



An exploratory social media intervention for perception and behavior on eating away from home: A cluster randomized trial in Chongqing, China

Tingting Wu^{a,d}, Ping Hu^{a,e}, Mao Zou^a, Fan Zhang^{a,b,c}, Huan Zeng^{a,b,c}, Manoj Sharma^f, Yong Zhao^{a,b,c,*}, Zumin Shi^g

^a School of Public Health and Management, Chongqing Medical University, Chongqing, 400016, China

^b Research Center for Medicine and Social Development, Chongqing Medical University, Chongqing, 400016, China

^c Research Center for Public Health Security, Chongqing Medical University, Chongqing, 400016, China

^d Department of Food and Nutrition, College of Medical and Life Sciences, Silla University, Busan, 46958, South Korea

^e Chengdu Blood Center, Chengdu, Sichuan, China

^f Department of Environmental & Occupational Health, School of Public Health, University of Nevada, Las Vegas, NV, 89119, Las Vegas, USA

^g Human Nutrition Department, College of Health Sciences, QU Health, Qatar University, Doha 2713, Qatar

ARTICLE INFO

Handling editor: Cecilia Maria Villas Bôas de Almeida

Keywords:

Eating away from home/school
Food waste
Sustainability behavior
Social media
Unreasonable diet

ABSTRACT

A modern diet with high energy density is harmful to health and negatively affects the environment. Eating out is particularly prevalent among young adults and has steadily increased in many countries over the last few decades. This study aims to assess the impact of nutrition education interventions on social media on cognitive and behavioral changes in the diet of university students. A cluster-randomized trial with an intervention group ($n = 853$) and a no-intervention control group ($n = 846$) was conducted in Chongqing. A two-month educational intervention was conducted through social media (WeChat official account, Sina Weiblog, and Tencent Weibo) with participants of the intervention group. Self-reported eating-out-related knowledge and behaviors were assessed at baseline and six and eight months after randomization. Multilevel mixed-effects logistic regression and linear regression analyses assessed the outcomes between the intervention and control groups. The proportion of participants in the high-level knowledge and attitude group in the intervention group increased by 13% and 8.5% compared with the control group ($p < 0.05$). The effects of the intervention on the outcomes significantly changed over time, as demonstrated by the achieved statistical significance for knowledge and attitude score (p for group and time interaction < 0.001) in the interaction between time and randomization groups. The high-frequency eating away from home/school at weekends decreased from 29.6% to 27.3% in the intervention group. In the control group, the high-frequency eating away from home/school at weekends in the increase was increased (26.3%–27.2%). A total of 73.6% of respondents in the intervention group reported that they consciously reduced their frequency of eating away from home/school. The possibility exists for narrowing the perception and behavior disparity gap through the effective use of social media, such as WeChat and Microblog, which could be a sustainable platform to provide health education or new food policies to promote healthy eating and reduce food waste among university students.

1. Introduction

A modern diet with high energy density is harmful to health and negatively affects the environment (Clark et al., 2019). As the process of urbanization continues, many environmental issues will increase. Urban metabolic activities have caused 80% of global greenhouse gas emissions, of which 19%–29% is related to food consumption (Song et al.,

2015). Food consumption is viewed as one of the most resource-demanding and polluting exercises among food chains (Perrignon et al., 2016). Food waste from eating away from the home accounts for a large proportion of China's waste (Yu, 2014). Half of the solid waste generated is food waste, which also creates an increasing number of environmental problems, such as water, air, and land pollution in China (Z. S. Li, Lei, Qu and Sui, 2009). Furthermore, eating away from

Abbreviations: KAB, Knowledge-Attitude-Behavior.

* Corresponding author. School of Public Health and Management, Chongqing Medical University, Chongqing, 400016, China

E-mail address: zhaoyong@cqmu.edu.cn (Y. Zhao).

<https://doi.org/10.1016/j.jclepro.2022.131206>

Received 1 May 2020; Received in revised form 1 December 2021; Accepted 2 March 2022

Available online 3 March 2022

0959-6526/© 2022 Elsevier Ltd. All rights reserved.

home accounted for higher meat consumption than eating at home, thus generating more carbon footprint caused by highly intensive methane emissions (J. Li, Song, Semakula and Zhang, 2019). Some studies found that eating outside of the home increased the risk for non-communicable diseases, such as obesity, diabetes, cardiovascular disease, and stroke (Afshin et al., 2019; Bissattini and Vignoli, 2017; Choi et al., 2019; Goffe et al., 2017; Ma et al., 2021; Nago et al., 2010). It is often a critical factor associated with foodborne diseases (Carl et al., 2011).

Nevertheless, food consumption outside the home tends to increase highly over the last few decades in many countries (Adams et al., 2015; Bezerra et al., 2021; Choi et al., 2019; Goffe et al., 2017; Kant et al., 2015), a practice particularly prevalent among young adults. In China, more than 36.1% of young adults reported that they dined out in 2015 (Ju et al., 2021), consuming more sodium, sugars, saturated fat, and alcohol and fewer grains, vegetables, and fruits. Furthermore, food delivery service is also considered as food consumption outside the home. Given the COVID-19 pandemic, more people rely on food delivery apps and other delivery services (L, 2020). In 2020, approximately 500 million people used food delivery services in China (Lee, 2021). Eating away from home and using food delivery services bring challenges, such as food safety, environmental pollution, and road accident (Bezerra, 2020; Xie et al., 2021).

