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Growth trajectories of peer norms, self-efficacy and condom use behavior among sexually active Chinese men who have sex with men: Latent class analysis and growth mixture modeling

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Abstract

Data from a randomized controlled trial in 2015 were used to estimate the growth trajectories of peer norms, self-efficacy, and condom use behavior, and to identify associated sociodemographic and behavioral factors among a sample of 804 Chinese men who have sex with men (MSM). Latent class analysis and growth mixture modeling were conducted using Mplus. Two growth trajectories were estimated for each outcome variable with good model fit. The growth trajectories of peer norms were related to age ($\beta = -0.066$, $p < 0.05$). The growth trajectories of self-efficacy were related to age ($\beta = 0.057$, $p < 0.01$) and using a condom during first sexual encounter with another man ($\beta = 0.777$, $p < 0.001$). The growth trajectories of condom use behavior were related to income ($\beta = 0.366$, $p < 0.01$) and having casual male partners ($\beta = -1.016$, $p < 0.001$). Predictors for the growth factors within each latent class were also estimated. For subsets of MSM who are older, richer, used a condom during their first sexual encounter with another man, and do

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CONTRIBUTORS

HL contributed to the conception and design of the study and drafted the paper. JT provided oversight for data collection, and WM, DK, ML, WT, and BJ assisted in the data collection. HL and GM searched the literature. HL and ESK analyzed the data. All authors revised the manuscript and approved the final version to be published.

HUMAN PARTICIPANT PROTECTION

This study was reviewed and approved by institutional review boards at the Guangdong Provincial Center for Skin Diseases and STI Control, University of North Carolina at Chapel Hill, and University of California San Francisco.

not have a casual male partner, condom videos may not have sufficient efficacy and other interventions may be necessary.

Keywords

condom use; growth trajectory; latent class analysis; growth mixture modeling; Chinese MSM

INTRODUCTION

Although notable progress in HIV prevention has been achieved worldwide, HIV incidence and prevalence rates remain high among men who have sex with men (MSM) globally (1). In China, the HIV prevalence among MSM is still increasing (2, 3). The proportion of HIV transmission attributed to MSM comprised 2.5% of all cases in 2006 and reached 25.8% in 2014 (4). Sexual risk behaviors have been identified as one of the leading causes of this rising trend (5). Many Chinese MSM engaged in high-risk sexual behaviors, such as condomless sex (6, 7). Meta–analysis and systemic reviews of condom use habits among Chinese MSM have further revealed low rates of consistent condom use (8, 9). According to a 2010 online survey, only 9.1% of MSM reported consistent condom use during oral sex, and 66.3% and 60.4% respectively during insertive and receptive anal sex in the past 6 months (5). Furthermore, a subsequent national study among Chinese MSM in 2013 found that the rate of consistent condom use during anal sex in the last 6 months were 48.8% for general MSM and 55.0% for commercial sex (10).

Peer norms and self-efficacy are two important constructs closely related to condom use behaviors. The health belief model suggests that self-efficacy is crucial for behavior change, in particular when preventive actions are difficult to adopt (11). According to the theory of reasoned action, peer norms are a key factor that predicts safer sex intentions (12). Condom use self-efficacy is defined as one’s confidence in one’s own ability to adhere to condom use guidelines in challenging situations (13). Condom use peer norms is defined as the expected patterns of behavior and attitudes toward condom use among one’s peers (14). These two constructs possibly play intercorrelated roles in determining sexual risk behaviors. In addition to knowledge gathered on condom use behavior, which is considered the overt behavior of using a condom when having sex (15), some scholars have integrated theoretical concepts in their specific studies, such as introducing the influence of peer norms into the health belief model (16). Studies conducted among Chinese MSM have reported that condom use peer norms and self-efficacy are associated with condom use behavior (17, 18). In order to improve intervention effects, preventive techniques guided by theories on peer norms and self-efficacy have been adopted to promote the active use of condoms among MSM (17, 19), and one study supported the importance of peer norms and self-efficacy in condom promotion interventions among MSM (20). In the current condom promotion intervention, peer norms, self-efficacy, and condom use behavior are three key constructs to be considered.

These condom use constructs have longitudinal changing paths, also called growth trajectories in structural equation modeling, since people can vary in their perceptions of

peer norms and self-efficacy, and behaviors of condom use over time both within and between persons. Growth trajectories of condom use are important because consistent condom use is one of the most effective means in preventing sexual transmission of HIV (21). Moreover, previous studies have found that MSM are diverse and include different subgroups (22, 23). This indicates that adopting person-centered methods to examine variability and clusters of individual growth trajectories of condom use may help to better understand individual differences and similarities in their condom use change process and patterns under a condition of intervention (24). However, there is a dearth of studies that examine growth trajectories of peer norms, self-efficacy, and condom use behavior over time. Drawing from a randomized controlled trial (RCT) that found no significant difference in condom use-related outcomes between two condom use video interventions (25), the current study seeks to explore condom use growth trajectories under an intervention condition, such as intervention responders and non-responders, and identify related sociodemographic and behavioral predictors. The current study will add new knowledge significantly to the existing findings of this RCT, including patterns of condom use growth trajectories, growth factors within each pattern (latent class), and related covariates. Such knowledge may facilitate the development of effective condom promotion interventions that are tailored to MSM with specific characteristics.

