

# The Association between Affective States and Sexual/Health-Related Status among Men Who Have Sex with Men in China: An Exploration Study Using Social Media Data

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## I. INTRODUCTION

**Abstract**—Objectives: The purpose of this study was to understand and examine the association between diurnal mood variation and sexual/health-related status among men who have sex with men (MSM) using data from MSM Chinese Twitter messages. The study consists of 843,745 postings of 377,610 MSM users located in Guangdong that were culled from the MSM Chinese Twitter App. Positive affect, negative affect, sexual related behaviors, and health-related status were measured using the Simplified Chinese Linguistic Inquiry and Word Count. Emotions, including joy, sadness, anger, fear, and disgust were measured using the Weibo Basic Mood Lexicon. A positive sentiment score and a positive emotions score were also calculated. Linear regression models based on a permutation test were used to assess associations between affective states and sexual/health-related status. In the results, 5,871 active MSM users and their 477,374 postings were finally selected. MSM expressed positive affect and joy at 8 a.m. and expressed negative affect and negative emotions between 2 a.m. and 4 a.m. In addition, 25.1% of negative postings were directly related to health and 13.4% reported seeking social support during that sensitive period. MSM who were senior, educated, overweight or obese, self-identified as performing a versatile sex role, and with less followers, more followers, and less chat groups mainly expressed more negative affect and negative emotions. MSM who talked more about sexual-related behaviors had a higher positive sentiment score ( $\beta = 0.29$ ,  $p < 0.001$ ) and a higher positive emotions score ( $\beta = 0.16$ ,  $p < 0.001$ ). MSM who reported more on their health status had a lower positive sentiment score ( $\beta = -0.83$ ,  $p < 0.001$ ) and a lower positive emotions score ( $\beta = -0.37$ ,  $p < 0.001$ ). The study concluded that psychological intervention based on an app for MSM should be conducted, as it may improve mental health.

**Keywords**—Affect, men who have sex with men, sexual-related behaviors, health-related status, social media.

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AFFECTIVE states, including sentiment and emotion, refer to the experience of feeling the underlying emotional state and are a critical determinant of health [1], [2]. Sentiment, including positive affect and negative affect, is a thought, view, or attitude. Emotion, including joy, sadness, anger, fear, and disgust, is a state of consciousness [3]. One study [4] found in 84 countries that individuals awaken in a good mood that deteriorates as the day progresses, but another study [5] in China found that negative affect peaked at 4 a.m. and showed a stable trend after 12 a.m. Negative affect and negative emotions are common components of depression, whereas positive affect can facilitate positive health behaviors across populations [6], [7]. Evidence in mental health research suggests that depression and anxiety are highly prevalent among MSM, for whom depression rates were 40% and 37.6% in America and China, respectively [8]–[10]. However, no prior studies have examined sentiment and emotions specifically among MSM using real-time social media technologies to assess and monitor mental health.

Blued, like Twitter and Facebook, is a social media site. Blued is an app in China for gay, bisexual, and other MSM for communicating with each other, finding sexual partners, and sharing information [11]. In 2016, Blued reported that it had 27 million users, making it the most influential gay app in China. There are indications that accessing Blued has become a daily activity for many MSM users: 20% spend at least 2 hours per day on Blued and 10% post over 200 messages per day, including postings and comments [12]. Additionally, due to its anonymity, MSM can talk freely on Blued about private issues, such as sexual-related behaviors, health, and HIV states [3], [13]. In recent years, an increasing number of studies have suggested that significant links exist between users' behaviors and indicators of emotional well-being based on analysis of user-generated textual data, indicating the potential of using Blued as a valuable data source to assess and monitor affective states, sexual-related behaviors, and health-related status among MSM [14]–[18].

Affect is associated with sexual behaviors, but research findings have been mixed. While it has been found that positive affect and positive emotions (e.g., joy) may increase sexual desire and sexual arousal can facilitate sexual behaviors [19], some studies have indicated that positive affect does not

always translate into behaviors [20]. Likewise, negative affect and negative emotions (e.g., sadness or anger) can both facilitate and inhibit sexual behavior. For example, anxiety has been found to facilitate genital responses, while another study suggested that individuals who experienced negative emotions practiced fewer sexual behaviors than those who had positive emotions [21], [22]. Further, some studies reported that MSM with depression or higher negative affect are more likely to practice condomless anal intercourse [23], [24]. Study on this topic specific to MSM is limited, and, consequently, more research is needed to explore the association between sexual-related behaviors and affect.

Recent studies have shown the feasibility of using social media to investigate various health-related issues in the general population, including sleep complaints, depression, anxiety, suicide, and HIV [18], [25]-[27]. However, the association between affect and health-related status is in its infancy [17], [24]-[26]. Therefore, this study was designed to examine affective states, including sentiment and emotions, and their association with sexual-related behaviors and health-related status. Specifically, this study aims to understand: (1) diurnal rhythms of sentiment and emotions; (2) the themes of negative postings during peak intensities of negative affect; and (3) the association with sexual-related behaviors and health-related status. This is the first study to assess MSM affective states using social media; as such, the study could enrich the knowledge on evidence-based psychological intervention.