Reducing eating out and consuming food away from home/or supporting young adults to make healthier choices when eating out of the home should be a priority for public health promotion. However, many interventions have been conducted using traditional methods, such as posters, leaflets, and lectures (Bruemmer et al., 2012; Pan et al., 2015; Roxana et al., 2015; Zibing W et al., 2015), which have higher cost and waste but less effect (Nelson et al., 2008). In recent years, many nutrition interventions programs have used modern technology, particularly social media (Klassen et al., 2018; Villinger et al., 2019). Adolescents and young adults are particularly amenable to such solutions because they exhibit high levels of social media usage (Auxier and ANDERSON, 2021). Despite Facebook and Twitter being blocked, Tencent WeChat and Weibo have attracted millions of users (Thomala, 2021). In 2020, China has approximately 926.8 million social media users.

Social media platforms, such as Facebook, Twitter, and WeChat, have driven public health interventions focused on a particular health topic, such as web-based coaching for drinking cessation (Kypri et al., 2018), weight loss (Hsu et al., 2018), healthy lifestyle behaviors (van Elten et al., 2018), and other health promotion interventions (Centola, 2013; Chou et al., 2013; Christakis and Fowler, 2013). Using different theoretical foundations (Hackman and Knowlden, 2014), these media interventions focused on broader age groups (van Dammen et al., 2021) or specific behaviors and clinical outcomes, such as vegetable intake or weight loss (Booth et al., 2008). Few studies have examined the efficacy of social media intervention on eating out habits among young adults. Social media is nearly universally utilized by young adults, but whether or how they will engage with health promotion information is uncertain (Klassen et al., 2018).

To design any program or policy, a deep understanding of young adults' opinions on messages and environmental change would encourage them to select healthier options when eating away from home/school is needed. Maher (Vandelanotte and Maher, 2015) argue that randomized controlled trials should be used to evaluate the efficacy of online social networking as a tool. Thus, in this study, we conducted an exploratory social media intervention by a cluster randomized controlled trial, which based the nutrition demand of the target population on dining out. We assessed the effectiveness and feasibility of intervention on these platforms. The ultimate expectation of reducing eating away from home/school and promoting university students keeps a sustainable dietary pattern and helps reduce food waste.

2. Material and methods

2.1. Participants and sampling

The study was conducted at College Town in Chongqing, China, located in the West of the Shapingba District, and 14 universities. This study used random cluster trials following CONSORT guidelines (Campbell et al., 2012). Two universities were randomly selected, Chongqing Medical University and Chongqing Normal University. Two departments in each university were randomly selected. All students in the selected departments were invited to participate in the research. In total, the number of students in each department was 545 (School of Public Health and Management), 603 (School of Basic Medicine), 378 (School of Applied Mathematics), and 300 (School of Thought and Politics). The randomization was based on departments. All participating students from the same department were assigned to either the intervention group or the control group. Students in the intervention and control groups were selected according to the inclusion criteria: (1) voluntary participation, (2) \geq six months of new media usage, and (3) active frequency of new media usage (information push rate: 3 or more per week). A questionnaire on the knowledge-attitude-behavior (KAB) and demand of all participants was conducted before the intervention. Finally, 1789 volunteers were enrolled in the study. The intervention group consisted of 885 participants, whereas the control group included 904 participants. Fig. 1 details the recruitment procedures.

2.2. Ethics statement

This project was reviewed and approved by the Ethical Committee of the Chongqing Medical University (record number: 2013036) and was registered in the Chinese Clinical Trial Registry (Number: ChiCTR-OCH-14004861). Written informed consent was obtained from all participants.

2.3. Intervention

2.3.1. Information of intervention

The intervention-based Knowledge-Attitude-Behavior theory model points out that health education's goal is to promote behavioral change. The KAB theory model has been widely used in health education research (Blake, 1996; Ward et al., 2002). To achieve this goal, knowledge or learning was used as the basis, and beliefs (correct beliefs or positive attitudes) were used as the motivation. Therefore, the intervention was based on knowledge related to eating away from home/school transformation and education, which may help change-related attitudes toward and behaviors of eating away from home/school. A total of 67 messages in images and texts were sent to the intervention group participants, which focused on the needs of participants from three aspects: (1) health hazards of long-term eating away from home/school, (2) food safety and nutritional quality issues caused by long-term eating away from home/school, and (3) suggestion for eating away from home/school, such as how to choose a healthy diet and how to deal with food safety problems. More details were provided in Supplementary 1.

2.3.2. Platforms of intervention

Before the intervention, participants were asked which multimedia was commonly used and which platforms they preferred to receive health knowledge information from. Questions about intervention preference were shown in Supplementary 2. Based on participants' selection, we chose WeChat, Sina Microblog, and Tencent Weibo as the intervention platforms, all of which were the most frequently used platforms among university students in China (CNNIC, 2018). All intervention groups were asked to follow any one of the health education group's social media platforms (WeChat, Tencent Weibo, or Sina Weibo) for eating away from home/school. The platforms are easy to