METHODS

Study population and procedure

The longitudinal data used in this analysis were from a non-inferiority RCT (26, 27) examining the effects of condom promotion videos on subsequent condom use among MSM in China. This RCT had two intervention groups. The one-minute video for the experimental group was developed through a crowdsourcing approach and depicted a wall protecting against cartoon viruses to figuratively demonstrate the protective function of condoms. The one-minute video for the standard care control group was developed through a collaboration between a social marketing team and the research team and depicted two men negotiating condom use before having sex so as to demonstrate sexual health as love. This RCT found no significant differences between the impacts of the two video interventions on MSM's condomless sex engagement, HIV testing, or other condom-related outcomes at 3 weeks and 3 months post-intervention (25). Data from the two groups were therefore combined as one in this analysis so as to have a larger sample to run complex growth mixture modeling, and the intervention group was used as a covariate in the models.

Data were collected online at baseline, 3weeks later, and 3 months later among MSM in China in 2015. Popular online and social media platforms in China were utilized to recruit participants nationwide, including the largest gay website (Danlan.org), a micro blogging platform (Weibo), a messaging app (WeChat), and a messaging platform (QQ). Participants were directed to an anonymous and voluntary survey via Qualtrics (Provo, Utah) after clicking on a banner ad. Inclusion criteria were being born biologically male, having had anal sex with a man at least once during their lifetime, having had condomless anal or vaginal sex in the past three months, and being at least 16 years of age (15, 28). Informed

consent was obtained from all eligible participants before the survey. Ethics approval was granted by institutional review boards at relevant institutes.

Measurements

Our research team has conducted several online surveys among Chinese MSM (15, 28). The current survey instrument was developed iteratively. We began with a previously developed survey that assessed sociodemographic characteristics, sexual history, HIV/STI testing, and risk behaviors. After a comprehensive literature search, we revised items. Research team members, local stakeholders, and MSM participants provided input for adaptations, such as refining the wording and checking the logic and flow of the questionnaire (27). Furthermore, two rounds of field-testing were conducted, and then a revised version was piloted among 150 MSM before the final survey was launched. Sociodemographic and sexual risk factors were assessed at baseline; peer norms, self-efficacy, and condom use behavior were assessed at baseline and both follow-ups.

Condom use peer norms—Peer norms for condom use were measured using a five-item scale (14, 29). Questions included participants' perceptions of their friends' attitudes towards condom use and safe sex. For example, participants were asked to evaluate the following statement: "If a friend knew that I might have sex on a date, he would ask me if I was carrying a condom." Answers were given in a five-point Likert format: strongly agree (5), agree (4), neutral (3), disagree (2), strongly disagree (1). Cronbach's alpha at baseline was 0.832. The mean score was calculated. Higher scores indicated higher self-reported strength of condom use peer norms.

Condom use self-efficacy—Condom use self-efficacy was measured using a seven-item scale (13). Participants were asked how comfortable they felt about negotiating and using a condom with sex partners. For example, participants were asked to evaluate the following statement: "I feel confident that I could refuse to have sex with a partner who did not want me to use a condom." Response options included the same five-point Likert format: Strongly agree (5) to strongly disagree (1). Cronbach's alpha at baseline was 0.823. The mean score was calculated. Higher scores indicated higher self-reported strength of condom use self-efficacy.

Condom use behavior—Frequency of condom use behavior with male partners was assessed with a single item (15). Participants were asked: "In the last three months, when you had anal sex with any male partner, how frequently did you use a condom?" (In the 3 week follow-up survey, participants were asked about the past 3 weeks.) Answers were given in a four-point Likert format: Always used (4), mostly used (3), sometimes used (2), and never used (1); thus, higher scores indicated higher self-reported frequency of condom use.

Statistical analyses

The original dataset had 1173 participants. In this analysis, men who did not report having anal sex with men in the last three months at baseline were excluded and 989 participants were retained, given the fact that the content of the videos was about sexual activities and

condom promotion between men. SPSS 19 was used for initial data analysis. Logistic regression was conducted to find that the missingness at both the three-week and three-month follow-ups (n = 185) were not related to condom use behavior, age, marital status, education and income levels at baseline. Participants who missed both follow-ups were then excluded (30), with 804 participants retained in the current analysis. There was no missing data at baseline. At the two follow-ups, there were missing data in peer norms, self-efficacy, and condom use. These three variables had the same missing rate and pattern at each wave. Two binary variables of missingness were created for the 2nd and 3rd waves respectively where "1" represents a missingness and "0" represents no missingness. Bivariate analyses indicated data missing at random (31). Data imputation was then used with the Markov Chain Monte Carlo approach in Mplus (32). Descriptive analysis of participants' sociodemographic characteristics was then conducted and longitudinal correlation patterns of indicators at different time points for peer norms and self-efficacy were examined. The observed large correlation coefficients among the indicators at the same time point provided evidences of a global latent factor for each of peer norms and self-efficacy. Also, the correlation coefficients among the indicators increased at each timepoint.

Mplus 7.4 was then used to conduct the following analyses. Given that the constructs of peer norms and self-efficacy were measured using scales, second-order growth mixture modeling were used for each of them (33). Second-order growth mixture modeling is an approach to investigate potential heterogeneity in second-order trajectories of global domains and is able to account for measurement error in the manifest indicators of confirmatory factors at the population level, which may provide a more precise test for population heterogeneity compared to other modeling with composite measures (33). The second-order growth mixture modeling consists of two components: longitudinal confirmatory factor analysis model for repeated measures of peer norms or self-efficacy at the first part and growth mixture modeling at the second part.