## II. METHOD

### A. Participants

From July 2013 to July 2016,  $P=843,745$  postings of  $U=377,610$  MSM users located in Guangdong were culled from Chinese MSM Twitter (Blued App) through its application programming interface (API). First, we adapted a typical Breadth-first search strategy to cull users located in Guangdong (User Profile Database). For each user we got, we saved all postings in a database. For each posting, we then saved all comments in another database. Finally, for each user, we saved followers and followees in a third database. Among these postings, users with 25 postings or more were included in the analysis [4]. Consequently, our sample for this study contains  $U=5,871$  active MSM users and  $P=447,374$  postings.

### B. Measures

#### 1. Demographic And Social Network Characteristics

Demographic characteristics, including age, educational level, geolocation, hometown, height, weight, and sex role were obtained from user profiles. Social network characteristics, including the number of followers, followees, and chat groups were also obtained from profiles. Age was categorized into “ $\leq 25$  years” and “ $> 25$  years” based on social and development psychology literature [15]. Educational level was classified as “high school or below,” “above high school,” and “unknown.” Geolocation was categorized into

Guangzhou, Shenzhen, Dongguan, and other cities in Guangdong Province. Hometown was classified as Guangdong, non-Guangdong, and unknown. Height and weight were transformed into body mass index (BMI) and BMI was categorized into underweight ( $BMI < 18.5$ ), normal ( $18.5 \leq BMI < 25$ ), overweight ( $25 \leq BMI < 30$ ), and obese ( $BMI \geq 30$ ) (BMI classification). Sex role was classified into insertive, receptive, versatile sexual roles, and unknown. A “chat group” was defined as an online forum that enables users to conduct instant message-based private conversations with other users. The number of followers, followees, and chat groups were log transformed for analysis.

#### 2. Affective States: Sentiment and Emotion

To measure affective states, we first calculated the probability of words related to affect across all postings for each user in a given hour ( $P(u,h)$ ). Then, we calculated each user’s baseline probability of affect (averaging  $P(u,h)$  across all hours). To measure diurnal mood rhythms, we calculated the grand mean of affect across all users and relative probability of affect per user. Finally, we calculated the general level of relative probability of affect across users who were active during hour  $h$ . Due to seven dependent variables (positive affect, negative affect, and five emotions) and many independent variables, there was the possibility of difficulties in exploring the true relationship between them. Thus, to ensure that emotion/sentiment expressed in one single measure by each posting, a positive emotions score and a positive sentiment score was defined.

Step 1: Probability of sentiment and emotions of postings were measured using the Simplified Chinese Linguistic Inquiry and Word Count (SC-LIWC) and Weibo Basic Mood Lexicon (Weibo-5BML) [28], [29]. The validities of SC-LIWC’s and Weibo-5BML’s performance for sentiment and emotion have been shown in other studies [5], [30]-[32]. “Positive affect” and “negative affect” dimensions from SC-LIWC were selected to measure perceived positive and negative affect. Basic emotions, including joy, sadness, anger, fear, and disgust that correspond to basic emotions identified by Ekman [33], were selected from Weibo-5BML to measure emotional states. The emotion of surprise was excluded because it can be both positive and negative and it is ambiguous without context. For each user in a given hour, we first counted the number of words of postings and the number of words related to positive affect/negative affect/joy/sadness/anger/fear/disgust, respectively, in postings. Then we calculated the following probability (e.g., for calculating positive affect):

$$PA(u, h) = \frac{||PAWORDS(u,h)||}{||WORDS(u,h)||} \quad (1)$$

We used  $U$  to index the set of users ( $u \in U$ ) and  $H$  to index the set of hours a day ( $h \in H$  and  $H = \{0,1,2,3 \dots 23\}$  (assuming 0–23 for a day)). The measurement for other sentiments or emotions was computed similarly.

Step 2: Regarding variables to assess a user’s sentimental

and emotional level, for each user we calculated his baseline probability of affect (averaging  $P(u, h)$  across all hours):

$$\overline{PA} = \frac{1}{||H||} \sum_{h \in H} PA(u, h) \quad (2)$$

Note that baseline probability of affect did not vary from hour to hour and therefore was an indication of the user's average affective state. Consequently, baseline probability of affect was used as a dependent variable in the multiple linear regression model.

