1 *Type of the Paper (Article)*

2 Suboptimal Health Status of High School Students in
3 Guangzhou, Shanxi, and Tibet, China: A Cross-Sectional
4 Study

5 **Gehendra Mahara[1†], Jiazhi Liang[2†],** Zhirong Zhang[3], **Qi Ge[1], Jinxin Zhang** [1, *]

6 1. Department of Medical Statistics and Epidemiology, School of Public Health, Sun Yat-
7   sen University, Guangzhou 510080, China; gbmahara@hotmail.com(G.M.);
8   geqi0777@163.com (GQ), zhjinx@mail.sysu.edu.cn (JZ)

9 2. Center for disease control and Prevention at Haizhu, Guangzhou, Guangdong, 510288
10   China. jiazhi5413@163.com (JL)

11 3. Nanhai District People's Hospital of Foshan City, Foshan, Guangdong, China:
12   Zhangzhirong613@126.com (ZZ)

13 * Correspondence: zhjinx@mail.sysu.edu.cn; Tel.: +86-20-87332453.
14   † Gehendra Mahara and Jianzhi Liang both are equally contributed for this work.

15

16 **Abstract:** Suboptimal health status (SHS) is a state between health and disease, has
17 several associated factors, although, its underlying mechanism is still unclear. This
18 study aimed to investigate the status of SHS and its associated factors of high school
19 students in three areas of China (Shanxi, Guangzhou, and Tibet). A
20 multidimensional sub-health questionnaire of adolescent (MSQA) is used to
21 evaluate SHS. Among 1461 respondents, females proportion 56.47% was higher than
22 males 43.53% where SHS was higher in Shanxi, followed by Tibet and then
23 Guangzhou. The rural area, grade, lack of sleep, home visit in a week, lack of
24 exercise, a heavy burden of study, smoking, drinking, and fewer friends were the
25 risk factors of SHS, while, families living status, seeking help, and extroversion were
26 the protective factors. SHS is significantly associated with different influencing
27 factors. For comprehensive prevention and control measures, reduce the risk factors,
28 and enhance the protective factors.

29

32

33 1. Introduction

34   Health is the functional phenomenon of human-being. The condition of being
35 sound in body, mind, spirit, and free from disease or pain is the meaning of health
36 [1]. In 1946s, The World Health Organization (WHO) defined that "health is a state
37 of complete physical, mental, and social well-being and, not merely the absence of

38   disease or infirmity"[2]. Likewise, the suboptimal health or sub-health status, also
39   known as suboptimal health status (SHS)[3] is the physical state of people which is
40   generally undiagnosed [4], however, some changes in psychological behavior or
41   physical characteristics can observe [5], In fact, SHS is an intermediate state between
42   health and disease condition [6]. In this state, there are no organic lesions in the body,
43   only characterized by persistent and recurrent fatigue, headaches, dizziness,
44   anxiety, depression, as well as a series of symptoms including non-specific pain and
45   sleep disorders [6–8].
46   Several studies suggested that SHS is as an intermediate state between health
47   and disease, which is due to the physical, psychological, and social stress of an
48   individual [4,9–12]. Due to the physical and psychological behavior, the overall
49   coordination of the body system become imbalance and dysfunction e.g. the nervous
50   system, endocrine system, and immune system that lead to the decline of
51   physiological, psychological, and social functions; however, the body has not yet
52   reached the disease stage [6,8]. Therefore, it is also regarded as a subclinical,
53   reversible stage of chronic diseases [3,6]. Because, it has been known that SHS is a
54   potential risk factor for chronic diseases such as type-II diabetes mellitus,
55   cardiovascular and stroke etc [6,11,13]. A number of studies have revealed that SHS
56   is mainly influenced by lifestyle factors [4,9,14]; these factors have a close
57   relationship with psychological symptoms or behavior of individuals [12,15]. Over
58   time, with the rapid development of technology and changes in environment and
59   lifestyles in China, the risk of SHS has been increasing consistantly[11]. Thus, SHS
60   has been recognized as a public health challenge globally, including China
61   [10,11,13,16].