The analysis was conducted in several steps. The first three steps were preliminary analyses to build the second-order growth mixture modeling. First, an unconstrained longitudinal confirmatory factor analysis (LCFA) was performed. The overall model fit was examined by using the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean residual (SRMR). Acceptable model fit is determined by a value of RMSEA less than 0.08, and values of CFI and TLI greater than 0.90, and a value of SRMR less than 0.08 (32). Some paths/correlations of interest were freed when their modification indices were more than 10 and made sense theoretically. The fit indexes were good and the models were retained. The estimated larger correlation coefficients among the indicators at the same time point comparing with other time points provided evidence of a global latent factor. The correlation coefficients among the indicators increased from time point 1 to 3.

Second, measurement invariance was examined by comparing nested LCFA models with equality constraints on loading, intercept, and residual variance, and trait factors (IT Model). The cut-off values of the changes in the CFI (△CFI) and the RMSEA (△RMSEA) between the unconstrained model and the constrained model should be less than 0.01 and 0.015 respectively (32). The assumption of measurement invariance was met.

Third, second-order growth curve: curve-of-factors models with equality constraints on the first order latent variable residual variances were conducted to examine the variances of the second order growth factors. Significant variation was found in the growth function between individuals, which provides evidence for the existence of heterogeneity in longitudinal changes of outcome variables.

Fourth, several latent class growth models, including latent class growth analysis (LCGA), growth mixture model with class-invariant variances and covariances (GMM-CI), growth mixture model with class-varying variances and covariances (GMM-CV), were estimated (32, 33). Before selecting the optimal class model, univariate skewness and kurtosis statistics were investigated with all absolute values less than 2, which indicated generally accepted multivariate normality (34). LCGA is a simplified GMM, which does not allow within-class variability. Multiple enumeration indices, sample size in each class, interpretability of each class trajectory, and parsimony were all taken into account in the model comparisons. Multiple enumeration indices include Bayesian Information Criterion (BIC), Sample-Size Adjusted BIC (ABIC), entropy, Lo-Mendell-Rubin Adjusted Likelihood Ratio Test (Adj. LMR-LRT), and Bootstrapped Likelihood Ratio Test (BLRT). According to Wickrama et al (2016), better fitting models are indicated by lower BIC and ABIC values; entropy values of .40, .60, .80 represent low, medium, and high class separation; a statistically significant p-value for Adj. LMR-LRT and BLRT indicates the current model provides a better fit than the model with one less class; the sample size in each class should not be less than 5.0%, and the size of the smallest class should not be less than 25 (33). When viewing the plots (see supplemental figures), each class trajectory should be clearly distinct and separate from other classes, and the classes should also be clearly interpretable and consistent with theory. A Wald chi-square test was also used to test mean equality across latent classes (33). Considering all of the available information simultaneously, the optimal latent class growth models were then selected.

Last, a 3-step approach was utilized to incorporate sociodemographic and behavioral factors into the optimal models. These factors included age, marital status (Not married = 1, engaged or married = 2, separated or divorced = 0), education, income, sexual identity (gay = 1, bisexual = 2, unsure = 0), number of male partners in the last 3 months, using a condom during the first sexual encounter with another man (Yes = 1, No = 0), having primary male partners (Yes = 1, No = 0), having casual male partners (Yes = 1, No = 0), and intervention group (crowdsourcing = 1, marketing = 0) (35–39). And then, categorical latent variable multinomial logistic regression was conducted with the identified class membership as an outcome variable and the aforementioned variables as predictors of class membership. Because the construct of condom use behavior was assessed with a single item, a first-order growth mixture model was conducted (40).

RESULTS

Sample characteristics

Among the 804 MSM, the mean age was 24.9 (SD = 6.5); 58.3% were ≤ 24 years of age; 10.8% were currently married to a woman or engaged; 67.8% had a college diploma or

higher level of education; 82% had an annual income less than 9678 USD (60000 RMB). (Please see the supplemental table for additional sample characteristics.)

Missing Data

The sample in the current analysis included 623 MSM who finished all three assessments and 181 MSM who finished the baseline and at least one follow-up. The variables with missing data included age (3 missing), number of male sex partners in the last 3 months (4 missing), peer norms at the 2nd (43, 5.3% missing) and 3rd time points (138, 17.2% missing), self-efficacy at the 2nd (43, 5.3% missing) and 3rd time points (138, 17.2% missing), condom use behavior at the 2nd (43, 5.3% missing) and 3rd time points (138, 17.2% missing). The missing data in age and the number of male sex partner in the last 3 months were due to non response to the items. The missing data in peer norms, self-efficacy, and condom use were due to attrition. Bivariate analysis found that the missingness at the 2nd wave was not related to condom use behavior or any item of peer norms at baseline, but was related to two items of self-efficacy (rho = 0.085, p = 0.016, and rho = 0.082, p = 0.021, respectively). The missingness at the 3rd wave was related to condom use behavior at baseline (rho = 0.121, p = 0.001) but not related to condom use behavior at the 2nd wave. Also, the missingness at the 3rd wave was related to having primary male partners in the last 3 months (rho = 0.087, p = 0.014), having casual male partners in the last 3 months (rho = −0.079, p = 0.025), two items of peer norms (rho = 0.130, p = 0.000 and rho = 0.075, p = 0.038, respectively) and two items of self-efficacy (rho = 0.105, p = 0.004, and rho = 0.075, p = 0.039, respectively) at the 2nd wave. These findings indicate that the data were not missing completely at random (MCAR), but the data might be more likely to be missing at random (MAR) and their missingness might not have large impact on the research results when missingness was treated with an appropriate method (i.e., data imputation).