Step 3: To measure diurnal mood rhythms, we then calculated the user's relative probability of affect as defined in (3), where the last term in (3) is the grand mean across all users over all hours. Relative probability of affect represents the user's deviation from his own baseline probability, which allows us to focus on the user's diurnal mood rhythms by the hour of the day.

$$RPA(u, h) = PA(u, h) - \overline{PA} + \frac{1}{||UH||} \sum_{(u, h) \in U, H} PA(u, h) \quad (3)$$

Step 4: Last, we calculated the general level of relative probability affect score as defined in (4), where  $U(h)$  is the subset of users who were active during hour  $h$  [4].

$$RPA(h) = \frac{1}{||U(h)||} \sum_{u \in U(h)} RPA(u, h) \quad (4)$$

Step 5: Due to seven dependent variables (positive affect, negative affect, and five emotions) and many independent variables, there is the potential for difficulty in exploring associations between them. The choice of focusing on two polarity scores (positive emotions score and positive sentiment score) rather than on positive affect, negative affect, and five emotions is justified by previous studies that showed how it is preferable to measure overall sentiment/emotions rather than intensity of sentiment/emotions when dealing with short pieces of texts like tweets [3], [34]. For each user given a posting, we defined the positive emotions score  $E_u^+$  as the difference between four negative emotions (sadness, anger, fear, and disgust) and one positive emotion (joy) in (5). Similarly, we also estimated the user's positive sentiment score  $S_u^+$  by subtracting positive affect from negative affect in (6) [3].

$$E_u^+ = \overline{E}_{joy} - \overline{E}_{sadness} - \overline{E}_{anger} - \overline{E}_{fear} - \overline{E}_{disgust} \quad (5)$$

$$S_u^+ = \overline{S}_{positive} - \overline{S}_{negative} \quad (6)$$

### 3. Sexual-Related Behaviors and Health-Related Status

Sexual-related words (e.g., “性爱” (sex), “安全套” (condom), and “亲吻” (kiss)) and health-related words (e.g., “感染” (infection), “失眠” (insomnia), and “运动” (exercise)) from SC-LIWC were applied to identify the words associated with sexual-related behaviors and health-related status in the postings, respectively [29], [32]. Measurement of these two dimensions was the same as measurement of sentiment and

emotions. Baseline probabilities of sexual-related behaviors and health-related status were calculated as independent variables.

### 4. Theme of Negative Postings

Negative affect peaked between 2 a.m. and 5 a.m., and therefore, 30 postings were selected randomly per time points per day to find out why users had high levels of negative affect. Finally, 840 postings were collected. To identify the themes of negative postings, we scanned all postings to determine the major themes [35]. These negative postings were categorized into the following themes: (1) expression of emotion and possible cause, (2) expression of health-related status, (3) expression of emotion and seeking support, (4) expression of sexual-related behaviors, and (5) expression of emotion.

### 5. Statistical Analysis

First, descriptive statistics (e.g., frequencies and mean) were calculated. Next, sentiment and emotions scores displayed a very skewed distribution and, therefore, a multiple linear regression model using permutation tests which do not assume normally-distributed errors was performed. Univariate and multivariate linear regression models were performed to examine associations between two predicted variables—sexual-related behaviors and health-related status and all outcome variables—sentiment (positive affect, negative affect, positive sentiment score) and emotions (joy, sadness, anger, fear, disgust, and positive emotions score). Factors that were adjusted included demographic characteristics and social network variables. Some 840 postings were iteratively coded and sorted into themes by two trained assistants separately. To ensure reliability, inter-rater reliability was measured and an additional assistant was invited to code postings which are classed as different themes. The R 3.4.3 version was applied for data analysis. Statistical significance was set at  $p < 0.05$ .

## C. Results

### 1. Demographic Characteristics

Of the MSM on Blued from Guangdong Province, 54.0% were less than or equal to 25 years old, while 35.3% had an education beyond high school and 13.1% MSM had an education with high school or below. Most MSM lived in Guangzhou (34.0%), Shenzhen (31.7%) or Dongguan (8.7%). As well, 48% MSM identified their hometown as Guangdong, while 36.5% MSM identified their hometown as non-Guangdong. Physically, 75.8% MSM were of normal weight, 16.4% were underweight, 6.6% were overweight and 1.2% were obese. Sexually, 28.9% MSM self-reported preference for the insertive sex role, 20.4% self-reported preference for the receptive sex role and 22.6% self-reported preference for the versatile sex role.

### 2. Affective States: Sentiment

The mean (SD) scores of positive affect, negative affect, and positive sentiment score were 0.014 (0.010), 0.016 (0.012), and -0.001 (0.015), respectively. Positive affect peaked between 8 a.m. to 10 a.m., while negative affect

peaked between 2 a.m. to 4 a.m. The positive sentiment score reached the minimum between 2 a.m. to 4 a.m. (See Fig. 1).

### 3. Affective States: Emotion

The mean (SD) scores of joy, sadness, anger, fear, disgust, and positive emotions score were 0.015 (0.012), 0.005 (0.005), 0.0005 (0.001), 0.0006 (0.001), 0.004 (0.007), and 0.005

(0.015), respectively. Joy peaked at 8 a.m. and at 4 p.m. Sadness peaked between 1 a.m. to 4 a.m. Disgust peaked between 2 a.m. to 4 a.m. Anger and fear showed a relatively stable trend over time. The positive emotions score reached the minimum between 2 a.m. to 4 a.m. (See Fig. 1).