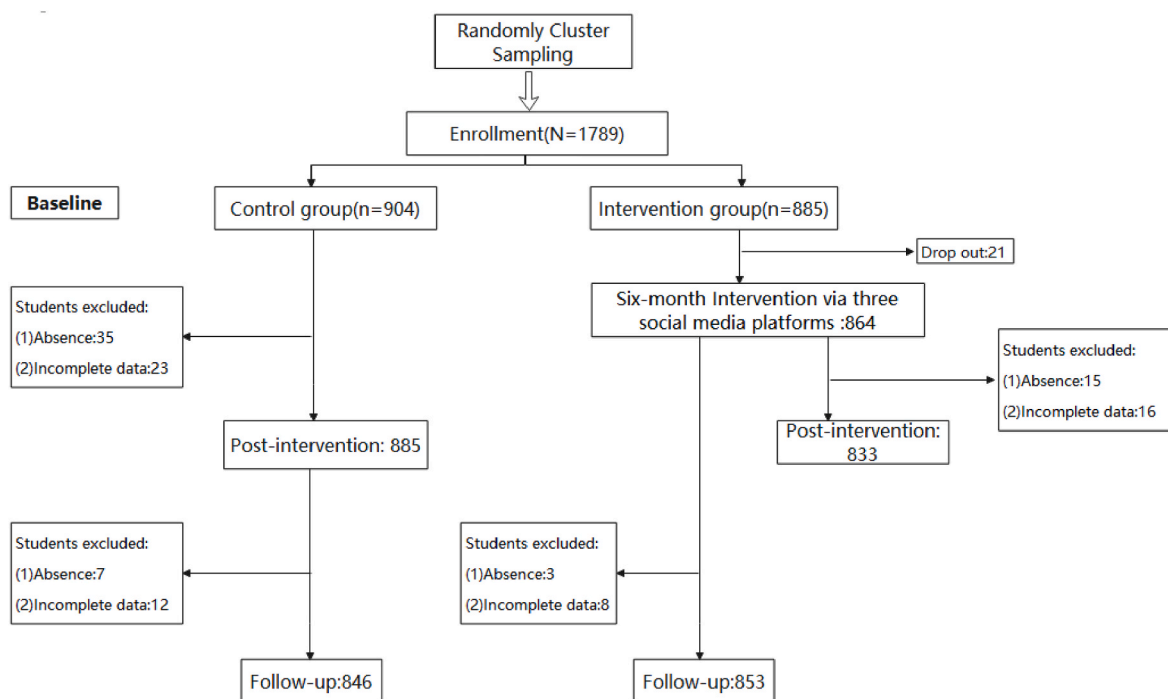


Fig. 1. Flowchart of the stepwise process of participants.

use, and the minimum requirement for installing WeChat, Sina Weiblog, and Sina Weibo for an IOS System was V.6.0, V.5.2, and V.3.1, respectively. The minimum requirements for the Android System were V.6.33, V.10.1, and V.6.10. The research team conducted a two-month intervention that delivered information about eating away from home/school to the intervention group through the three social media platforms. In contrast, the control group did not receive any intervention.

2.3.3. Intervention time and frequency

The intervention lasted two months during summer vacation (from July 20 to September 20, 2014). The detailed time and frequency of posting the intervention information was 10:00 everyday night. We chose the time based on when the students finished their exams and were more active on social media platforms. We likewise published a question related to the intervention information in the platforms to review the intervention knowledge and increase the reading interest of participants. Participants with high participation and/or high answer accuracy were given a monetary reward every two weeks (*Hongbao* in Chinese, worth 1–2 RMB).

2.4. Outcome measurements

2.4.1. Frequency of eating

The frequency of eating away from home/school was assessed by the question “how often did you eat away for home/school for dinner or lunch per week (includes weekdays and weekends) in the last month?” And the food delivery service is also considered as food consumption outside the home/school. The analysis categorized the responses into three levels as less than once, 1–3 times, and 3–5 times. The change in the frequency of eating away from home/school was one of the main outcome measures. We also assessed the changes in behaviors, including “ordering behaviors,” “using tea or boiled water instead of sugared beverages,” “paying attention to the disinfection of the tableware,” and “paying attention to the hygiene of the restaurant.”

In the intervention group, participants were asked about their

opinion of the intervention by three questions: “Do you consciously reduce the frequency of eating away from home/school after receiving intervention information?” “What do you think about this information?” “Did you change your behavior of eating away from home/school after the intervention?”

2.4.2. The score of knowledge and attitude related to eating away from home/school

The knowledge of eating away from home/school was assessed by 20 single-choice questions, covering issues of basic nutrition (e.g., following healthy dietary patterns; choosing the right types of foods; and avoiding foods with high amounts of oils, salt, and fats) and food safety (e.g., expiry of food ingredients and bacteria). Each question was assigned a score of 1. The attitude toward eating away from home/school was assessed by eight single-choice questions with disagree, neutral, and agree options. In the analysis, the answers were assigned a score from 0 to 2. Furthermore, evaluating the effect of the intervention on the knowledge and attitudes of the whole participants of the group is it is to better, we recode knowledge and attitudes score into categorical variables based on their total scores, which were divided into high and low levels based on 60% of the total score of knowledge and attitude as the cut point. Supplementary 3 shows questions used to assess the knowledge and attitude.

2.5. Statistical analysis

Statistical analysis was performed using Stata statistical software for Windows (Stata, version 15.1, Cary, NC, USA). Continuous variables were analyzed using an independent sample *t*-test, and binary and categorical outcomes were used a Pearson Chi-Square, Fisher’s exact test, or Fisher-Freeman-Halton exact test. The differences in outcomes between the intervention and control groups were accessed by multilevel mixed-effects logistic regression and linear regression analyses with the model adjusted for residence, mothers’ education level, and living place. Furthermore, results are expressed as marginal means per time point. An interaction term between time and intervention was tested. The

frequency of eating away from home/school was expressed as a percentage. All statistics were analyzed through a two-sided test. A p-value less than or equal to 0.05 was considered statistically significant.

3. Result

The demographic characteristics of the study population are presented in Table 1. This study included 1789 students, with 885 participants in the intervention group and 904 participants in the control group. Nearly 70% of the participants were female. No significant difference was observed between the control and intervention groups regarding age, body mass index, father's education level, and monthly food expenses. Of the participants in the intervention group, more than 50% were from rural areas, and 25.1% had mothers who finished high school or secondary school. Only 19.7% of the participants had mothers who finished high school or secondary school in the control group. Most of the participants (94.2%) in the intervention group lived in the dormitory during the study, whereas 89.9% of the participants in the control group did. Furthermore, 60% of the participants lived at home during holidays (Table 1).

3.1. Primary outcomes

3.1.1. The change in eating away from home/school related knowledge and attitude

Fig. 2 shows the estimated marginal means for a score in the intervention and the control group over the different time points. The effects of the intervention on the outcomes significantly change over time, as demonstrated by the fact that interaction between time and randomization group achieve statistical significance for knowledge, attitude, and cognition score ($P < 0.001$). Although the intervention group's

Table 1
Comparison of the baseline characteristics between the two group.