Preliminary analyses

The unconstrained longitudinal confirmatory factor analysis (LCFA) models had good fit indexes (for peer norms, RMSEA = 0.051, 90% CI 0.043–0.059, CFI = 0.981, TLI = 0.969, SRMR = 0.046; for self-efficacy, RMSEA = 0.047, 90% CI 0.042–0.053, CFI = 0.962, TLI = 0.948, SRMR = 0.037). The LCFA models with equality constraints on loading and intercept across time points had good fit indexes (for peer norms, RMSEA = 0.053, 90% CI 0.046–0.060, CFI = 0.973, TLI = 0.966, SRMR = 0.062; for self-efficacy, RMSEA = 0.047, 90% CI 0.042–0.052, CFI = 0.956, TLI = 0.948, SRMR = 0.044). The changes in CFI (△CFI for peer norms = 0.008, △CFI for self-efficacy = 0.006) were smaller than a cut-off value of 0.01. The changes in RMSEA (△RMSEA for peer norms = 0.002, △RMSEA for self-efficacy = 0.000) were all smaller than a cut-off value of 0.015. These results support the assumption of measurement invariance. Furthermore, second-order growth curve: curve-of-factors models with equality constraints on the first order latent variable residual variances were constructed. The fit indexes were good (for peer norms, RMSEA = 0.053, 90% CI 0.046–0.060, CFI = 0.973, TLI = 0.966, SRMR = 0.061; for self-efficacy, RMSEA = 0.045, 90% CI 0.040–0.050, CFI = 0.960, TLI = 0.953, SRMR = 0.044). The variances for the intercept (I) and slope growth (S) factors were statistically significant (for peer norms, Ψ_I= 0.208, p = 0.000 and Ψ_S = 0.045, p = 0.000, respectively; for self-efficacy, Ψ_I = 0.361, p = 0.000 and Ψ_S = 0.041, p = 0.003, respectively), indicating significant variation in the

growth function between individuals. This is evidence for the existence of heterogeneity in longitudinal changes of condom use peer norms and self-efficacy.

Optimal latent class model for condom use peer norms

As shown in Table 1, the models with 3 classes were questionable, as indicated by bootstrap draws not converging and a latent variable covariance matrix being not positive definite. Additionally, the non-significant Adj. LMR-LRT, small class sizes, and low entropy values of the 3-class model indicated the 2-class model was preferred. After comparing all of the available information simultaneously among the six models, the 2-class GMM-CI model with the slope growth factor mean of the 2nd latent class being fixed at zero was selected as the best fitting model because of highest entropy value, comparatively low BIC and ABIC values, and adequate class sizes. As shown in Supplemental Figure 1, latent class 1 had an initially moderate and increasing trajectory ($\alpha = 2.60$ $p < 0.001$, $\beta = 0.381$ $p < 0.01$) with an observed effect size of 1.699, showing increases of condom use peer norms from time point 1 to 3, whereas latent class 2 had a consistently higher trajectory ($\alpha = 3.694$ $p < 0.001$, β being fixed at zero) with an observed effect size of 0.038.

Optimal latent class model for condom use self-efficacy

As shown in Table 2, the models with 3 classes again had convergence problems (e.g., local maxima, latent variable covariance matrices being not positive definite, bootstrap draws not converging). Also, GMMs did not produce reasonable solutions and had convergence problems, indicating no considerable variability across individuals in terms of their baseline performance and growth, which supports the use of the LCGA model with zero variance of intercept and slope. The 2-class LCGA model with significant Adj. LMR-LRT, acceptable entropy, and adequate class sizes was therefore selected as the best fitting model. As shown in Supplemental Figure 2, latent class 1 had a consistently higher trajectory ($\alpha = 4.276$ $p < 0.001$, $\beta = 0.073$ $p < 0.05$) with an observed effect size of 0.20, whereas latent class 2 had an initially moderate and slightly increasing trajectory ($\alpha = 3.281$ $p < 0.001$, $\beta = 0.115$ $p < 0.001$) with an observed effect size of 0.276, showing slight increases of condom use self-efficacy from time point 1 to 3.

Optimal latent class model for condom use behavior

As shown in Table 3, the 2-class GMM-CI model (with the slope growth parameter of the first class being fixed at zero) did not have convergence problems and had the highest entropy value, reasonable class sizes, comparatively small BIC and ABIC, and significant BLRT. It was therefore selected as the best fitting model. As shown in Supplemental Figure 3, latent class 1 had an initially lower and stable trajectory ($\alpha = 6.737$ $p < 0.001$, $\beta = -0.479$ $p = 0.096$) with an observed effect size of 0.221, whereas latent class 2 had an initially low and increasing trajectory ($\alpha = 9.137$ $p < 0.001$, $\beta = 3.624$ $p < 0.001$) with an observed effect size of 0.798, showing increases of condom use behavior from time point 1 to 2, and then slight decreases from time point 2 to 3.

The effects of covariates on the categorical latent classes

Table 4 shows significant associations between latent class membership and sociodemographic and sexual risk factors. Age was significantly associated with the categorical latent classes of peer norms and self-efficacy. Using a condom during first sexual encounter with another man was significantly associated with the categorical latent classes of self-efficacy. Having casual partners and income were significantly associated with the categorical latent classes of condom use behavior.

