Journal of Abnormal Psychology

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BRIEF REPORT

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Sexual and gender minority (SGM) populations are at increased risk for several negative psychological outcomes, including self-injury. Although correlates of self-injurious thoughts and behaviors (SITBs) have been identified, it is unclear which factors are prospective predictors of SITB engagement in SGM youth. The current study investigated an online sample of 252 SGM adolescents over a 6-month period. Participants reported attitudes based on SGM identity, depression, self-criticism, body image, family support and family strain, friend NSSI engagement, and experiences of everyday discrimination. Lasso and elastic net regularized logistic regressions were used to examine which baseline variables were associated with SITB engagement at follow-up. Models resulted in excellent predictive accuracy of nonsuicidal self-injury and suicidal ideation (mean Area Under the Receiving Operating Characteristics Curve [AUC] of 0.90 and 0.91), good predictive accuracy for suicide plans (mean AUC = 0.85), and fair predictive accuracy for suicidal behaviors (mean AUC = 0.78). Several variables emerged as prospectively related to SITB risk, with varied associations across different SITBs. Results suggest that minority-specific factors may predict SITBs in SGM adolescents.

General Scientific Summary
This study examined adolescents identifying as a sexual or gender minority (e.g., lesbian, gay, bisexual, transgender) over six months. After using 24 factors to create a predictive statistical model, the final model found that factors related to minority identity predicted engagement in self-harm.

Keywords: self-injury, sexual minority, gender minority, adolescents, minority stress

Supplemental materials: http://dx.doi.org/10.1037/abn0000483.supp

Individuals who identify as sexual and/or gender minorities (SGMs) are at increased risk for a host of negative physical and mental health outcomes compared to their heterosexual, cis-gender peers (Kidd, Howison, Pilling, Ross, & McKenzie, 2016; Steever, Francis, Gordon, & Lee, 2014). Perhaps most alarmingly, SGM populations are at increased risk for self-injurious thoughts and behaviors (SITBs), including suicidal thoughts and behaviors (e.g., suicidal ideation, suicide attempts), and nonsuicidal self-injury (NSSI). Given that SITBs are a leading cause of death and injury in adolescents (Centers for Disease Control and Prevention, 2017), the relationship between SGM status and SITBs is especially concerning. The present study sought to examine risk factors for SITBs in this high-risk group.

The minority stress model proposes that stigma and stress due to minority identification may contribute to psychopathology and SITB risk among SGMs (Meyer, 2003). Factors related to this stress include discrimination, internalization of stigma, and lack of support for one's identity. Providing support for this model, there is evidence that sexual minority adolescents report more experiences of victimization than their heterosexual peers (i.e., those who reported no sexual attractions; Coulter, Herrick, Friedman, & Stall, 2016), and SGM-specific bullying is associated with higher rates of past year-suicidal ideation and behaviors among SGM adolescents (Bouris, Everett, Heath, Elsaesser, & Neilands, 2016). Re-

lately, SGM youth with lower levels of perceived family support report higher rates of NSSI and suicide attempts (Reisner, Biello, Perry, Gamarel, & Mimiaga, 2014). In a longitudinal study of SGM youth, Mustanski and Liu (2013) found that LGBT-specific victimization was a significant risk factor for self-harm (intent unspecified) and suicidal ideation. However, this study included only a small number of gender minority youth and did not differentiate between suicidal and nonsuicidal self-injury.

In addition to these SGM-specific factors, SGM-identifying youth may also be at higher risk of SITBs because they experience elevated levels of more "general" factors previously shown to be related to SITBs. Such factors include self-criticism (Fox et al., 2018; Hooley, Ho, Slater, & Lockshin, 2010), negative body image (Muehlenkamp & Brausch, 2012), depression (Marshall, Tilton-Weaver, & Stattin, 2013; Mustanski & Liu, 2013; Wang, Shi, & Luo, 2017), and contagion via friends engaging in SITBs (Jarvi, Jackson, Swenson, & Crawford, 2013). Providing support for this possibility, there is evidence that self-criticism (Puckett, Levitt, Horne, & Hayes-Skelton, 2015) and negative body image (Kaminski, Chapman, Haynes, & Own, 2005; McGuire, Doty, Catalpa, & Ola, 2016) are more common among people identifying as SGM. Additionally, meta-analyses suggest that SM-identifying adolescents report significantly higher rates of depressive symptoms than their heterosexual peers (Marshal et al., 2011). However, it remains unclear whether these general factors serve as prospective predictors of SITBs among SGM youth.