62   In addition, some scholars believe that the changes in the living environment, over
63   work-load, interpersonal relationship, lack of sleep time, excessive psychological
64   stress, unbalanced diet, and an inappropriate exercise may lead to the formation of
65   SHS. Likewise, a study reported that socio-cultural factors are the key determinants
66   of SHS of students [9]. Furthermore, a survey conducted by Xie et al. among the
67   middle school students' found that school environmental and psychological factors,
68   life events, lifestyle, social, natural, and family factors are the risk factors for SHS
69   [17]. Similarly, Tu et al. [18]', reported that the causes of SHS among
70   teenagers/adolescence are excessive academic burden, family stress, noise, sleep
71   time, less exercise, social and living environmental impacts, lifestyle, and
72   physiological factors. Similarly, Fang et al. [19], found that drug abuse, eating habits,
73   weight loss, exercise, internal injury, suicide, and internet addiction are the major
74   risk factor for the psychological SHS in middle school students. To date, there has
75   not been found the exact cause of the SHS. It has believed that SHS occurs due to
76   different associated factors, although, its underlying mechanism is remaining
77   unclear.

78   Previous studies have quantified that SHS is a public health problem in China.
79   However, studies regarding SHS and its associated factors of high school students

80　in the study settings are limited. Therefore, this study aimed to examine the SHS of
81　High School Students in Guangzhou, Shanxi, and Tibet, and we also quantify the
82　associated factors of SHS among participants.

83　## 2. Materials and Methods

84　A community based, cross-sectional study conducted in China to investigate the
85　SHS and its associated factors among high school students. We first selected three
86　regions in China by means of convenient sampling (central areas in the central part:
87　Shanxi Yuci, developed coastal areas: Guangzhou, Guangdong, remote areas in the
88　west: Linzhi, Tibet) [20]. We selected key high school and ordinary high school. In
89　each school, two classes from each grade student (High-I, II & III) were randomly
90　selected by a stratified cluster sampling method. The sample size of this survey was
91　calculated based on the National Normal Model Survey, where the detection rate of
92　physical SHS and psychological SHS of high school students in China were
93　(34.6%~53.9%) [21], the relative error was not more than 20%, and the confidence
94　level reached 95%. The requirements are calculated by substituting the formula to
95　obtain a minimum sample size of 182 in each region and 546 in three regions. In this
96　survey, a total of 1472 high school students were surveyed. Excluded the
97　questionnaires having missing items (leakage rate >10%), 1461 students were
98　effectively surveyed with a 99.25% effective rate, which could meet the sample size
99　requirements for this study.

100　### 2.1. SHS evaluation

101　Since our study was based on the Chinese population, we used the
102　"Multidimensional sub-health Questionnaire of Adolescents (MSQA)" to know the
103　SHS of respondents [21]. MSQA is an effective, sensitive, and validated SHS tool for
104　adolescents [22]. The adolescent's degree of SHS was evaluated by the level of
105　physiological SHS and psychological SHS. MSQA questionnaire has 71 items; each
106　item has 6 levels. The score of SHS is 1 to 6 points. The higher score of the point
107　indicates the more serious SHS [21]. (Appendix-1)

108

109　### 2.2. Associated factors of SHS

110　The researcher from other countries has been using chronic fatigue as a syndrome
111　in the research content [23], while its definition is different from the SHS. Therefore,
112　this study combined the actual situation of Chinese students based on the Chinese
113　scholars' studies and the current knowledge of sub-health theories regarding factors
114　affecting the SHS [21,24]. The factors affecting SHS are divided into *self-factors*
115　(Gender, ethnicity, BMI index, grade, whether they are only children, time spent on
116　school, sleep time, learning burden, frequency on exercise, internet surfing, smoking
117　habit, alcohol consumption, diet, seeking help, personality, etc), *family factors* (family
118　location, family structure, parental expectations, parental education, the annual
119　income of family, level), *school factors* (key high school and ordinary high school),
120　and *other factors* (student source, interpersonal relationship) etc (S.Table 1).