The effects of covariates on the continuous latent growth factors

Table 5 shows significant associations between latent growth factors (i.e., the intercept and slope) and sociodemographic and sexual risk factors. Peer norms latent class 1 had an initially moderate and increasing trajectory. Being bisexual and the number of male sex partners in the last 3 months were negatively associated with the intercept factor; being gay was negatively associated with the slope growth factor. Peer norms latent class 2 had a consistently higher trajectory. Using a condom during first sexual encounter with another man was positively associated with the intercept factor, but no covariates were significantly associated with the slope growth factor. Taken together, these significant associations indicate that covariates had interactions with the latent class membership, in regard to their effects on the growth trajectories of peer norms.

Self-efficacy latent class 1 had a consistently higher trajectory than latent class 2's initially moderate and slightly increasing trajectory. Using a condom during the first sexual encounter with another man was positively associated with the intercept factor for latent class 1, but no covariates were significantly associated with the slope growth factor. Self-efficacy latent class 2's intercept factor was not significantly associated with any covariates; however, having primary sex partners was negatively associated with the slope growth factor. This indicates that covariates had interactions with the latent class membership, in regard to their effects on the growth trajectories of self-efficacy.

Condom use behavior latent class 1 had an initially lower and stable trajectory and class 2 had an initially low and inverted-V shaped trajectory. For both classes, being engaged or married, using a condom during first sexual encounter with another man, and having primary sex partners were significantly associated with the intercept factors, while being gay and bisexual were negatively associated with the slope growth factors. This indicates that covariates did not have interactions with the latent class membership, in regard to their effects on the growth trajectories of condom use behavior.

DISCUSSION

In this study, a data-driven, participants-centered approach was used to understand the homogeneity and heterogeneity of growth trajectories of peer norms, self-efficacy, and condom use behavior among a sample of 804 online sexually active Chinese MSM in an RCT. The growth trajectories were estimated among three outcome variables respectively in latent class models. Sociodemographic factors (i.e., age, marital status, income, and sexual identity) and sexual risk behavioral factors (i.e., number of male partners in the last 3

months, using a condom during first sexual encounter with another man, having primary male partners, and having casual male partners) were found to be related to the categorical latent classes, and continuous intercept and/or slope growth factors in the growth mixture models. These structural equation modeling analyses added significantly to the findings of this RCT. The responders and non-responders of the video interventions were identified regarding the three research outcomes respectively through the analyses of the growth trajectories. It was subsequently discovered that the estimations of related sociodemographic and behavioral factors can be used to refine effective condom promotion interventions tailored for MSM with specific characteristics.

The study identified two categorical latent classes for each outcome variable. One latent class had a clearly changing trajectory (the responders of the interventions), and another latent class had a stable trajectory, which barely changed (the non-responders of the interventions). The patterns of growth trajectory regarding condom use peer norms and self-efficacy share some characteristics. Intervention responders who had lower perceptions of condom use peer norms and self-efficacy at baseline developed these perceptions faster after the video interventions, compared to the non-responders who had higher perceptions at baseline. However, for condom use behavior, there were different patterns of growth trajectory. The responders' scores were initially low and increasing, whereas the non-responders' scores were initially lower and stable. These clear distinctions in the growth trajectories could be attributed to the effects of the video interventions. This observation confirms an important issue of heterogeneous growth trajectories in condom use constructs among online sexually active Chinese MSM, which is consistent with a longitudinal study conducted in the United States, showing heterogeneous sexual risk trajectories among MSM (23). In this regard, the heterogeneity of growth trajectory can be fully utilized to identify the responders and non-responders of the video interventions.

These categorical latent classes of responders and non-responders (between-class variabilities) were estimated to be related to some sociodemographic and behavioral factors, such as age, income, using a condom during first sexual encounter with another man, and having casual male partners. These factors have been reported to be related to condom use in previous studies (35–37, 39, 41). MSM who were older and used a condom in their first sexual encounter with another man were more likely to not respond regarding peer norms and self-efficacy (in a consistently higher and not obviously changing trajectory). These characteristics of the subgroup could be attributed to the fact that aging may have increased their knowledge and perception about condom use peer norms and self efficacy, and use of condom at first sex may have increased their confidence and skills in using condoms. As such, videos on condom use may have provided little additional benefit, resulting in an ineffective intervention for this specific subgroup of men. This is consistent with other studies reporting that age and the experience of using a condom during first sexual encounter with another man were related to perceptions about condoms (35, 42), which supports the argument that early condom use life may impact condom use later in life (43). These findings indicate it is necessary to embed condom promotion into MSM's developmental phase in life, and highlight the importance and urgency of promoting condom use in the first sexual encounter, particularly for younger MSM.

For condom use behavior specifically, MSM who had higher income and did not have casual male partners were more likely to be the non-responders (in an initially lower and stable trajectory). These characteristics of the subgroup could be due to the fact that some rich MSM used their economic power to choose and maintain stable partners, which could be perceived as an alternative way of protecting themselves from getting HIV. This finding is consistent with an ethnographic study conducted in China, describing that some rich MSM were more powerful in selecting sex partners whom they perceived as safe, and then used no condom (44). Scholars have argued that HIV is related to inequality, and often associated with social economic transition (45). This further suggests that relational dynamics may shape the risk environment for HIV in ways that are complex and multidimensional with asymmetric economic power relationship influencing sexual behaviors (46).