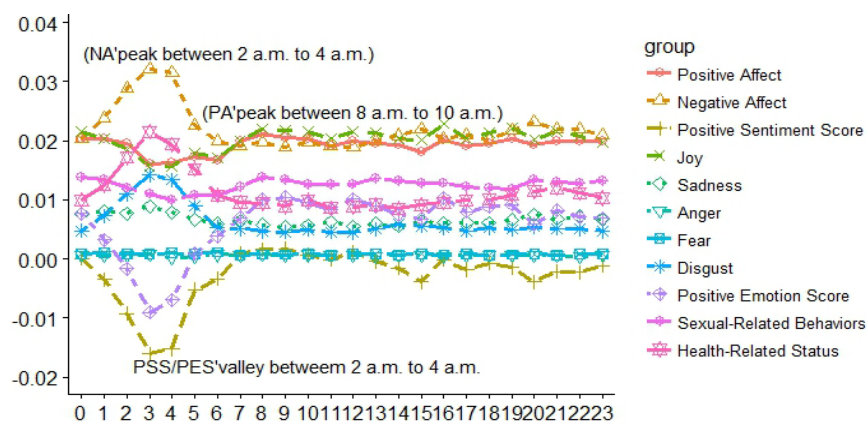


Fig. 1 Hourly changes in individual sentiment, emotions, sexual-related behaviors, and health-related status

### 4. Theme of Negative Postings

The proportion of negative, positive, and neutral affect was 46.1% (387/840), 33.8% (284/840), and 20.1% (169/840), respectively between 2 a.m. to 5 a.m. 79.9% (671/840) postings contained emotional information. As well, 11.5% (97/840) of postings contained health-related information and 3.1% (26/840) postings contained sexual-related information.

Among 387 negative postings, the kappa (agreement) values of expression of health-related status, expression of emotion and seeking support, expression of sexual related behaviors, expression of emotion and possible cause, and expression of emotion were 0.91 (97%), 0.63 (93%), 0.56 (98), 0.96 (98) and 0.92 (99), respectively. Some 25.1% (97/387) of postings are directly related to health-related status, among which, 86.6% are on sleep health or mental health, and another 13.4% are on physical health. Expression of emotion and seeking support accounted for 13.4% (52/387), and expression of sexual-related behaviors accounted for 2.6% (10/387). Of the postings, 55.0% (213/387) expressed strong emotion and described possible cause, among which the topics varied, from daily life events (e.g., amusement and work, 51.2%, 109/213) and relationship (e.g., partnership and friendship, 37.5%, 80/213) to philosophy of life (11.3%, 24/213). 3.9% (15/387) postings only expressed strong emotion. Example responses included the following:

“Waking up in the middle of the night suddenly and I couldn’t fall asleep at night. No one to hug me and feeling lonely. (半夜突然醒来，再也无法入眠。没有一个人的旁边抱着，感觉很孤独).” (Sleep health or mental health).

“I want to find a boyfriend in Shenzhen, but ugly men couldn’t get a boyfriend (满深圳求男友，可丑男一枚

找不到男朋友)”. (Expression of emotion and seeking support).

“Very irritated. I feel I am in a rut and I try my best to control my sexual behaviors (好烦，仿佛到了发情期，得拼命用理智控制自己)”. (Expression of sexual related behaviors).

“Alas, I can’t seem to do anything to progress in life. Try to sleep rather than thinking which makes me upset (哎，啥求事都干不成，睡吧，想多了心烦)”. (Daily life event).

“Even though I tried to be strong, I couldn’t help but cry (心里再明白再坚强 眼泪又是止不住)”. (Expression of emotion).

### 5. Social Network

The mean (SD) scores of followers, followees, and chat groups were 2.341 (0.430), 1.786 (0.889) and 0.277 (0.331) after log transformations, respectively.

### 6. Sexual Related Behaviors and Health-Related Status

The mean (SD) scores of sexual-related behaviors and health-related status were 0.009 (0.008) and 0.008 (0.008), respectively. Sexual-related behaviors peaked at 12 p.m. and 8 a.m. Health-related status peaked between 2 a.m. to 4 a.m. (see Fig. 1).

### 7. The Association between Affective States and Demographic Characteristics

Tables I-III show the association between affective states and demographic characteristics. Multivariable models demonstrated that compared with younger MSM (“ $\leq 25$  years old”), senior MSM (“ $> 25$  years old”) expressed more negative affect ( $\beta = 0.0004$   $p < 0.001$ ), more anger ( $\beta =$

0.00003,  $p < 0.001$ ), more fear ( $\beta = 0.00004$ ,  $p = 0.04$ ), and less positive affect ( $\beta = -0.0004$ ,  $p < 0.001$ ), less joy ( $\beta = -0.0003$ ,  $p < 0.001$ ), and less disgust ( $\beta = -0.0001$ ,  $p = 0.03$ ), and had a lower positive sentiment score ( $\beta = -0.0009$ ,  $p < 0.001$ ) and a lower positive emotions score ( $\beta = -0.0003$ ,  $p = 0.03$ ).

MSM with an education beyond high school expressed more sadness ( $\beta = 0.0004$ ,  $p = 0.02$ ) and fear ( $\beta = 0.00006$ ,  $p < 0.001$ ) and had a lower positive sentiment score ( $\beta = -0.0009$ ,  $p = 0.03$ ).