121　### 2.3. Data collection

122   The pre-test is conducted prior to the formal investigation. The first grade of an
123   ordinary high school in Guangzhou was selected by means of convenient sampling
124   for the pre-test. The information associated with survey questions and calculated
125   scales were revised after getting feedback from the pre-test and then finalized the
126   questionnaire for the final study.

127   Students are filled with information anonymously by means of centralized filling,
128   independent answering, on-the-spot recycling, and on-the-spot investigation. At the
129   spot, the local education authorities and their subordinate schools co-operated
130   closely. Investigators collect all filled questionnaires after the survey is completed.
131   The interview/survey was excluded from those participants who declined to
132   participate in the survey. The questionnaire was finished by each respondent within
133   20 min. All information of the respondents was kept strictly confidential.

134   *2.4. Ethical Approval*

135   Ethical approval had been approved by the Ethics Committee of the School of Public
136   Health, Sun Yat-Sen University, Guangzhou, China. The ethical approval number is
137   2018 (050). The written and verbal sign was taken with each respondent in an
138   informed consent form at the beginning of each survey.

139   *2.5. Statistical analysis*

140   Epidata-3.1 software is used to record the database. Normality distributed
141   quantitative data were displayed as mean and standard deviations, where non-
142   normally distributed data were represented as medians and quartiles (P_{25}~P_{75}).
143   Qualitative data were presented as a rate or percentage. A Pearson chi-square ($\chi2$)
144   test was applied to compare between groups. The influencing factor of SHS was
145   estimated using logistic regression analysis for multivariate analysis, by adjusted
146   Odds ratios (AOR) and 95% confidence interval (CI). All statistical analyses carried
147   out using SPSS 23.0 software. All reported P values were two-sided, and $P < 0.05$ was
148   considered statistically significant.

149   **3. Results**

150   *3.1. Basic characteristics of respondents*
151   A total of 1472 respondent, 11 participants were excluded due to missing items or
152   information in the questionnaire. Finally, 1461 high school students were enrolled
153   in this survey. There were 43.53% (636) male and 56.47% (825) female with the mean
154   age of 17.30 ± 1.27 years, and participants from Shanxi 31.76% (464), Guangzhou
155   33.61% (491), and Tibet 34.63% (506) (STable. 2). The result showed that tiredness
156   and fatigue were high (11.98%) observe in physical SHS, while challenging to study
157   at home (19.10%) in psychological SHS, among other symptoms, detail about the
158   symptoms of both groups is displayed in Table1.
159   **Table 1. Symptoms of SHS and Mental SHS**

160

Sub-health symptoms			Mental sub-health symptoms		
Symptoms	Respondent	Detection rate (%)	Symptoms	Respondent No.	Detection rate (%)
Tiredness, Fatigue	175	11.98	It's hard to study at home	279	19.10
Dry eyes	149	10.20	Concentration on study	233	15.95
Nasal congestion	128	8.76	Unwilling to talk to others	215	14.72
I can't sleep well.	121	8.28	I don't want to see help	209	14.31
Drink more and eat more	120	8.21	Hesitate	207	14.17
Wake up too early	115	7.87	Difficult to remember learning content	205	14.03
Difficulty falling asleep	112	7.67	Unnecessary thoughts	203	13.89
Sore eyes	102	6.98	Irritable	200	13.69
Weak limbs	99	6.78	No hope in the future	170	11.64
			Do not trust others	165	11.29
			Worried about the teacher asking questions	164	11.23
			Feel difficulty of learning	163	11.61

161
162 The survey results showed that there were significant differences in the physical SHS
163 and psychological SHS along with different detection rates among the high school
164 students in the three regions. Psychological SHS was higher in Shanxi (20.69%)
165 followed by Tibet (18.77%) and Guangzhou (13.03%) among surveyed populations
166 (S.Table 3).
167
168 *3.2. SHS detection Score and rate by gender*
169 The results of this study showed that the detection rate of physical SHS symptoms
170 and the Psychological SHS of females was higher than that of males, which is the
171 statistically significant (STable 3,4,5).
172 *3.3. Multiple logistic regression analysis of influencing factors with SHS and*
173 *Psychological* **SHS**
174 In order to know the comprehensive effect of the factors affecting the SHS, a stepwise
175 multi-factor unconditional logistic regression analysis was carried out. The result of
176 this analysis showed that the region, lack of sleep time, heavy learning burden, lack
177 of exercise, drinking alcohol, lack of frequent home visit, and eating habit were the

178 statistically significant associated risk factors of SHS, while an hour of daily internet
179 access was found to be a protective factor for the SHS (Table 2).