There were class-varying effects of covariates for both peer norms and self-efficacy. For the responders regarding peer norms, MSM who were bisexual and had more male sex partners were more likely to have lower perceptions of peer norms at baseline, while MSM who were gay were more likely to have lower rates of change after the interventions, compared to MSM who were unsure of their sexual identity. For the responders regarding self-efficacy, MSM who had primary male partners were more likely to have lower rates of change after the interventions. For the non-responders regarding both peer norms and self-efficacy, however, only use of a condom during first sexual encounter with another man was related to the intercept latent growth factor. In this regard, the latent class memberships moderated the relationship between the covariates and the within-class growth trajectories. These men's response to the video interventions was not only determined by their age and use or non use of a condom during their first sexual encounter with another man, but also related to the interactions of some other covariates and the latent class memberships. The video interventions may be more effective for those MSM who were uncertain about their sexual identity in terms of enhancing peer norms. This is consistent with a study reporting that online Chinese MSM were less accepting their sexual orientation (47), which is related to the issues of minority stress, including internalized homonegativity and concealment (48). Also, the video interventions may be more effective for those MSM who did not have a primary male partner in terms of enhancing self-efficacy, which is consistent with a study in the United States reporting that low condom use self-efficacy was related to unprotected sex with a primary partner (49). Researchers need to take into account the interactions between specific covariates (i.e., sexual identity, having primary male partners or not) and the latent class memberships (i.e., responders versus non-responders) so as to develop more tailored and effective interventions to improve condom use peer norms and self-efficacy.

Further modeling estimations showed no class-varying effect of covariates for condom use behavior. For both responders and non-responders, MSM who used a condom during first sexual encounter with another man, were engaged/married, and did not have a primary male partner were more likely to have higher level of condom use behavior at baseline, while MSM who were gay or bisexual were more likely to have lower rates of change after the interventions, compared to MSM who were unsure of their sexual identity. In this regard, the latent class memberships did not moderate the relationship between the covariates and the within-class growth trajectories. These men's response to the video interventions regarding

condom use behavior was only determined by their income and having casual male partners or not.

Implications for subsequent intervention projects have emerged from the analyses of both between-classes and within-class variabilities. First, video interventions should be designed giving consideration to sociodemographic and behavioral differences among key sub-populations. For example, younger MSM with lower income who did not use a condom during their first sexual encounter with another man and have casual male partners may be more likely to respond better to video interventions, which indicates potential utility of video-based interventions for MSM who are at a phase of sexual exploration. It is promising to develop condom promotion videos with more tailored contents using crowdsourcing and social marketing approaches, which should be attractive and interesting for this specific subgroup of MSM, and address their needs and express their voices.

Second, although younger MSM with lower income may respond better to the video interventions, more careful strategies that take into account deep-seated issues related to these men are required. Future research and interventions that focus on younger MSM should make efforts to develop and promote skills of negotiation and real practice of condom use at first sexual encounter particularly, and take into account related issues, such as struggles with sexual identity and minority stress.

Third, the use of videos as stand-alone interventions for high risk MSM may not be effective enough as our findings demonstrate that income and having no casual male partners are significantly related to the real practices of condom use behavior, indicating that economic empowerment and alternative means of protection, such as pre-exposure prophylaxis (PrEP) and post-exposure prophylaxis (PEP), should be considered in HIV prevention for specific subgroups of MSM (50). The use of PrEP and PEP may be feasible specifically for older and richer MSM who used a condom during their first sexual encounter with another man and do not have a casual male partner.

Limitations

This study is subject to limitations. The longitudinal data had only three waves, which is acceptable in structural equation modeling but still limits the growth trajectory analyses of condom use constructs. Longitudinal datasets with more frequent data collection occasions are needed in future studies. Moreover, the missing data were managed using a single imputation, and underestimates of variances, overestimates of correlations, and underestimates of standard errors could be possible. Furthermore, recruiting only high-risk MSM limited the study's ability to assess the general MSM population in China; however, this recruitment strategy enabled analyses to focus on HIV prevention for this key population. Also, the frequency of condom use was measured using self-reported data, so social desirability bias may be a concern. Finally, unlike many developmental studies conducted in naturalistic conditions, the current growth trajectory analyses were conducted in the context of an RCT with the goals of improving participants' condom use behaviors and refining the intervention content.

CONCLUSIONS

Latent class analyses were used to estimate different growth trajectories of condom use peer norms, self-efficacy, and condom use behavior respectively in the context of an RCT. The patterns of growth trajectories were further assessed in relation to age, income, using a condom during first sexual encounter with another man, and having casual male partners. Also, covariates of sexual identity and having primary male partners interacted with the subgroups of responders and non-responders to influence condom use peer norms and self-efficacy. The study suggests that for Chinese MSM who are older, richer, used a condom during their first sexual encounter with another man, and do not have a casual male partner, the one-minute condom use video interventions that focused on general knowledge of the protective function of condoms and negotiation of condom use as love may not be effective enough. Hence, other ways of intervention taking into account economic power imbalances and alternative means of protection (e.g., PrEP, PEP) are urgently warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Fit statistics for peer norms LCGAs and GMMs among online sexually active men who have sex with men in China, 2015 (n = 804)