Although key risk factors remain elusive, over the past 50 years, numerous longitudinal studies have examined risk factors for SITBs in the general population (see Franklin et al., 2017), although few studies to date have examined longitudinal risk factors for SITBs among SGM youth. In light of evidence that specific risk factors could be experienced more intensely or function differently in different minority populations (e.g., McGuire et al., 2016), understanding whether and how specific risk factors are related to SITB risk within SGM youth is essential for effective treatment and prevention in this population. Thus, the present study exclusively involved SGM-identifying youth to shed light on psychological phenomena that are particularly relevant for this high-risk group (Else-Quest & Hyde, 2016). We focused on adolescents aged 14–15 years because both SITB engagement (Nock et al., 2013) and SGM identity begin to develop during this period (Calzo, Antonucci, Mays, & Cochran, 2011).

The present study aimed to test whether general and minority-specific variables are prospectively related to NSSI, suicidal ideation, suicide plans, and suicidal behaviors in SGM youth. Specifically, we examined correlates and predictors of SITBs in a sample of SGM youth who completed two assessments over a six-month period. We hypothesized that SGM-specific stressors would be significantly associated with self-criticism, depression, and negative body image and with prior SITB engagement. Moreover, we hypothesized that both SGM-specific and more general factors would each predict engagement in SITBs six months later.

Method

Participants

Participants were adolescents age 14–15 years old, recruited from Internet platforms (e.g., Instagram, Tumblr) to complete an hour-long online study. Because this analysis pertains to various minority stress constructs, only participants reporting sexual and gender minority identities are included in the present analyses. We included 252 participants between 14 and 15 years of age, including those identifying as homosexual female, bisexual female, questioning/other female, and/or gender minority. SGM identity was assessed via three categorical items ("Sex at Birth," "What is your gender?" and "Sexual Orientation"). Participants who identified a sex at birth that differed from their gender identity were classified as gender minority participants. Because male and female sexual minorities may experience sexual discrimination and harassment in different ways (Mitchell, Ybarra, & Korchmaros, 2014), male sexual minorities were excluded from the sample to reduce the impact of gender differences observed in SITBs (Bakken & Gunter, 2012). However, we included all minority identities in the gender minority group, to remain inclusive of these minority identities as well as increase statistical power. Only two gender minority participants identified their sexual orientation as heterosexual; the remaining identified as sexual minorities.

Baseline sample characteristics are summarized in Table 1. Of the 252 SGM participants who completed the initial assessment, 240 indicated that they would be willing to be contacted about a follow-up survey, and 156 completed the follow-up survey. We ran several analyses to test whether participants who completed the follow-up assessment were unique from those who did not. One-way analysis of variance (ANOVAs) demonstrated no significant differences in terms of age, socioeconomic status (SES), lifetime NSSI frequency, lifetime suicidal ideation frequency, or lifetime suicidal behavior frequency ($ps > .18$). Wald's Chi-Square tests

Table 1
Participant Baseline Characteristics and Reported SITBs

Characteristic		N (%)
N		252
Age, Mean (SD)		14.66 (.50)
Sexual and gender identity		
Homosexual female		57 (22.6)
Bisexual female		61 (24.2)
Questioning/Other female		61 (24.2)
Gender minority		73 (29.0)

Engagement in SITBs	Baseline N (%)	6 Months N (%)
NSSI	143 (56.7)	65 (42.2)
Suicidal ideation	206 (81.7)	102 (66.2)
Suicide plans	185 (73.4)	82 (53.6)
Suicidal behavior	98 (38.9)	40 (26.6)