180 **Table 2. Detection of SHS in different regions**

Area	Number of respondents	Sub-health		Psychological SHS	
		Symptom check-out	Status check out	Symptom check-out	Status check out
Shanxi	464	207(44.61)	115(24.78)	242(52.16)	96(20.69)
Guangdong	491	188(38.29)	88(17.93)	203(41.34)	64(13.03)
Tibet	506	199(39.33)	106(20.95)	229(45.26)	95(18.77)
Chi test	χ^2	4.520	6.754	11.459	10.640
	P	0.104	**0.034**	**0.003**	**0.005**
Comparison	—	Shanxi，Guangdong，Tibet	Shanxi[b] Guangdong, Tibet	Shanxi[b]，Guangdong[a]，Tibet	Shanxi[b]，Guangdong[a]，Tibet[ab]

181 *Note: a: is compared with Shanxi, and the difference is statistically significant; b: is compared with Guangdong, and the difference is*
182 *statistically significant.*

183

184 Similarly, the results of logistic regression analysis exhibited that the region (rural),
185 grade of class, lack of sleep time, heavy learning burden, less than one time per week
186 home visit, lack of exercise, smoking, drinking, and fewer friends were the risk
187 factors for psychological SHS, while females (gender), family, township, seeking
188 help, and extroversion were the protective factors for the occurrence of
189 psychological SHS (Table 3-4).

190 **Table 3. A multi-factor unconditional logistic regression model of associated factors of**
191 **psychological SHS**

Variables	Number (%)	OR	AOR	95% CI		P-value
				Lower	Upper	
Area						
Guangzhou	491(33.61)	—	—	—	—	**0.009**
Shanxi	464(31.76)	1.908	1.887	1.239	2.874	**0.003**
Tibet	506(34.63)	1.239	1.285	0.699	2.399	0.430
Gender						
Female	825(56.47)	0.583	0.679	0.470	0.980	**0.039**
Grade						
High-I	521(35.67)	—	—	—	—	0.029
High-II	536(36.68)	1.811	1.728	1.097	2.720	**0.018**
High-III	404(27.65)	1.738	1.752	1.128	2.723	**0.013**
Residence						
Urban	465(31.82)	—	—	—	—	0.037
Rural	77(5.27)	0.402	0.588	0.351	0.983	**0.043**
Township	138(9.45)	0.856	1.141	0.541	2.406	0.730
County	69(4.74)	1.391	1.450	0.772	2.723	0.248

Suburb	712(48.74)	0.709	0.802	0.350	1.837	0.602
Home visits						
No visit	238(16.29)	—	—	—	—	0.013
3 or mode days	205(14.03)	3.155	2.478	1.295	4.745	**0.006**
1-2 visit	1018(69.68)	1.759	1.410	0.757	2.627	0.279
Sleep time						
>8 hours	158(10.81)	—	—	—	—	0.002
<6 hours	1234(84.46)	11.417	9.459	2.035	43.971	**0.004**
6-8 hours	69(4.72)	6.715	5.077	1.148	22.459	**0.032**
Learning burden						
Very light	307(21.01)	—	—	—	—	**<0.001**
Light	556(38.06)	0.379	0.232	0.018	2.965	0.261
General	536(36.69)	2.074	2.084	0.828	5.244	0.119
Heavy	40(2.74)	2.289	2.427	1.566	3.761	**<0.001**
Very heavy	22(1.51)	0.919	0.990	0.674	1.454	0.960
Frequency of movement						
2-3 hours	329(22.52)	—	—	—	—	**<0.001**
3 or more times	575(39.36)	2.507	2.472	1.629	3.750	**<0.001**
No movement	557(38.12)	0.933	0.914	0.611	1.369	0.663
Smoking	105(7.19)	2.202	2.138	1.170	3.906	**0.013**
Drinking	246(16.83)	1.969	2.344	1.558	3.526	**<0.001**
Seeking help	1329(90.96)	0.386	0.378	0.227	0.630	**<0.001**
Interpersonal communication						
>6 and above	36(2.46)	—	—	—	—	**<0.001**
No.	367(25.12)	14.232	10.324	3.902	27.314	**<0.001**
1-2	629(43.05)	2.701	2.543	1.580	4.092	**<0.001**
3-5	429(29.36)	1.842	1.839	1.196	2.828	**0.006**
Personal Behaviour	1040(71.18)	0.576	0.647	0.456	0.917	**0.014**