Demographic Variables	Intervention(N = 885)	Control (N = 904)	p-value
Gender			0.088
Male	225(25.4)	250(27.7)	
Female	648(73.2)	599(66.3)	
Age	19.69 ± 1.06	19.80 ± 1.07	0.121
BMI			0.326
Thin (<18.5)	169(20.0)	171(22.2)	
Normal (18.5–23.9)	626(74.3)	546(71.0)	
Overweight or obese (≥24)	48(5.7)	52(6.8)	
Residence			0.030*
Urban	405(45.9)	369(40.8)	
Rural	477(54.1)	535(59.2)	
Father's education level			0.081
Primary school or below	141(16.1)	177(19.8)	
Middle school	373(42.5)	377(42.2)	
High school/secondary	249(28.4)	250(28.0)	
College education or more	114(13.0)	88(9.9)	
Mother's education level			0.003*
Primary school or below	240(27.3)	314(35.1)	
Middle school	358(40.8)	342(38.3)	
High school/secondary	220(25.1)	176(19.7)	
College education or more	60(6.8)	61(6.8)	
Monthly food expenses (CNY)			0.224
<600	634(72.1)	619(69.0)	
600–900	213(24.2)	236(26.3)	
>900	31(3.5)	37(4.1)	
Living place during holidays the semester			< 0.001*
University accommodation	833(94.2)	806(89.9)	
Home/Renting house	51(5.8)	90(10.0)	
Living place during holidays			0.007*
University accommodation	66(7.5)	60(6.7)	
Home/Renting house	563(92.5)	513(93.2)	

Note: Baseline characteristics are presented as means and standard deviations (SD) for continuous variables, and as percentages (%) and total number of participants (N) for categorical data. * $p < 0.05$.

knowledge score is significantly different from the control group in baseline ($\beta = 0.718, p = 0.001$), the differences become more extensive over time ($\beta = 1.683, \text{vs. } \beta = 2.479$).

Besides, before the intervention, no significant difference was found in the proportion of participants in the high-level knowledge and attitude groups between the intervention and control groups. After the intervention, the proportion of participants in the high-level knowledge group in the intervention group increased by 13% and was significantly different from the control group ($p < 0.05$). The same finding was also found in the proportion of participants in the high-level attitude group, which increased by more than 8.5%, $p < 0.05$. (Table 2).

3.1.2. Behavior changes of eating away from home/school

The frequency of eating away from home/school for lunch and dinner during weekdays for two groups changed after intervention. The high-frequency eating away from home/school (≥ 9) decreased from 8.5% to 5.0% in the intervention group and from 10.6% to 8.7% in the control group ($p = 0.048 \text{ vs. } p < 0.001$). No significant difference was observed in eating away from home/school for lunch and dinner on the weekend at the three time points. The same result was found for the control group ($\chi^2 = 10.04, p = 0.262 \text{ vs. } \chi^2 = 7.95, p = 0.438$). The number of participants with high-frequency eating away from home/school (≥ 4) at street food vendors decreased by 2%–3% after the intervention ($p = 0.02$), which is higher than the decline in the proportion of the control group (Table 3).

After the social media intervention, the number of participants who never or seldom paid attention to the hygiene of the restaurant when they ate decreased from 18% to 11.5% and increased in the proportion of participants who often or always paid attention to restaurant hygiene (82.1% vs. 86.6%). The participants' attention to hygiene continued to increase to 88.50% at the two-month follow-up ($p = 0.014$). Furthermore, the proportion of participants who often or always drank tea or boiled water instead of the sugared beverages when eating away from home/school increased to 67.9% from 44.6%. Participants who often or always ordered fewer high-fat dishes when eating away from home/school highly increased from 55% to 70% ($P < 0.001$). These changes continued at the two-month follow-up (23.0%, 30.5%, and 76.6%, $p < 0.001$) (Table 4).

After the intervention, participants in the intervention group were more likely to pay attention to the restaurant's hygiene than the participants in the control group ($P < 0.001$). No significant difference between the two groups was noted when paying attention to the cleanliness of the tableware ($P = 0.11$) or in ordering fewer high-fat dishes ($P = 0.55$). However, the results showed that the participants in the intervention group were more likely to pay attention to the cleanliness of the tableware and selection of fewer high-fat dishes than the participants in the control group at the two-month follow-up ($P < 0.001$). The participants in the intervention group were also more likely to order tea or boiled water instead of sugary beverages than those in the control group at the post-intervention and two-month follow-up ($p < 0.001$) (Table 4).

3.2. Secondary outcome

Table 5 shows the personal subjective assessment of the effects of social media intervention. Among the 833 follow-up participants in the intervention group, 44.9% of the respondents reported that the information presented in the intervention improved their perception and guided their behaviors when eating away from home/school, 48.7% showed that the information in the intervention improved their understanding of eating away from home/school, but implementing changes in behavior is complex. These statements mean that 93.6% of the respondents considered the intervention helpful and reported improving their perception. After the two-month intervention, 73.6% of the respondents reduced their frequency of eating away from home/school, and 67.8% indicated that the behavior of eating away from home/school