Frequency of SITBs	Baseline Mean (SD)	6 Months Mean (SD)
NSSI	21.83 (49.48)	4.44 (13.55)
Suicidal ideation	81.62 (192.98)	21.80 (43.36)
Suicide plans	40.35 (116.49)	11.00 (27.04)
Suicidal behavior	3.39 (23.59)	2.64 (11.78)

Note. "6 Months" denotes engagement and frequency of SITBs during the follow-up period (i.e., number of participants who reported engaging in SITBs during the follow-up period, mean number of episodes during the follow-up period). NSSI = nonsuicidal self-injury; SITB = self-injurious thoughts and behaviors.

indicated that participants who did and did not complete the follow-up assessment were not significantly different in terms of race and SGM status ($ps > .35$).

Procedure

In an effort to reach a large number of eligible participants, we joined online social media websites and posted study advertisements in forums related to sexual and gender minority populations. We also purchased advertisements on social media platforms (e.g., Instagram), using search tags related to SGM identities. Additionally, we distributed flyers in and around high schools, with a link to the online study.

Interested participants completed an online screening questionnaire, and those who were eligible received a link to the full assessment via e-mail. Participants were paid $5 in online gift cards to either Starbucks or Amazon upon study completion. To maintain anonymity, participants were encouraged to use an e-mail address that did not contain identifying information.

The online assessment included measures of depression symptoms (Children's Depression Inventory 2; Kovacs, 2010), body image (Body Image Scale; Orbach & Mikulincer, 1998), self-injurious thoughts and behaviors (Abbreviated Self-Injurious Thoughts and Behaviors Interview [SITBI]; Nock, Holmberg, Photos, & Michel, 2007), self-criticism (Self-Rating Scale; Hooley, et al., 2010), family support and strain (adapted from Walen & Lachman, 2000), negative SGM identity (Lesbian, Gay, and Bisexual Identity Scale; Mohr & Kendra, 2011), and experiences of discrimination (Expanded Everyday Discrimination Scale; Williams et al., 2008). Supplement 1 contains more information regarding each self-report measure. Participants who indicated willingness to complete a follow-up survey were sent an additional assessment six months after completing baseline, in which we used items of the SITBI to assess engagement in SITBs during the past six months (i.e., yes/no items to assess engagement in NSSI, suicidal ideation, suicide plans, and suicidal behaviors, and items assessing the number of episodes in the past six months).

Data Analytic Plan

Baseline associations. We conducted zero-order correlations to examine associations among minority-specific stressors, general factors of interest, and SITBs.

Modeling approach. To examine which baseline variables were associated with SITB engagement at follow-up, we conducted lasso regularized logistic regressions. Models included 24 predictors: lifetime engagement (presence/absence) in NSSI; lifetime engagement (presence/absence) in suicidal ideation; lifetime engagement (presence/absence) in suicide plans; lifetime engagement (presence/absence) in suicidal behaviors; frequency of lifetime engagement in NSSI; frequency of lifetime engagement in suicidal behaviors; acceptance concerns; concealment motivation; internalized stigma; difficult process; self-criticism; depression; body image feelings and attitudes; family support; family strain; experiences of everyday discrimination; gender minority status; sexual orientation; race; SES; school status; number of friends identifying as SGM; number of friends who have engaged in NSSI; and number of people the participant knows who identify as SGM and have engaged in NSSI.

Outcome variables for these analyses were presence/absence of SITB engagement during the six-month follow-up period. Although the classic method of predictor selection within a regression framework is stepwise regression, there are numerous shortcomings with these methods (see Harrell, 2015, for an overview). Machine learning methods such as lasso penalization provide several advantages over classic stepwise methods. More specifically, lasso penalization more effectively addresses issues of multicollinearity among predictors and prevents overfitting (McNeish, 2015; Tibshirani, 1996) by applying a penalization parameter to shrink smaller coefficients to zero, leaving only the "best" predictors in the model. We chose to use lasso penalization over other regularization techniques (e.g., ridge regression) in order to perform predictor selection, as lasso penalizes the regression coefficients of some variables down to zero, whereas ridge does not. However, as evidence indicates that elastic net regression (a compromise between lasso and ridge regression) can sometimes outperform the lasso, we also performed elastic net regularization.