192

4. Discussion

    This study aimed to distinguish the SHS and its associated influential factors among high school students in three geographic regions of China. The study found that the overall detection rate of SHS was 55.10%, where the detection rates of physical SHS and Psychological SHS were 25.80% and 46.13%. Compared with the previous studies among high school students by using MSQA scale [24,25], their detection rates of SHS symptoms ranged from 27.00% to 75.30%, and the detection rate was 12.40%~in the range of 41.12%, except for the symptoms of the physical SHS which was slightly lower. The results of the above surveys are almost the same as the results of our study, which indicates that the SHS occurrence stages among the high school students were ubiquitous. The detection rate of physical and psychological SHS was lower than the national level (physical SHS-34.60%,

205   Psychological SHS-46.84%, and overall detection rate at the national level SHS-
206   53.92%) [21]. An earlier study conducted in our study area found that the overall
207   SHS detection rate in urban high school students in Guangzhou City was 38.53%
208   [25]. The detection rate difference might be due to the difference between the survey
209   method and the measurement scale.
210   Several SHS measuring tools have been established. Additional, a
211   comprehensive and validated tool for SHS stands the Suboptimal Health Status
212   Questionnaire (SHSQ-25) [3], predominantly targeted at the Physiological and
213   Psychological status of people, has been widely applying at the national or
214   international level in different ethnic groups (Asian, African, and Caucasians),
215   which is also a new mechanism to enables people for early intervention in terms of
216   Predictive, Preventive and Personalized Medicine (PPPM) [26–28]. Similarly, MSQA
217   scale evaluates the SHS of adolescents, which is a valid and approved tool in China,
218   which is formulated by Tao et al. [21]. The test-retest reliability, Cronbach alpha (α)
219   coefficient, and split-half reliability coefficient were 0.87, 0.96, and 0.94, respectively,
220   which was conducted among 7104 middle school students [22]. The study of Xing
221   Chao confirmed that MSQA is a credible, effective, and sensitive SHS tool for
222   adolescents. Therefore, to assess the SHS of adolescents, MSQA is a suitable
223   measuring scale; thus, we applied in our study.
224   The study result showed that the geographical region, rural area, lack of sleep
225   time, heavy learning burden, drinking alcohol, lack of frequent home visit, and
226   eating habit were significant risk factors for SHS, similarly the region (rural), the
227   grade of class, lack of sleep time, heavy learning burden, personal behaviour, less
228   than one time per week home visit, lack of exercise, smoking, and drinking, were
229   risk factors for psychological SHS. Interestingly, only an hour of daily internet access
230   was found to be a protective factor for physical SHS, whereas, seeking help, and
231   extroversion were the protective factors for the psychological SHS. Consisting, Zhao
232   [29] and Hou et, al [12], reported that the main physiological problems of middle
233   school students are fatigue, dizziness, gastrointestinal discomfort, and poor sleep
234   tendency. Proper and active exercise, a balanced diet, avoid alcohol, and tobacco
235   habit is the best way to overcome from SHS.

236   Notably, this study found that surfing the internet for no more than an hour in
237   a day was a protecting factor for SHS for high school students. This finding is
238   supported by a study that long-term internet access, high frequency of internet
239   access, and internet addiction are the significant risk factors for SHS [30], which is
240   consistent with our study. The short-term internet access can alleviate the student's
241   stressful learning pressure to a certain extent so that their life rhythm can be slowed
242   down.