Compared to MSM who lived in Guangzhou, those who lived in Shenzhen expressed less sadness ( $\beta = -0.0004$ ,  $p < 0.001$ ) and less anger ( $\beta = -0.00001$ ,  $p = 0.049$ ); MSM who lived in Dongguan expressed less positive affect ( $\beta = -0.0004$ ,  $p < 0.001$ ) and less joy ( $\beta = -0.0007$ ,  $p < 0.001$ ); MSM who lived in other cities in Guangdong expressed more negative affect ( $\beta = 0.0006$ ,  $p < 0.001$ ) and more joy ( $\beta = 0.001$ ,  $p <$

0.001).

Compared to MSM whose hometowns were in Guangdong, non-Guangdong MSM residents expressed more joy ( $\beta = -0.0003$ ,  $p = 0.02$ ), more fear ( $\beta = 0.00002$ ,  $p = 0.005$ ), less negative affect ( $\beta = -0.0003$ ,  $p < 0.001$ ), less anger ( $\beta = -0.00005$ ,  $p < 0.001$ ), and had a higher positive sentiment score ( $\beta = 0.0007$ ,  $p < 0.001$ ) and a higher positive emotions score ( $\beta = 0.0006$ ,  $p = 0.02$ ).

Compared to MSM of normal weight, underweight MSM expressed less positive affect ( $\beta = -0.0004$ ,  $p = 0.02$ ) and less anger ( $\beta = -0.00005$ ,  $p < 0.001$ ); Overweight MSM expressed more negative affect ( $\beta = 0.0008$ ,  $p < 0.001$ ), more sadness ( $\beta = 0.0004$ ,  $p < 0.001$ ), and less fear ( $\beta = -0.00006$ ,  $p = 0.04$ ) and had a lower positive sentiment score ( $\beta = -0.0008$ ,  $p = 0.04$ ); Obese MSM expressed less positive affect ( $\beta = -0.0004$ ,  $p = 0.04$ ) and more negative affect ( $\beta = 0.0006$ ,  $p = 0.03$ ) and had a lower positive sentiment score ( $\beta = -0.0009$ ,  $p = 0.03$ ).

TABLE I  
UNIVARIATE AND MULTIVARIATE ANALYSIS OF SENTIMENT, SEXUAL-RELATED BEHAVIORS, AND HEALTH-RELATED STATUS (N = 5871)

Variables		Positive Affect		Negative Affect		Positive Sentiment Score	
		Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis
		$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )
Sexual-related behaviors							
Health-related status		0.3171***	0.3107(0.0026)***	0.01	0.0153(0.0001)	0.3072***	0.2947(0.0025)***
Covariant		-0.0233*	-0.0224(-0.0002)*	0.8079***	0.8088(0.0065)***	-0.8312***	-0.8306(-0.0066)***
Demographic characteristics							
Age ( " $> 25y$ " )	ref= " $\leq 25y$ "	-0.0002***	-0.0004(-0.0004)***	0.0006***	0.0004(0.0004)***	-0.0008***	-0.0009(-0.0009)***
Educational level							
Above high school	ref= High school or below	-0.0001	-0.0003(-0.0003)	0.0008***	0.0006(0.0006)	-0.0009	-0.0009(-0.0009)*
Unknown	ref= High school or below	0.0001 <sup>#</sup>	0.00006(0.00006)	-0.0011***	-0.0009(-0.0009)***	0.0012***	0.0010(0.0010)***
Geolocation							
Shenzhen	ref= Guangzhou	0.0002	0.00006(0.000006)	-0.0004	-0.0004(-0.0004)	0.0006	-
Dongguan	ref= Guangzhou	-0.0002 <sup>#</sup>	-0.0004(-0.0004)***	-0.0003	-0.0002(-0.0002)	0.00007	-
Other cities in Guangdong	ref= Guangzhou	0.0001	0.00008(0.00008)	0.0005 <sup>#</sup>	0.0006(0.0006)***	-0.0004	-
Hometown							
Non-Guangdong	ref=Guangdong	0.0004***	0.0004(0.0004)	-0.0003*	-0.0003(-0.0003)***	0.0006***	0.0007(0.0007)***
Unknown	ref=Guangdong	0.0001	-0.00007(-0.00007)	-0.0001	0.0002(0.0002)*	0.0002	-0.0004(-0.0004)*
BMI classification							
Underweight	ref=Normal weight	-0.0005*	-0.0004(-0.0004)*	-0.0005***	0.0002(0.0002)	-0.000001	-0.0006(-0.0006)
Overweight	ref=Normal weight	-0.0001	0.00008(0.00008)	0.0005 <sup>#</sup>	0.0008(0.0008)***	-0.0006*	-0.0008(-0.0008)*
Obese	ref=Normal weight	-0.0003*	-0.0004(-0.0004)*	0.0002 <sup>#</sup>	0.0006(0.0006)*	-0.0005 <sup>#</sup>	-0.0009(-0.0009)*
Sex role							
Versatile	ref=Receptive	0.0002	-	0.0002**	0.0001(0.0001)*	0.00004	-
Insertive	ref=Receptive	-0.0004	-	-0.0004***	-0.0003(-0.0003)***	0.00001	-
Unknown	ref=Receptive	-0.0001	-	-0.0005	-0.0005(-0.0005)***	0.0004	-
Social network variables							
Number of chat groups		0.0014***	0.0008(0.0002)***	-0.0003	-	0.0017***	0.0011(0.0004)***
Number of followees		0.0003***	0.000004(0.000003)	0.0002*	0.00007(0.00007)	0.0001	-
Number of followers		0.0025***	0.0020(0.0008)***	0.00004	-	0.0024***	0.0020(0.0009)***
Model Fitting		-	F=34.4, $p$ <0.001, adjR2=0.08	-	F=153, $p$ <0.001, adjR2=0.31	-	F=144.5, $p$ <0.001, adjR2=0.23

