement rates outside research contexts. For instance, participants spoke about gaining an increased ability to both pinpoint their emotional states and sit with these emotions in a more calm, nonjudgmental manner, which, in turn, improved their day-to-day mood over the course of the study. Moreover, some participants noted that participating in the study motivated them to engage in mindfulness activities even outside of the context of the study. This feedback suggests that the timing and content of the intervention were largely acceptable to participants.

Notably, participants in the no-intervention condition (Introduction Only) showed a positive estimate for life satisfaction ($b = 12.08$, $p = 0.003$, 95% CI [4.26, 19.90],

$\eta^2 p = 0.129$). Given the non-significant omnibus test, this exploratory finding should not be interpreted as a confirmed detrimental effect of the control condition. Several factors may explain this pattern. Measurement reactivity may have occurred, whereby the act of daily self-monitoring prompted increased self-awareness and reflection, which participants described as beneficial in qualitative interviews. Study participation effects, including regular contact with research staff and structured daily engagement, may also have contributed to improved well-being independent of meditation content. Regression to the mean cannot be ruled out, as participants may have enrolled during periods of elevated stress.

There were also potential threats to feasibility and acceptability that were notable. First, some participants reported having trouble sitting with their feelings and emotions during the meditation. This is a notable concern and be lost to follow-up. At the same time, part of the process of mindfulness meditation is reappraisal and sitting with one’s emotions following stressful events (Bishop et al., 2004). However, this potential experience of the intervention is something to consider in future protocols. In future research, investigators may want to measure the level of stress before or after the meditation and consider adjusting the meditations in a way to reduce the likelihood that participants experience distress from the meditations.

Second, our sample was primarily people of color who had varying cultural experiences. There were a few participants who, in response to this, described hesitancy to continue using the HMP app because the app itself did not include a body of diverse voices and exercises. In other words, these participants may be more receptive and open to engaging if the app included more racially and culturally diverse voices. As of the writing of this paper, the HMP has added more diverse voices to the mindfulness meditation application, which we hope addresses this threat to acceptability.

Third, individuals who were assigned to all three intervention components (i.e., Awareness, Connection, and Purpose) may have felt burdened by the time spent on the mindfulness meditations during the study period, although this was not explicitly stated in the follow-up interviews. However, relative to the other intervention groups, those assigned to all three intervention components were more likely to be lost to follow-up, which suggests that this intervention may constitute a burden on participants that outweighs the benefits of participating in the study (e.g., mood improvement, financial incentives). However, it is unclear if this is due to the time it takes to complete the meditations, something related to the content of the meditations, or difficulties in juggling three different mindfulness meditations. To address this limitation, future protocols should consider implementing ways to decrease participant burden while maintaining the scientific rigor of the study protocol (e.g., encourage

participants to complete only one practice per day regardless of their assigned condition).

Limitations and Future Directions

Consistent with MOST methodology, the preparation phase is designed to be iterative, with researchers expected to cycle through preparation activities (e.g., refining the conceptual framework, conducting additional pilot work, revisiting optimization objectives) as many times as needed before advancing to the optimization phase (Collins, 2018; Collins et al., 2024). The need for additional preparation work described below reflects this standard iterative process, not a study limitation. A strength of this approach is that each preparation cycle strategically narrows the research questions and refines the component specifications for subsequent optimization trials, increasing the likelihood that the eventual optimized intervention will be both effective and efficient.

There are a few things to address in the next phase of this research that will help fill some of the gaps related to feasibility and acceptability. A key next step is to return to the preparation phase of MOST in order to convene our team, community members, and other experts to parse out conflicting findings. For instance, it is unclear why there were no statistically significant differences associated with the Awareness and Purpose condition in the quantitative analysis, even though it was evaluated positively in the qualitative findings. It could be the case that these two components together acted to increase an understanding of discrimination experienced on a daily basis, but did not change the level of stress experienced. Thus, it may be the case that these components need to be created to work in tandem with another component if we would like to see an overall effect on stress reduction.

This study also points to a need to examine engagement strategies more critically. To have full effects of the mindfulness meditation, it is important that participants stay engaged with the meditation. Thus, it is important to think about how to incorporate engagement strategies in future research reduce loss to follow-up and increase effectiveness and engagement in the intervention application long term (Nahum-Shani et al., 2022). For instance, research suggests that the design of the app influences engagement, and apps need to be convenient and relevant to users across a wide range of ages and identities (Druce et al., 2019; Simblett et al., 2019). Examples of engagement strategies that could be utilized in future research include push notifications that are customized to be sent at convenient times for each participant as well as an in-app messaging platform that allows users to easily reach out to study staff should any questions and/or issues arise (Druce et al., 2019). Further, qualitative research should explore potential differences in engagement across varying identities (e.g., gender, race/ethnicity)

in order to more appropriately tailor engagement strategies for diverse populations. In summary, this study provides preliminary evidence of feasibility and acceptability for a mindfulness meditation intervention among young SGM, while the largely non-significant quantitative findings underscore the need for larger optimization trials to evaluate component effects.

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Author Contribution SHC conceptualized the study, collected data, analyzed the data, and drafted the manuscript. EPW, MR, and MD helped to collect data and made significant contributions to editing the manuscript. RT, SG, SJ, and EG made significant contributions to editing the manuscript. All authors read and approved the final manuscript.

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Data Availability No datasets were generated or analyzed during the current study.

Declarations

Ethics Approval This study was approved by the New York University Institutional Review Board.

Informed Consent Written informed consent was obtained from all individual participants included in this study.

Conflict of interest The authors declare no competing interests.

Use of Artificial Intelligence No AI tools were used in the preparation of this manuscript.

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