243   An earlier study [30] suggested that, in terms of gender, females have their own
244   physiological characteristics, those are more sensitive, delicate as well as the more
245   complex during the physical and psychological changes of adolescence period, thus
246   difficult to guide them at this period, which makes females more likely to have SHS.

247   Our study also found that SHS was high among female students, which is also
248   supported by the study of Cao H, et al [19]   and Yao Y et al [15]. The number of
249   friends or pair groups is a very important influencing factor for the psychological
250   SHS of young students. The results of previous studies [30,31] displayed that the
251   relationship with classmates, the number of friends, misunderstanding between
252   friends of the middle school students had more SHS, which are closely similar to our
253   study. Interpersonal relationships and the number of friends showed a positive
254   relationship with students; in this stage, students are more willing to share their
255   inner world with others, resulting in they can exchange social support. When they
256   encounter difficulties, they can flexibly use the surrounding interpersonal
257   relationships to enhance their confidence, strength, and overcome.

258   Similarly, poor lifestyle behaviors such as; smoking and drinking are the main
259   influencing factors of Psychological SHS [4]. A study of Lolokote et al reported that
260   significant relationship between SHS and the use of tobacco and alcohol in the
261   college students [9]. Our study also found that smoking and drinking are risk factors
262   for SHS of high school students. A study to investigate the risky health behavior of
263   middle school students reported [31] that smoking behaviors among adolescent
264   students are often accompanied by drinking behavior, by which they show obvious
265   psychological issues such as depression, anxiety, nervousness, and temper, because
266   it has well known that SHS is highly influenced by unhealthy lifestyle [32].

267   This survey analyzed the status of SHS among high school students in three
268   economic, geographical, cultural, and environmentally different regions of China,
269   including associated factors of SHS, and results provided a holistic picture of both
270   subjective and objective health measures from the perspective of PPPM [12]. PPPM
271   is a new comprehensive approach in the healthcare sector that allows predicting
272   individual predisposition before the onset of the disease, also provide targeted
273   preventive methods, and create personalized treatment procedures tailored to the
274   person [27]. In recent days, treatment for the non-communicable disease (NCD) are
275   executed after disease onset, which is a very much slow approach from the PPPM
276   perspective [12]. Therefore, timely diagnosis and management of SHS in the society
277   is the holistic approach in terms of PPPM.

278   However, some limitations must be considered when interpreting the findings
279   of this study. This study used a prospective questionnaire survey method, which is
280   difficult to avoid bias and errors caused by differences in understanding an ability
281   among students from different regions or ethnic groups. This was a cross-sectional
282   survey, which did not allow us to assess accurate causality between psychological
283   symptoms and physical SHS. And data was obtained by the self-rating
284   questionnaire, which might have led to information bias. The participants were
285   selected by a convenient sampling method, which leaves the potential for selection
286   bias, and limited generalizability, the relevancy of results to other populations.

287   **5. Conclusions**

288   This study evaluated the SHS of high school students in three regions in
289   China, where SHS was found high in Shanxi, followed by Tibet and Guangzhou.
290   The SHS among females was high than that of males. Rural areas, grades of class,
291   lack of sleep time, heavy study burden, low number of home visits per week, lack of
292   exercise, smoking, drinking, and fewer friends were risk factors for SHS, while,
293   family in townships, seeking help, extroversion person were a protective factor for
294   the occurrence of SHS. Through the comprehensive prevention and control
295   measures of the school and family of the student, promote students to develop good
296   habits, promptly guide various psychological problems and adjust social
297   adaptability, timely detect and treat the sub-health symptoms that have emerged,
298   and effectively prevent and control the student's health.

299   **Supplementary Materials:** The following supplementary including appendixes files are
300   available online at www.mdpi.com/xxx/s1, Supplementary file 1(Appendix-1 Youth Sub
301   Health Status Questionnaire, Appendix-1: Appendix 2: Introduction to the study locations);
302   Supplemantary-2 (Table S1: Indicators of SHS used in questionnaire, Table S2: Basic
303   characteristics of the study groups, Table S3: Distribution of physical SHS and Psychological
304   SHS in different regions, Table S4: The genders score of SHS symptoms, Table S5: A SHS
305   detection rate by gender)

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