Fit statistics	2 Classes	3 Classes
LCGA		
LL (No. of Parameters)	−13159.366 (52)	−13068.558 (55)
BIC	26666.591	26505.043
ABIC	26501.461	26330.387
Entropy	0.749	0.730
Adj. LMR-LRT (*p*)	526.487 (0.0001)	172.996 (0.0797)
BLRT (*p*)	552.721 (0.0000)	181.617 (0.0000) [a]
Group size (%) C1	585(72.8%)	387(48.4%)
C2	219(27.2%)	340(42.3%)
C3		75(9.3%)
GMM-CI		
LL (No. of Parameters)	**−13023.197 (54)**	−13011.639 (58)
BIC	**26407.632**	26411.275
ABIC	**26236.151**	26227.092
Entropy	**0.823**	0.768
Adj. LMR-LRT (*p*)	**53.860 (0.0085)**	21.558 (0.6019)
BLRT (*p*)	**56.544 (0.0000)**	22.632 (0.0000)
Group size (%) C1	**56(7.0%)**	31(3.8%)
C2	**748(93.0%)**	692(86.1%)
C3		81(10.1%)
GMM-CV		
LL (No. of Parameters)	−12997.781(57)	−12997.781 (64) [b]
BIC	26376.869	26423.696
ABIC	26195.861	26220.459
Entropy	0.390	0.615
Adj. LMR-LRT (*p*)	104.765 (0.4068)	0.000(0.5061)
BLRT (*p*)	107.375 (0.0000)	0.000(1.0000)
Group size (%) C1	432(53.7%)	432(53.7%)
C2	372(46.3%)	372(46.3%)
C3		0(0%)

Note. LCGA = Latent Class Growth Analysis. GMM-CI = Growth Mixture Model with class-invariant variances and covariances. GMM-CV = Growth Mixture Model with class-varying variances and covariances. LL = Log-Likelihood value. No. of Parameters = Number of estimated (freed) parameters. BIC = Bayesian Information Criteria. ABIC = Sample Size Adjusted BIC. LMR-LRT = Lo-Mendell-Rubin Likelihood Ratio Test. Adj. LMR-LRT = Adjusted LMR. BLRT = Bootstrap Likelihood Ratio Test. *p* = *p*-value.

[a] Bootstrap draws not converge.

[b] Latent variable covariance matrix not positive definite.

Table 2.

Fit statistics for self-efficacy LCGAs and GMMs among online sexually active men who have sex with men in China, 2015 (n = 804)

Fit statistics	2 Classes	3 Classes
LCGA		
LL (No. of Parameters)	**−19284.542 (74)**	−19267.030 (76)
BIC	**39064.114**	39042.469
ABIC	**38829.122**	38801.125
Entropy	**0.744**	0.834
Adj. LMR-LRT (p)	**624.163 (0.0000)**	604.320 (0.0000)
BLRT (p)	**655.264 (0.0000)**	634.432 (0.0000) [a]
Group size (%) C1	**492 (61.2%)**	327 (40.7%)
C2	**312 (38.8%)**	473 (58.8%)
C3		4 (0.5%)
GMM-CI		
LL (No. of Parameters)	−19200.204 (77)	−19195.29 (82) [b]
BIC	38915.507	38939.128
ABIC	38670.988	38678.731
Entropy	0.575	0.731
Adj. LMR-LRT (p)	27.337 (0.2322)	25.243 (0.5534)
BLRT (p)	28.699 (0.0000)	26.500 (0.0000) [c]
Group size (%) C1	627 (78.0%)	573 (71.3%)
C2	177 (22.0%)	227 (28.2%)
C3		4 (0.5%)

Note. LCGA = Latent Class Growth Analysis. GMM-CI = Growth Mixture Model with class-invariant variances and covariances. GMM-CV = Growth Mixture Model with class-varying variances and covariances, which is not presented in the table due to convergence problems (i.e., covariance matrix not positive definite, information matrix singularity due to unidentified model or empty cells). LL = Log-Likelihood value. No. of Parameters = Number of estimated (freed) parameters. BIC = Bayesian Information Criteria. ABIC = Sample Size Adjusted BIC. LMR-LRT = Lo-Mendell-Rubin Likelihood Ratio Test. Adj. LMR-LRT = Adjusted LMR. BLRT = Bootstrap Likelihood Ratio Test. p = p-value.

[a] No repeated log-likelihood value (i.e., local maxima).

[b] Latent variable covariance matrix not positive definite.

[c] Bootstrap draws not converge.

Table 3.

Fit statistics for condom use LCGAs and GMMs among online sexually active men who have sex with men in China, 2015 (n = 804)

Fit statistics	2 Classes	3 Classes
LCGA		
LL (No. of Parameters)	−2697.996 (8)	−2678.126 (11)
BIC	5449.509	5429.837
ABIC	5424.105	5394.906
Entropy	0.797	0.621
Adj. LMR-LRT (*p*)	448.413 (0.0000)	37.855 (0.0045)
BLRT (*p*)	470.757 (0.0000)	39.741 (0.0000)
Group size (%) C1	184 (22.9%)	140 (17.4%)
C2	620 (77.1%)	365 (45.4%)
C3		299 (37.2%)
GMM-CI		
LL (No. of Parameters)	**−2677.691 (12)**	−2653.015 (17) [a]
BIC	**5435.658**	5419.753
ABIC	**5397.551**	5365.768
Entropy	**0.815**	0.646
Adj. LMR-LRT (*p*)	**10.775 (0.3294)**	14.214 (0.0004)
BLRT (*p*)	**11.312 (0.0465)**	14.923 (0.6444)
Group size (%) C1	**92 (11.4%)**	252 (31.3%)
C2	**712 (88.6%)**	140 (17.4%)
C3		412 (51.2%)
GMM-CV		
LL (No. of Parameters)	−2662.985 (13) [ab]	−2644.240 (18) [acd]
BIC	5412.935	5408.894
ABIC	5371.653	5351.734
Entropy	0.572	0.732
Adj. LMR-LRT (*p*)	38.639 (0.0001)	24.195 (0.0000)
BLRT (*p*)	40.083 (0.0000) *	25.1 (0.2895)
Group size (%) C1	268 (33.3%)	151 (18.8%)
C2	536 (66.7%)	28 (3.5%)
C3		625 (77.7%)