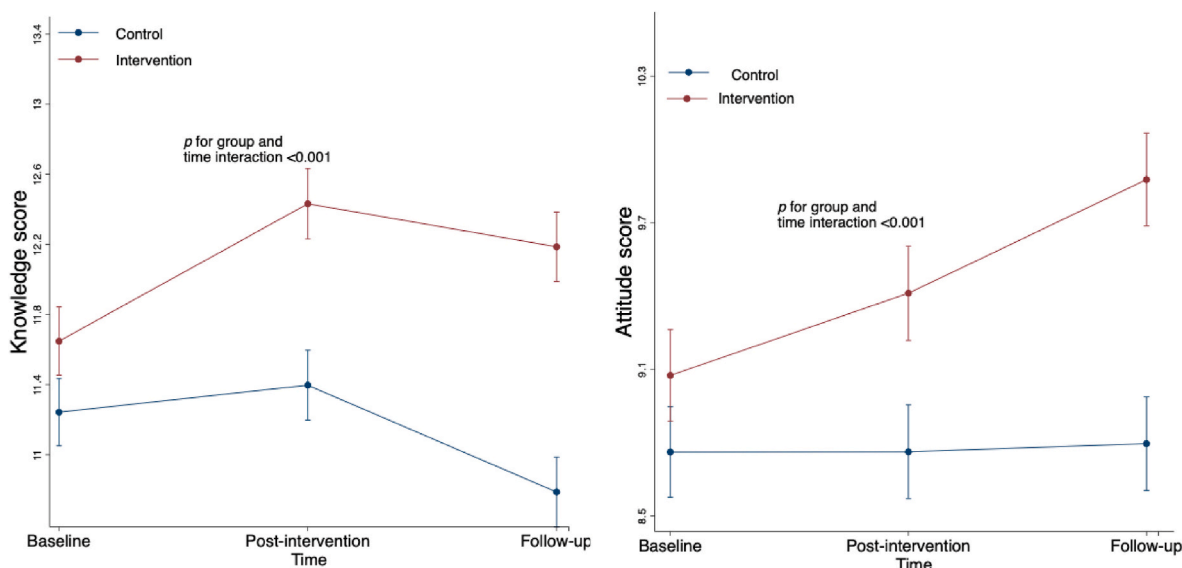


Fig. 2. Intervention effect on knowledge and attitude score. Note: Values represent marginal mean (95%CI). Model was adjusted for residence, mothers' education level, and living place.

Table 2
Comparison of percentage change of High level of knowledge and attitude on intervention group with control group.

	Time	Percentage change of High level (N %,95%CI)	p-value	Interaction effect OR (95% CI)
High level of Knowledge	Baseline	2.23(-0.023,0.068)	0.334	-
	Post-intervention	13.15(0.084,0.179)	p < 0.001	1.55 (1.18, 2.04) p = 0.002
	Follow-up	13.00(0.084,0.176)	p < 0.001	1.58 (1.20,2.08) p = 0.001
High level of Attitude	Baseline	2.81(-0.018, 0.074)	0.237	-
	Post-intervention	8.50(0.037,0.132)	p < 0.001	1.26 (0.96,1.65) p = 0.094
	Follow-up	13.90 (0.092,0.186)	p < 0.001	1.56(1.20, 2.05) p = 0.001

Note: Differences and 95% confidence intervals (95% CI) were analyzed by multilevel mixed-effects logistic regression analysis. Model adjusted for residence, mothers' education level, living place. And an interaction term between time and intervention was used in the model.

Table 3
Frequency of eating out per week in the last month at different time (n%).

Frequency	Intervention group				Control group			
	Baseline	Post-intervention	Follow-up	p	Baseline	Post-intervention	Follow-up	p
Weekdays (Lunch and Dinner)								
1-3	574(64.8)	525(63)	554(65)	0.048*	610(67.5)	572(64.6)	588(69.5)	<0.001*
4-8	236(26.7)	266(31.9)	243(28.5)		193(20.4)	236(26.7)	183(21.6)	
≥9	75(8.5)	42(5.0)	54(6.3)		96(10.6)	71(8.0)	74(8.7)	
Weekends (Lunch and Dinner)								
0	69(7.8)	63 (7.6)	74(8.7)	0.262	107(11.8)	92(10.4)	98(11.6)	0.438
1-2	546(61.7)	543(65.2)	568(66.6)		533(59.0)	546(61.7)	545(64.4)	
3-4	262(29.6)	227(27.3)	211(24.7)		243(26.9)	241(27.2)	200(23.6)	
Eating at street food vendors				0.02*				0.005*
0	246(27.8)	255(30.6)	298(34.9)		435(48.1)	435(49.2)	417(49.3)	
1-3	490(55.4)	462(55.5)	440(51.6)		397(43.9)	400(45.2)	389(46.0)	
≥4	145(16.4)	115(13.8)	90(13.4)		58(6.4)	32(5.2)	32(4.4)	

Note: *p < 0.05, obtained from McNemar test at different time.

was improved by this intervention (Table 5).

4. Discussion

Social media as an active part of the intervention mechanism improved participants' cognition score of eating away from home/school effectively, and the effects of the intervention on the outcomes change over time significantly. This finding differed from the meta-analysis results of social media interventions for diet and exercise behaviors (Gillian et al., 2014). The discrepancy could be because the participants in the present study were university students and social media users in China (CNNIC, 2018). Social media provides effective ways to increase user interaction and peer-to-peer support and widens access to health intervention (Madej, 2016). A significant increase was found in the cognition score on eating away from home/school in the intervention and control groups. However, the level of increase in the control group was lower than that for the intervention group. Future interaction is the most prominent feature of the intervention conducted through social media (Madej, 2016). Participants in the intervention group may share useful knowledge about eating away from home/school through social media or a network after they receive the information. Therefore, members in the control group will also have the chance to receive intervention information.

The participants in the intervention group significantly decreased

Table 4
The eating out behavior change of the intervention group in the last month at different time.