Following the recommendation of Kuhn and Johnson (2013), we used 10-fold cross-validation with three repetitions to select the optimal lambda (shrinkage) parameter for lasso and elastic net, and the optimal alpha (mixing) parameter for elastic net, and to obtain a cross-validation estimate of model performance for both lasso and elastic net. Whereas splitting the model into a single training and test data set has limited ability to accurately characterize uncertainty in results, particularly for small sample sizes, repeating the training/testing process can provide more reasonable estimates of how accurately the model can predict outcomes on future data sets that it has not previously encountered (Kuhn & Johnson, 2013). We calculated a 95% bias-corrected and accelerated confidence interval (CI) of the model performance metric (AUC) using 5,000 bootstrapped resamples. For models with unbalanced classes (e.g., more than 70% of cases belonging to one class), we used upsampling to improve the balance across classes. We then refitted a model using the optimal lambda parameter to examine variable importance/coefficients for the best-fitting model. Statistical analyses were performed in R (R Core Team, 2018) using the *caret* package (Kuhn, 2008) and the *boot* package (Canty & Ripley, 2017).

Model fit indices. We used a mean cross-validation estimate of Area Under the Receiving Operating Characteristics Curve (AUC) to assess the overall prediction accuracy for all regressions. Guidelines for AUC scores range from extremely poor (0.5–0.59), poor (0.60–0.69), fair (0.70–0.79), good (0.80–0.89), to excellent (>0.90).

Results

Baseline Correlations

Correlations among study variables at baseline are provided in Figure 1. Several SGM-specific stressors were significantly correlated with family support, self-criticism, body image, and depressive symptoms; few were significantly correlated with SITBs. Depression symptoms, self-criticism, body image, and family strain were correlated with lifetime frequency of NSSI, suicidal ideation, and suicide plans, but not suicidal behaviors.
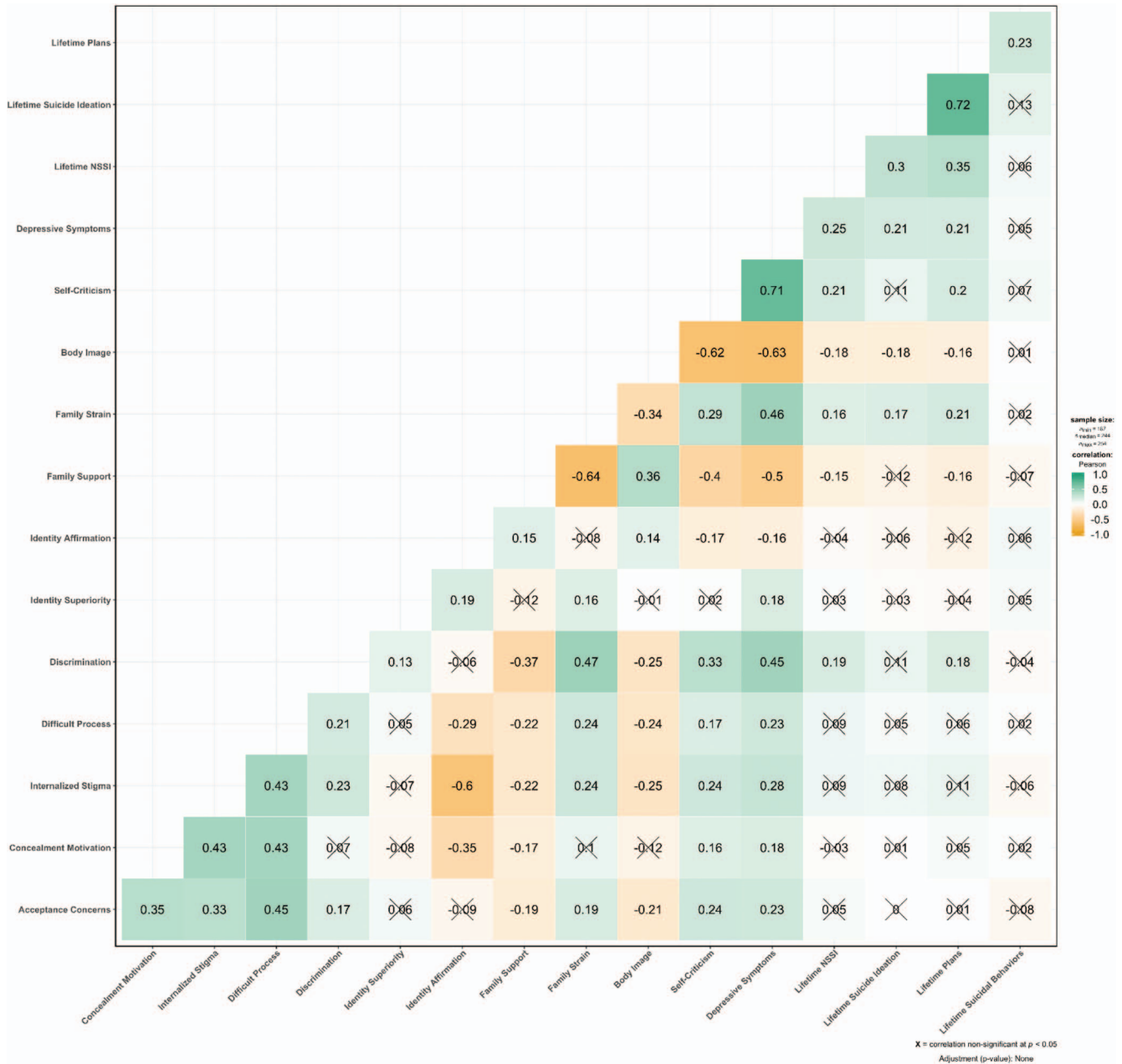
Figure 1. Associations among SGM-related factors, general factors, and SITBs. SGM = sexual or gender minority; SITB = self -injurious thoughts and behaviors; NSSI = nonsuicidal self-injury. See the online article for the color version of this figure.