<sup>#</sup>:  $p < 0.02$ ; \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$ .

Compared to MSM who prefer receptive anal intercourse, those preferring insertive anal intercourse expressed less negative affect ( $\beta = -0.0003$ ,  $p < 0.001$ ), while those preferring

versatile anal intercourse expressed more negative affect ( $\beta = 0.0001$ ,  $p = 0.04$ ).

#### 8. The Association between Affective States and Social

## Networks

In multivariable models (Tables I-III), MSM with more chat groups expressed more positive affect ( $\beta = 0.0008, p < 0.001$ ), more joy ( $\beta = 0.0022, p < 0.001$ ), and less sadness ( $\beta = -0.0003, p = 0.03$ ), and had a higher positive sentiment score ( $\beta = 0.0011, p < 0.001$ ) and a higher positive emotions score ( $\beta = 0.0024, p < 0.001$ ). MSM with more followers expressed more sadness ( $\beta = 0.0002, p < 0.001$ ) and more disgust ( $\beta = 0.0003, p < 0.01$ ). MSM with more followees expressed more positive affect ( $\beta = 0.002, p < 0.001$ ), more joy ( $\beta = 0.003, p < 0.001$ ), less sadness ( $\beta = -0.0001, p = 0.04$ ), and more disgust ( $\beta = 0.003, p = 0.02$ ) and had a higher positive sentiment score ( $\beta = 0.002, p < 0.001$ ) and a higher positive emotions score ( $\beta = 0.0027, p < 0.001$ ).

## 9. The Association between Affective States and Sexual-Related Behaviors

In multivariable models (Tables I-III), MSM who talked more about sexual-related behaviors not only expressed more

positive affect ( $\beta = 0.3107, p < 0.001$ ) and joy ( $\beta = 0.2292, p < 0.001$ ), but also expressed more sadness ( $\beta = 0.0705, p < 0.001$ ) and more disgust ( $\beta = 0.3065, p < 0.001$ ). More important, MSM who talked about sexual-related behaviors had a higher positive sentiment score ( $\beta = 0.2947, p < 0.001$ ) and a higher positive emotions score ( $\beta = 0.1608, p < 0.001$ ).

## 10. The Association between Affective States and Health-Related Status

In multivariable models (Tables I-III), MSM who reported more about health-related status not only expressed less positive affect ( $\beta = -0.0224, p = 0.02$ ) but also expressed more negative affect ( $\beta = 0.8088, p < 0.001$ ) and negative emotions, including sadness ( $\beta = 0.0705, p < 0.001$ ), anger ( $\beta = 0.0052, p < 0.001$ ), fear ( $\beta = 0.0058, p < 0.001$ ), and disgust ( $\beta = 0.3065, p < 0.001$ ). Moreover, MSM who reported more health-related status had a lower positive sentiment score ( $\beta = -0.8306, p < 0.001$ ) and lower positive emotions score ( $\beta = -0.3742, p < 0.001$ ).

TABLE II

UNIVARIATE AND MULTIVARIATE ANALYSIS OF EMOTIONS (JOY, SADNESS AND DISGUST), SEXUAL-RELATED BEHAVIORS, AND HEALTH-RELATED STATUS (N = 5871)