Behavior	Baseline	Post-intervention	Follow-up	p [#]
Pay attention to the hygiene of the restaurant				
Never or seldom	158 (17.9%) ^a	112(13.3%) ^b	98(11.5%) ^b	<0.001*
Often or always	727 (82.1%) ^b	722 391 (86.6%) ^b	755 (88.5%) ^b	
p ^{##}	0.889	<0.001*	<0.001*	
Pay attention to the disinfection of the tableware				
Never or seldom	347 (39.3%) ^a	366(31.9%) ^b	169 (23.0%) ^c	<0.001*
Often or always	349 (60.8%) ^a	340(67.8%) ^b	413 (77.0%) ^c	
p ^{##}	0.081	0.110	<0.001*	
Use tea or boiled water instead of sugary beverages				
Never or seldom	486(54.8) ^a	268(32.2%) ^b	260 (30.5%) ^c	<0.001*
Often or always	400 (44.6%) ^a	565(67.9%) ^b	593 (69.5%) ^c	
p ^{##}	0.237	0.049*	<0.001*	
Order less high-fat dishes				
Never or seldom	396 (44.7%) ^a	249(29.9%) ^b	200 (23.4%) ^b	<0.001
Often or always	488 (55.2%) ^a	584(70.1%) ^b	653 (76.6%) ^b	
p ^{##}	0.108	0.550	<0.001*	

Note: ##, obtained from a chi-square test compared with the control group at the same time, *p < 0.05; #, obtained from McNemar test at different time, *p < 0.05. The "a, b, c," subscript letter denotes a subset of time after intervention categories whose column proportions whether differ significantly from each other at the level of 0.05. The different superscript letter means it is different significantly with each other at the level of p < 0.05.

Table 5
Personal subjective assessment of effects of the social media intervention.

Personal reported effect of the intervention of respondents	Response	
	n	%
The information of the intervention would improve my knowledge and guide my behaviors of eating out.	372	44.9
The information of the intervention would improve my knowledge of eating out, but it's hard to implement to change my behavior	406	48.7
After receiving the information, I have consciously reduced the frequency of eating out.	613	73.6*
After receiving the information, my eating out behavior was changed somewhat.	565	67.8*

Note : * More than 60% of the respondents chose the option.

their frequency of eating away from home/school for lunch and dinner on weekdays, and the places for eating away from home/school also changed after the intervention. However, some participants in this group had fewer significant changes in their frequency of eating away from home/school on weekends than in the baseline survey. University students usually leave campus to meet friends on weekends, which leads to socializing and eating away from home/school (Ping Hu et al., 2017). Meanwhile, students who choose not to go out would instead order take-out food. In this study, eating take-out food is also defined as an eating-out behavior. Eating away from home/school on weekends seems to be challenging to avoid. Thus, supporting young adults to make healthier choices when eating away from home/school of the home should prioritize public health.

Nevertheless, we can promote the quality of meals when eating away from home/school by improving the knowledge and behavior associated with eating away from home/school (Ren et al., 2020). A previous study

found that more than 20% of university students preferred to eat out at street food vendors (Ping Hu et al., 2017). Such vendors often provide food that has received ample attention for poor hygiene quality (Steyn et al., 2011). The present study found a decrease in the frequency of eating at street food vendors after the intervention, a positive change for participants. This result indicates that the intervention materials focused on the hygiene and safety of roadside food stalls are efficacious.

Previous studies have pointed out that dietary interventions require a long time to work. An American study reported that the intervention for eating away from home/school through implementing menu nutrition labeling regulations significantly changed the energy intake of diners after 18 months (Brummer et al., 2012). After this intervention, the participants in the intervention group were likely to pay attention to the sanitation practices of the restaurant and the cleanliness of the tableware. Furthermore, participants used their napkins and washed their hands after ordering when eating away from home/school. They ordered fewer high-fat dishes and drank tea or boiled water to lessen their fat and sugar intake. These changes in behavior coincide with the problems researchers pointed out in a previous study (Konwea et al., 2016). Behavioral changes during meals eaten out require a gradual process. The social media intervention period for the current study was only two months, and the effects are minor. Further studies should accommodate the intervening time or follow-up assessment to obtain more detailed outcome indicators. Even so, the intervention produced many subjective favorable comments from respondents who acknowledged that their frequency of eating away from home/school and unhealthy eating behavior were consciously changed, attesting to the relatively efficacious design of the core intervention material, which may guide future research.

Opportunities for narrowing the health disparity gap exist through the effective use of social media as a communication and health promotion platform (Jane et al., 2018). Social media has often been used as an intervention tool to influence various outcomes related to healthy eating and exercise in the United States among adults, but such programs are rare in China. Researchers have provided health education through Facebook, which has led to positive health promotion outcomes, and have encouraged others to build Facebook-based health education platforms and programs (Jacobs et al., 2014). Given the first intervention based on social media platforms, such as WeChat and Microblog, in Chongqing, China, the rate of loss to follow-up in this study was 13%, which is lower than that in other network projects (Booth et al., 2008). Thus, our social media intervention on WeChat and Microblog could offer greater and different types of health education in China, especially among university students.

This exploratory study aimed at designing a more definitive study, which should be interpreted with caution because of several limitations. First, the self-reported frequency of eating away from home/school may produce recall bias. We do not have behavioral observations of the participants even though the questionnaire used demonstrated validity and reliability and strict quality control approaches were introduced in all field surveys (P. Hu et al., 2016; Ping Hu et al., 2017). Furthermore, more longitudinal studies are needed to examine whether the changed behaviors sustain and the participants search out more health information after the intervention, for example, monitoring their actual behavior through observation or using social media to check-in at dining locations. Second, we only evaluated the changes in the knowledge and attitude score and the frequency of eating away from home/school of participants. The specific transmission path of the intervention information, whether or not the participants received the information, were not discussed, and strategies were not used for monitoring the information reception. Further research is needed to explore the actual reception of the frequency and the intensity of intervention information for participants. Third, this study is a public health intervention project that cost-benefit evaluation is essential to improve the scalability of the intervention project with effectiveness and feasibility. Further exploring on cost-benefit evaluation is needed. Furthermore, more longitudinal

research is necessary to examine whether the changed behaviors sustain and whether participants search for more health information after the intervention.