Prospective Model Performance

Model performance indices for all lasso and elastic net regularized logistic regressions are reported in Table 2. At six-month follow-up, both lasso and elastic net regularized logistic regressions produced excellent predictive accuracy for predicting suicidal ideation, good predictive accuracy for predicting NSSI and suicide plans, and fair predictive accuracy for predicting suicidal behaviors. These results indicate that the algorithms performed well in identifying true positives and true negatives.

Predictor Importance

Coefficients for the variables in each model are shown in Table 3. Predictors remaining in both models are listed below, in decreasing order of importance to the final models.

NSSI. Following regularization, both minority-specific and general variables remained in the lasso and elastic net models for the prediction of NSSI. For both lasso and elastic net models, lifetime presence of NSSI, family support, self-criticism, lifetime frequency of NSSI, lifetime presence of

Table 2
Model Performance of Lasso and Elastic Net Regularized Logistic Regressions

	Lasso		Elastic net		
Outcome variable	Mean AUC [95% CI]	λ	Mean AUC [95% CI]	λ	α
NSSI	.88 [.86, .91]	.012	.89 [.86, .92]	1.051	.1
Suicide ideation	.91 [.86, .95]	.056	.93 [.90, .95]	.095	.4
Suicide plans	.81 [.75, .86]	.084	.84 [.79, .88]	.13	.6
Suicide behaviors	.78 [.72, .83]	.074	.79 [.74, .84]	.059	.9

Note. AUC = area under the ROC curve. Lambda (penalization) and alpha (mixing) parameters were identified through ten-fold cross-validation repeated three times for both the lasso and elastic net models.

suicidal behaviors, and everyday discrimination emerged as variables of most importance. Of note, the coefficients for family support in both models were negative, indicating that more family support was associated with a decreased likelihood of NSSI at follow-up.

Suicidal ideation. Variables remaining for the prediction of suicidal ideation in both lasso and elastic net models were primarily SITBs and general factors, rather than minority-specific factors. The most important variables in both models were a lifetime presence of suicidal ideation, depression symptoms, suicide plans, suicidal behaviors, and NSSI.