Variables		Joy		Sadness		Disgust	
		Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis
		$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )
Sexual-related behaviors							
Health related status		0.2440***	0.2292(0.0019)***	0.0451***	0.0443(0.0004)***	0.0214***	0.0256(0.0002)***
Covariant		0.0164	0.0161(0.0001)	0.0697***	0.0705(0.0006)***	0.3078***	0.3065(0.0024)***
Demographic characteristics							
Age ( " > 25y" )	ref= "≤25y"	-0.0001	-0.0003(-0.0003)***	0.0002***	0.00004(0.00004)	-0.0002*	-0.0001(-0.0001)*
Educational level							
Above high school	ref= High school or below	0.0002	-	0.0005	0.0004(0.0004)*	0.00007***	0.00009(0.00009)
Unknown	ref= High school or below	-0.00003	-	-0.0004***	-0.0004(-0.0004)***	-0.0004	-0.0005(-0.0005)***
Geolocation							
Shenzhen	ref= Guangzhou	-0.00003 <sup>#</sup>	-0.0002(-0.0002)	-0.0005***	-0.0004(-0.0004)***	-0.0002	-0.0001(-0.0001)
Dongguan	ref= Guangzhou	-0.0004	-0.0007(-0.0007)***	-0.0001	-0.00009(-0.00009)	0.00003	0.00004(0.00004)
Other cities in Guangdong	ref= Guangzhou	0.0009 <sup>#</sup>	0.0010(0.0010)***	0.0004***	0.0003(0.0003)	0.0002*	0.0002(0.0002)
Hometown							
Non-Guangdong	ref=Guangdong	0.0003***	0.0003(0.0003)*	-0.00007	-0.0001(-0.0001)	-0.0002*	-0.0001(-0.0001)
Unknown	ref=Guangdong	0.0005***	0.0002(0.0002)	0.0002***	0.0002(0.0002)***	0.00005	0.0002(0.0002)
BMI classification							
Underweight	ref=Normal weight	-0.0002	-0.0001(-0.0001)	-0.0001	-0.00003(-0.00003)	-0.0004*	-0.0002(-0.0002)
Overweight	ref=Normal weight	-0.0001	0.00005(0.00005)	0.0005***	0.0004(0.0004)***	-0.0006***	-0.0002(-0.0002)
Obese	ref=Normal weight	-0.0005 <sup>#</sup>	-0.0004(-0.0004)	-0.0002	-0.0002(-0.0002)	0.00002	0.00004(0.00004)
Sex role							
Versatile	ref=Receptive	-0.00007 <sup>#</sup>	0.0001(0.0001)	0.0003	0.0003(0.0003)	-0.0001*	0.00002(0.00002)
Insertive	ref=Receptive	-0.0005	-0.0003(-0.0003)	-0.00006**	-0.00008(-0.00008)	-0.00005	0.000(0.000)
Unknown	ref=Receptive	0.0002*	-0.0002(-0.0002)**	-0.0004***	-0.0003(-0.0003)	0.000007	-0.0002(-0.0002)
Social network variables							
Number of chat groups		0.0029***	0.0022(0.0007)***	-0.0002*	-0.0003(-0.0003)*	0.0001	-
Number of followees		0.0004***	-0.0001(-0.00009)	0.0002***	0.0002(0.0002)***	0.0004***	0.0003(0.0003)**
Number of followers		0.0036***	0.0030(0.0013)***	-0.0001 <sup>#</sup>	-0.0001(-0.0001)*	0.0005***	0.0003(0.0001)*
Model Fitting		-	F=16.7, $p$ <0.001, adjR2=0.04	-	F=8.46, $p$ <0.001, adjR2=0.02	-	F=46, $p$ <0.001, adjR2=0.12

<sup>#</sup>: $p < 0.02$ ; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

TABLE III  
UNIVARIATE AND MULTIVARIATE ANALYSIS OF EMOTIONS (ANGER, FEAR, AND POSITIVE EMOTION SCORE), SEXUAL-RELATED BEHAVIORS, AND HEALTH-RELATED STATUS (N = 5871)

Variables		Anger		Fear		Positive Emotions Score	
		Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis	Univariate analysis	Multivariate analysis
		$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )	$\beta$	$\beta$ (standardized $\beta$ )
Sexual-related behaviors							
Health related status		-0.00009	0.00003(0.0000002)	-0.0009	-0.0014(-0.00001)	0.1784***	0.1608(0.0014)***
Covariant		0.0060***	0.0058(0.00005)***	0.0054***	0.0052(0.00004)***	-0.3726***	-0.3742(-0.0030)***
Demographic characteristics							
Age (" > 25y")	ref= "≤25y"	0.00002#	0.00003(0.00003)***	0.00004***	0.00004(0.00004)*	-0.0002	-0.0003(-0.0003)*
Educational level							
Above high school	ref= High school or below	-0.000001*	0.000(0.000)	0.00008#	0.00006(0.00006)***	-0.0005**	-0.0005(-0.0005)
Unknown	ref= High school or below	-0.00002#	-0.00002(-0.00002)*	-0.00006***	-0.00005(-0.00005)	0.0009***	0.0007(0.0007)**
Geolocation							
Shenzhen	ref= Guangzhou	-0.00001#	-0.00001(-0.00001)*	-0.00006***	-0.00006(-0.00006)	0.0007***	0.0005(0.0005)
Dongguan	ref= Guangzhou	0.0000006	-0.00001(-0.00001)	-0.00002#	-0.00001(-0.00001)	-0.0003	-0.0006(-0.0006)
Other cities in Guangdong	ref= Guangzhou	-0.00002#	-0.00003(-0.00003)	0.00001	0.00001(0.00001)	0.0004	0.0004(0.0004)
Hometown							
Non-Guangdong	ref=Guangdong	-0.00005***	-0.00005(-0.00005)***	0.00003***	0.00002(0.00002)**	0.0006***	0.0006(0.0006)*
Unknown	ref=Guangdong	0.00003*	0.00005(0.00005)***	-0.00001	0.000(0.000)	0.0003	-0.0002(-0.0002)
BMI classification							
Underweight	ref=Normal weight	-0.00006*	-0.00007(-0.00007)***	-0.00007*	-0.00006(-0.00006)	0.0004	-
Overweight	ref=Normal weight	-0.00007#	-0.00007(-0.00007)	-0.00003	-0.00006(-0.00006)*	0.0002	-
Obese	ref=Normal weight	-0.00004#	-0.00003(-0.00003)	-0.00007	-0.00005(-0.00005)	-0.0001	-
Sex role							
Versatile	ref=Receptive	-0.00004	-0.00004(-0.00004)	0.00001	-	-0.0002	-
Insertive	ref=Receptive	-0.00002	-0.00001(-0.00001)	-0.00001#	-	-0.0004	-
Unknown	ref=Receptive	0.00007***	0.00009(0.00009)***	-0.00005#	-	0.0006*	-
Social network variables							
Number of chat groups		-0.00009#	-0.00009(-0.00003)	0.00003	-	0.0031***	0.0024(0.0008)***
Number of followees		-0.00001	-	-0.00002	-	-0.0002	-
Number of followers		0.00005	-	0.00001	-	0.0031***	0.0027(0.0012)***
Model Fitting		-	F=2.1, $p<0.01$ , adjR2=0.003		F=1.8, $p<0.05$ , adjR2=0.002		F=32, $p<0.001$ , adjR2=0.06