5. Conclusions

Frequent eating away from home/school is common in young Chinese adults. Our results showed that using WeChat and Weibo as platforms is effective and feasible when conducting an intervention on eating away from home/school behaviors among university students. As a short-term intervention, the effect appears to be moderate. Food hygiene was paid more attention, and the frequency of eating away from home/school and unhealthy eating behavior were consciously changed after intervention. The effectiveness and feasibility of this intervention study warrant further research in low- and middle-income countries to help reduce food waste and improve nutritional behavior and status among young adults and other age groups. Further studies should focus on the long-term effect of social media intervention on eating away from home/school behaviors and food waste problems.

Funding

This research was funded by the KFC (Kentucky Fried Chicken) Catering Health Fund in 2014 (No. 201433) and was supported by the Top-talent Notch students' program of Chongqing Medical University (BJRC201804).

CRediT authorship contribution statement

Tingting Wu: Conceptualization, Methodology, Formal analysis, Software, Writing – original draft, preparation, Writing – review & editing, Visualization. **Ping Hu:** Investigation, Resources, Visualization, Validation. **Mao Zou:** Investigation, Resources, Visualization, Validation. **Fan Zhang:** Investigation, Resources, Visualization, Validation. **Huan Zeng:** Investigation, Resources, Visualization, Validation. **Manoj Sharma:** Writing – review & editing. **Yong Zhao:** Funding acquisition, Supervision, Visualization. **Zumin Shi:** Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to thank all teachers and class leaders who helped us coordinate the survey as well as all the students who participated in it. We would like to acknowledge the support provided by Yan Zhan, Wenjie Huang, Lu Lu during the field investigation. And we would also like to acknowledge the comments of the professor Xiaorong Hou and Xun Lei for manuscript revising. And we would like to thank the support of Chongqing Collaborative Innovation Center for Functional Food, Chongqing University of Education, Department of Food and Nutrition, College of Medical and Life Sciences, Silla University and National Key R&D Program of China : Research and Application Demonstration of Information Technology for Food Safety Social Co-governance (2017YFC1602000)

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jclepro.2022.131206>.

References

- Adams, J., Goffe, L., Brown, T., Lake, A.A., Summerbell, C., White, M., Adamson, A.J., 2015. Frequency and socio-demographic correlates of eating meals out and take-away meals at home: cross-sectional analysis of the UK national diet and nutrition survey, waves 1–4 (2008–12). *Int. J. Behav. Nutr. Phys. Activ.* 12 (1) <https://doi.org/10.1186/s12966-015-0210-8>.
- Afshin, A., Sur, P.J., Fay, K.A., Cornaby, L., Ferrara, G., Salama, J.S., Murray, C.J.L., 2019. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 393 (10184), 1958–1972. [https://doi.org/10.1016/s0140-6736\(19\)30041-8](https://doi.org/10.1016/s0140-6736(19)30041-8).
- Auxier, B., Anderson, M., 2021. Social Media Use in 2021. PEW RESEARCH CENTER. <https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021/>.
- Bezerra, I.N., 2020. Away-from-home food during coronavirus pandemic. *Publ. Health Nutr.* 23 (10) <https://doi.org/10.1017/s1368980020001470>, 1855–1855.
- Bezerra, I.N., Medeiros, H.B., de Moura Souza, A., Sichieri, R., 2021. Contribution of away-from-home food to the energy and nutrient intake among Brazilian adolescents. *Publ. Health Nutr.* 24 (11), 3371–3378. <https://doi.org/10.1017/S1368980020001573>.
- Bissattini, A.M., Vignoli, L., 2017. Let's eat out, there's crayfish for dinner: American bullfrog niche shifts inside and outside native ranges and the effect of introduced crayfish. *Biol. Invasions* 5, 1–14.
- Blake, A.J., 1996. The testing of a theoretical model: effect of a nutrition course on the dimensions of knowledge, attitude and behavior relative to diet/exercise and cardiovascular disease relationship. *J. Am. Diet Assoc.* 96 (9-suppl-S), A104.
- Booth, A.O., Nowson, C.A., Helen, M., 2008. Evaluation of an interactive, Internet-based weight loss program: a pilot study. *Health Educ. Res.* 23 (3), 371–381. <https://doi.org/10.1093/her/cyn007>.
- Bruemmer, B., Krieger, J., Saelens, B.E., Chan, N., 2012. Energy, saturated fat, and sodium were lower in Entrées at chain restaurants at 18 Months compared with 6 Months following the implementation of mandatory menu labeling regulation in king county, Washington. *J. Acad. Nutr. Diet.* 112 (8), 1169–1176. [10.1016/j.jand.2012.04.019](https://doi.org/10.1016/j.jand.2012.04.019).
- Campbell, M.K., Piaggio, G., Elbourne, D.R., Altman, D.G., 2012. Consort 2010 statement: extension to cluster randomised trials. *BMJ* 345 (sep04 1). <https://doi.org/10.1136/bmj.e5661> e5661-e5661.
- Carl, L., Nguyen Bao, K.L., Huynh, T.T.T., Roomsarijn, V., Eunice, N., Dominique, R., Patrick, K., 2011. Factors associated with eating out of home in Vietnamese adolescents. *Appetite* 57 (3), 649–655. [10.1016/j.appet.2011.08.003](https://doi.org/10.1016/j.appet.2011.08.003).
- Centola, D., 2013. Social media and the science of health behavior. *Circulation* 127 (21), 2135–2144. <https://doi.org/10.1161/circulationaha.112.101816>.
- Choi, M.-K., Lee, Y.-K., Heo, Y.-R., Hyun, T., Lyu, E.-S., Park, H., Bae, Y.J., 2019. Association between the frequency of dining out and the risk of obesity, diabetes mellitus, and dyslipidemia among Korean adults. *Ecol. Food Nutr.* 58 (6), 560–574. <https://doi.org/10.1080/03670244.2019.1644327>.
- Chou, W.Y., Prestin, A., Lyons, C., Wen, K.Y., 2013. Web 2.0 for health promotion: reviewing the current evidence. *Am. J. Publ. Health* 103 (1), e9–18. <https://doi.org/10.2105/ajph.2012.301071>.
- Christakis, N.A., Fowler, J.H., 2013. Social contagion theory: examining dynamic social networks and human behavior. *Stat. Med.* 32 (4), 556–577. <https://doi.org/10.1002/sim.5408>.
- Clark, M.A., Springmann, M., Hill, J., Tilman, D., 2019. Multiple health and environmental impacts of foods. *Proc. Natl. Acad. Sci. U. S. A.* 116 (46), 23357–23362. <https://doi.org/10.1073/pnas.1906908116>.
- CNNIC, 2018. The 42nd Statistical Report on the Development of China's Internet. 2018. China Internet Network Information Center. Retrieved from. http://www.cnnic.net.cn/hlwzjy/hlwzjy/hlwzjy/201808/t20180820_70488.htm.
- Gillian, W., Hamm, M.P., Jocelyn, S., Ben, V., Lisa, H., 2014. Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials. *BMJ Open* 4 (2), e003926. [10.1136/bmjopen-2013-003926](https://doi.org/10.1136/bmjopen-2013-003926).
- Goffe, L., Rushton, S., White, M., Adamson, A., Adams, J., 2017. Relationship between mean daily energy intake and frequency of consumption of out-of-home meals in the UK National Diet and Nutrition Survey. *Int. J. Behav. Nutr. Phys. Activ.* 14 (1), 131. <https://doi.org/10.1186/s12966-017-0589-5>.
- Hackman, C., Knowlden, A., 2014. Theory of reasoned action and theory of planned behavior-based dietary interventions in adolescents and young adults: a systematic review. *Adolesc. Health Med. Therapeut.* 101. <https://doi.org/10.2147/ahmt.s56207>.
- Hsu, M.S.H., Rouf, A., Allman-Farinelli, M., 2018. Effectiveness and behavioral mechanisms of social media interventions for positive nutrition behaviors in adolescents: a systematic review. *J. Adolesc. Health : Off. Publicat. Soc. Adolescent Med.* 63 (5), 531–545. <https://doi.org/10.1016/j.jadohealth.2018.06.009>.
- Hu, P., Huang, W., Bai, R., Zhang, F., Sharma, M., Shi, Z., Zhao, Y., 2016. Knowledge, attitude, and behaviors related to eating out among university students in China. *Int. J. Environ. Res. Publ. Health* 13 (7). <https://doi.org/10.3390/ijerph13070696>.
- Hu, P., Wu, T., Zhang, F., Zhang, Y., Lu, L., Zeng, H., Zhao, Y., 2017. Association between eating out and socio-demographic factors of university students in chongqing, China. *Publ. Health Nutr.* 14 (11), 1322. <https://doi.org/10.3390/ijerph14111322>.
- Jacobs, M.A., Cobb, C.O., Abrams, L., Graham, A.L., 2014. Facebook apps for smoking cessation: a review of content and adherence to evidence-based Guidelines. *J. Med. Internet Res.* 16 (9), e205.
- Jane, M., Hagger, M., Foster, J., Ho, S., Pal, S., 2018. Social media for health promotion and weight management: a critical debate. *BMC Publ. Health* 18 (1). <https://doi.org/10.1186/s12889-018-5837-3>.