Suicide plans. Variables remaining for the prediction of suicide plans in both lasso and elastic net models were primarily SITBs and general factors, rather than minority-specific factors. The most important variables in both models were a lifetime history of suicidal behaviors, ideation, and plans, as well as self-criticism.

Suicidal behaviors. Variables remaining for the prediction of suicide plans in both lasso and elastic net models were both minority-specific and general factors. The most important variables in both models were a lifetime history of suicidal behaviors, depression, and experiences with everyday discrimination.

Table 3
Coefficients for Variables in Lasso Regularized Logistic Regression

	NSSI		Suicidal ideation		Suicide plans		Suicidal behaviors	
Predictor	Lasso	Elastic net	Lasso	Elastic net	Lasso	Elastic net	Lasso	Elastic net
Self-injurious thoughts and behaviors (SITBs)								
NSSI (lifetime frequency)	.31	.04	—	—	—	—	—	—
Suicidal behaviors (lifetime frequency)	−.30	—	—	—	—	—	—	—
NSSI (lifetime presence)	1.59	.2	.02	.11	—	—	—	—
Suicidal ideation (lifetime presence)	.24	—	.79	.58	.28	.26	—	—
Suicide plan (lifetime presence)	—	—	.08	.17	.16	.17	—	—
Suicidal behaviors (lifetime presence)	.17	.05	.03	.18	.44	.35	.37	.44
SGM-specific factors								
Acceptance concerns	—	—	—	—	—	—	—	—
Concealment motivation	—	—	—	—	—	—	—	—
Internalized stigma	.29	—	—	—	—	—	—	—
Difficult process	−.64	—	—	—	—	—	—	—
Everyday discrimination	.02	.01	—	—	—	—	.11	.18
Friends identifying as SGM	.04	—	—	—	—	—	—	—
People identifying as SGM & engaging in NSSI	—	—	—	—	—	—	—	—
Gender minority status	—	—	—	—	—	—	—	—
Sexual orientation	−.21	—	—	—	—	—	—	—
General factors								
Self-criticism	.47	.02	—	.02	.04	.08	—	—
Depression symptoms	−.49	—	.31	.28	—	—	.33	.4
Body image	—	—	—	—	—	—	—	—
Family support	−.48	−.02	—	—	—	—	—	—
Family strain	.20	—	—	.044	—	—	—	—
Race	—	—	—	.09	—	—	—	—
Socioeconomic status	—	—	—	—	—	—	—	—
School status	.11	—	—	—	—	—	—	—
Friends engaging in NSSI	—	—	—	—	—	—	—	—

Note. NSSI = nonsuicidal self-injury; SITB = self-injurious thoughts and behaviors; SGM = sexual or gender minority. Lasso coefficients represent the final model, identified through ten-fold cross-validation repeated three times to identify the optimal lambda (penalization) parameter. Elastic net coefficients represent the final model, identified through ten-fold cross-validation repeated three times to identify the optimal lambda (penalization) parameter and alpha (mixing) parameter. Coefficients from both models are interpreted in the same way as standard (non-regularized) logistic regression models.

Discussion

SGM-identifying youth experience elevated risk for a range of health risk behaviors, including SITBs. However, risk factors for SITBs within this high-risk population remain largely unclear. The minority stress model posits that minority-related stressors, including discrimination, desire to conceal SGM identity, internalized stigma toward one's identity considering cisgender and heterosexual culture, and familial difficulties may play an important role in increasing SITB engagement. The present study tested both minority-stress specific and more general risk factors as correlates and predictors of NSSI, suicidal ideation, suicide plans, and suicidal behaviors in a sample of adolescents reporting SGM status. Models resulted in excellent predictive accuracy of NSSI and suicidal ideation, good predictive accuracy for suicide plans, and fair predictive accuracy for suicidal behaviors. Results provided modest but limited support for the minority stress model.