#: $p<0.02$ ; \* $p<0.05$ ; \*\* $p<0.01$ ; \*\*\* $p<0.001$ ;

### III. DISCUSSION

This is the first study to assess MSM affective states using social media data in China. In addition, this study is the first to examine affective states as a correlate of sexual-related behaviors and health-related status. Therefore, this study shows the potential of using social media to investigate health issues among MSM, and made a meaningful contribution to Internet-based psychological intervention for app-using MSM.

In this study, MSM were more likely to express negative affect and negative emotions between 2 a.m. and 4 a.m. In addition, a quarter of negative postings were directly related to MSM's health and about one-eighth reported that MSM needed social support during that sensitive period. Due to high prevalence of depression and anxiety among MSM, it is essential to implement a psychological intervention based on this app [8]-[10]. No previous studies have assessed MSM affective states based on social media, but two studies found that there was a peak of negative affect at midnight among Twitter users and Weibo users [4], [5]. Due to prejudice,

stigma, and social pressures for MSM, they may tend to avoid discussing their health, needs, and mood in real life [36]. However, Blued provides an anonymous environment for MSM to exchange opinions and share information, which possibly explains why these men tended to talk more openly about health-related topics, express affect, and seek help [13]. These findings highlight the unmet emotional requests of MSM.

In this study also, sexual-related behavior was associated with positive affect, positive emotions, and negative emotions. More important, MSM who talked more about sexual-related behaviors had a higher positive sentiment score and a higher positive emotions score. Previous studies found that positive affect facilitated sexual-related behaviors [18], [19], [37]. It is generally acknowledged that positive affect can increase sexual arousal and sexual desire and therefore facilitate sexual behavior. In contrast, MSM with negative emotions may use sex as a mood regulator and may practice more condomless anal sex with casual partners [23], [38]-[40]. One possible

explanation for this finding is that health-compromising behaviors (e.g., unprotected sex) may be used as coping mechanisms to manage the effects of negative emotions. Due to the high prevalence of HIV among MSM, practicing more risky sexual behaviors, in turn, may lead to a higher psychological burden [41]. In general, sexual-related behavior seemed to be more associated with positive affect and positive emotions in this study.

Health-related status was also associated with positive affect, negative affect, and negative emotions, but MSM who reported more about their health-related status may express more negative affect and negative emotions. Positive affect facilitates positive health behavior, leading to favorable health outcomes such as fewer symptoms and less pain [7]. Nevertheless, negative affect and negative emotions usually coexist with illness and may influence one's functional status and health-related quality of life, meaning that measuring negative affect and negative emotions may provide a valuable means for understanding MSM health [42].

It is important to acknowledge the limitations of this study. First, the generalizability of this study is limited by the characteristics of the study participants. Compared to a community sample of Chinese MSM, the Internet sample was significantly younger and more educated [13]. In addition, compared to other studies using millions of users' messages, the sample size is not big enough to measure affective states precisely [4]. Second, though keyword research was used to measure sexual-related behaviors and health-related status, social media data may not be fully representative of a user's actual behaviors, indicating that a combination of social media data and survey research is essential to understanding the association between sexual behaviors, health-related status, and affective states.

#### IV. CONCLUSIONS

MSM mainly express positive affect and positive emotions at 8 a.m. and express negative affect and negative emotions between 2 a.m. and 4 a.m. in China. Of the negative postings, 25.1% were directly related to health. In addition, increased sexual-related behaviors were associated with a higher positive sentiment score and higher positive emotions score. Talking more about health status was associated with a lower positive sentiment score and lower positive emotions score. We believe that psychological intervention based on an app should target MSM, as it may improve mental health and slow the spread of HIV in this vulnerable population.

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