Note. LCGA = Latent Class Growth Analysis. GMM-CI = Growth Mixture Model with class-invariant variances and covariances. GMM-CV = Growth Mixture Model with class-varying variances and covariances, which are not presented in the table due to convergence problems (i.e., the best loglikelihood value not replicated, a non-positive definite fisher information matrix, the standard errors of the model parameter estimates not computed, a non-positive definite first-order derivative product matrix, information matrix singularity due to unidentified model or empty cells). LL = Log-Likelihood value. No. of Parameters = Number of estimated (freed) parameters. BIC = Bayesian Information Criteria. ABIC = Sample Size Adjusted BIC. LMR-LRT = Lo-Mendell-Rubin Likelihood Ratio Test. Adj. LMR-LRT = Adjusted LMR. BLRT = Bootstrap Likelihood Ratio Test. *p* = *p*-value.

[a]The best loglikelihood value was not replicated

[b]Information matrix singularity due to unidentified model or empty cells.

[c]A non-positive define first-order derivative product matrix.

[d]The model estimation has reached a saddle point.

Table 4.

Categorical latent variable multinomial logistic regressions among peer norms, self-efficacy, and condom use behavior among online sexually active men who have sex with men in China, 2015 (n=804)

	Peer norms Latent class#1 vs Latent class#2			**Self-efficacy Latent class#1 vs Latent class#2**			**Condom use behavior Latent class#1 vs Latent class#2**		
	β	**SE**	**p-value**	**β**	**SE**	**p-value**	**β**	**SE**	**p-value**
Age	−0.066	0.032	**0.040**	0.057	0.020	**0.004**	−0.007	0.023	0.763
Using condom during first sex with male	−0.129	0.274	0.636	0.777	0.156	**0.000**	−0.113	0.244	0.643
Having casual partners	0.386	0.311	0.216	−0.088	0.177	0.621	−1.016	0.274	**0.000**
Income	0.135	0.138	0.328	0.117	0.081	0.150	0.366	0.115	**0.001**

Table 5.

Continuous latent variable mixture regressions among peer norms, self-efficacy, and condom use behavior for each latent class among online sexually active men who have sex with men in China, 2015 (n=804)

Peer norm	Latent class#1 (the responders)						Latent class#2 (the non-responders)					
	Intercept factor			Slope growth factor			Intercept factor			Slope growth factor		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Being gay	−0.256	0.247	0.30	−0.36	0.116	**0.002**	−0.024	0.079	0.763	0.05	0.061	0.417
Being bisexual	−0.536	0.249	**0.031**	−0.20	0.15	0.182	−0.103	0.083	0.214	0.084	0.064	0.189
No. of male partner	−0.015	0.005	**0.001**	−0.002	0.01	0.827	−0.003	0.002	0.096	0.00	0.002	0.874
Crowdsourcing group [a]	−0.268	0.085	**0.002**	−0.047	0.104	0.652	−0.037	0.033	0.263	0.027	0.027	0.308
Using condom during first sex with male	−0.02	0.096	0.837	0.122	0.129	0.346	0.088	0.032	**0.007**	0.006	0.024	0.809
Self-efficacy	Latent class#1 (the non-responders)						Latent class#2 (the responders)					
	Intercept factor			Slope growth factor			Intercept factor			Slope growth factor		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Using condom during first sex with male	0.126	0.048	**0.009**	−0.048	0.042	0.256	0.056	0.061	0.364	0.021	0.047	0.654
Having primary partners	0.055	0.077	0.474	−0.029	0.047	0.54	0.166	0.092	0.071	−0.17	0.055	**0.002**
Condom use	Latent class#1 (the non-responders)						Latent class#2 (the responders)					
	Intercept factor			Slope growth factor			Intercept factor			Slope growth factor		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Being engaged or married	0.591	0.30	**0.049**	−0.444	0.809	0.583	0.591	0.30	**0.049**	−0.444	0.809	0.583
Using condom during first sex with male	0.655	0.119	**0.000**	−0.283	0.24	0.239	0.655	0.119	**0.000**	−0.283	0.24	0.239
Having primary partners	−0.427	0.153	**0.005**	−0.071	0.35	0.84	−0.427	0.153	**0.005**	−0.071	0.35	0.84
Crowdsourcing group [a]	0.249	0.117	**0.034**	−0.344	0.235	0.142	0.249	0.117	**0.034**	−0.344	0.235	0.142
Being gay	−0.051	0.323	0.874	−1.316	0.661	**0.046**	−0.051	0.323	0.874	−1.316	0.661	**0.046**
Being bisexual	0.116	0.338	0.732	−1.612	0.689	**0.019**	0.116	0.338	0.732	−1.612	0.689	**0.019**

Note.

[a]The association between being in a crowdsourcing group and latent intercept factors of peer norms and condom use behavior appeared within specific latent classes. Independent samples t test found no significant difference in peer norms, self-efficacy, and condom use behavior between the two intervention groups at baseline and follow-ups.