Supporting the minority stress model, the present study indicated cross-sectional associations among several SGM-specific stressors and more general risk factors, including depression, self-criticism, and body image (negatively). Moreover, everyday discrimination experiences were associated with NSSI and suicide plans. However, contrary to the minority stress model and some prior research on this topic (House, Van Horn, Coppeans, & Stepleman, 2011), no other SGM-specific factors were associated with SITBs. Reasons for these mixed effects remain unclear. One possibility relates to the high rate of SITB engagement in the present sample. Additional, multi-timepoint studies involving younger samples may be needed to test whether general risk factors mediate the relationship between SGM-specific risk factors and SITB onset, and to test whether other forms of minority stress are directly related to SITB engagement.

Also supporting the minority stress model and some preliminary longitudinal research (Mustanski & Liu, 2013), several minority stress factors predicted future engagement in NSSI (e.g., internalized stigma, difficult process, discrimination) and suicidal behaviors (i.e., discrimination) using lasso models. Results suggest that minority stress-related factors may longitudinally predict some SITBs in SGM adolescents. Of note, however, the strength of these relationships was less consistent when comparing both lasso and elastic net models, which may indicate a limited effect. Inadequate assessment of SGM-minority stress in adolescents and high rates of endorsement for all SITBs at baseline may have impacted these results. In addition, the difference between lasso and elastic net models regarding treatment of collinear predictor variables (Zou & Hastie, 2005) may have influenced some of the differences between models in predicting NSSI and suicidal ideation (see Table 3), highlighting the challenge of prediction using highly correlated variables.

More general factors also emerged as predictors of SITBs among SGMs. Self-criticism, which is identified as a key risk factor within the benefits and barriers model of NSSI (see Hooley & Franklin, 2018), emerged as a significant predictor of NSSI and suicide plans. Depression also emerged as a significant predictor of suicidal ideation and suicidal behaviors. Relatedly, a prior history of SITB engagement emerged as a significant predictor of all SITB outcomes including NSSI, paralleling previous meta-analytic evidence (Ribeiro et al., 2016). Results suggest that even within SGM populations, these more general SITB risk factors may play im-

portant roles in the decision to engage in SITBs. Of note, none of these factors on their own were strong predictors of SITB outcomes; it was only when combined within the larger statistical models that stronger predictive accuracy occurred. Contrary to prior research, NSSI emerged only as a significant predictor of NSSI and suicidal ideation, but not suicide plans or behaviors. Results suggest that NSSI may be a weaker predictor of suicide plans and behaviors among SGMs, perhaps because of limited SITB variance (i.e., higher overall rates) observed within this population. However, interpretation of this relationship is limited without replication in other SGM samples, particularly samples recruited prior to the onset of NSSI.

Results should be interpreted in light of study limitations. First, the majority of participants in our study reported SITB engagement at baseline, and prior SITB engagement and frequency were among the strongest predictors of these outcomes at follow-up. The strength of these factors prior to SITB onset may be quite different, especially considering that SITBs tend to be among the strongest predictors of these outcomes (e.g., Ribeiro et al., 2016). Future studies including younger samples could be helpful in this regard. Second, the present analyses did not include male SMs or a heterosexual comparison group, limiting our ability to infer differences between SGMs and other populations. Third, participants were recruited from online forums and social media platforms in which study advertisements were preferentially aimed at users who "liked" or "followed" content related to LGBTQ interests. The present sample may not generalize to other SGM youth. Finally, because the present study only included assessments at two timepoints, it was not possible to test whether general risk factors may mediate the relationship between minority-related stressors and SITB engagement.

The present study has several important implications. First, we used a two time-point design and provided some of the first longitudinal evidence investigating risk factors for SITBs among SGM adolescents. Second, the present work used a novel approach in the study of adolescents, allowing for anonymous participation, avoiding parental involvement, and decreasing incentive to conceal SGM status and/or SITB engagement. Third, the present study used advanced statistical methods to account for the relatively high level of multicollinearity among study variables. More longitudinal and experimental research is needed to test whether and how minority-related stressors impact risk for psychopathology and SITBs in SGM youth.

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