- Ju, L., Yu, D., Guo, Q., Fang, H., Xu, X., Li, S., Zhao, L., 2021. [Eating out behavior and its impact on obesity among Chinese residents aged 18-59 in 2015]. *J. HygieneRes.* 50 (3), 395–400. <https://doi.org/10.19813/j.cnki.weishengyanjiu.2021.03.008>.
- Kant, A.K., Whitley, M.I., Graubard, B.I., 2015. Away from home meals: associations with biomarkers of chronic disease and dietary intake in American adults, NHANES 2005-2010. *Int. J. Obes.* 39 (5), 820–827. <https://doi.org/10.1038/ijo.2014.183>.
- Klassen, K.M., Douglass, C.H., Brennan, L., Truby, H., Lim, M.S.C., 2018. Social media use for nutrition outcomes in young adults: a mixed-methods systematic review. *Int. J. Behav. Nutr. Phys. Activ.* 15 (1) <https://doi.org/10.1186/s12966-018-0696-y>.
- Konwea, P., Ogunbile, S., Olowoselu, M., Reports, 2016. Assessment of eating habits and nutritional status of nursing and midwifery students in Ekiti state Nigeria. *J. Sci. Res.* 12 (2), 1–7.
- Kypri, K., Vater, T., Bowe, S.J., Saunders, J.B., Cunningham, J.A., Horton, N.J., Mccambridge, J., 2018. Web-based alcohol screening and brief intervention for university students: a randomized trial. *JAMA Intern. Med.* 12, 1218–1224.
- L, B., 2020. How Food Delivery Apps Are Responding to the Coronavirus.
- Lee, A., 2021. In: China, Food Delivery Order Volume Is Reaching 500 Million Users in 2020.
- Li, J., Song, G., Semakula, H.M., Zhang, S., 2019. Climatic burden of eating at home against away-from-home: a novel Bayesian Belief Network model for the mechanism of eating-out in urban China. *Sci. Total Environ.* 650 (Pt 1), 224–232. <https://doi.org/10.1016/j.scitotenv.2018.09.015>.
- Li, Z.S., Lei, Y., Qu, X.Y., Sui, Y.M., 2009. Municipal solid waste management in Beijing City. *Waste Manag.* 29 (9), 2596–2599.
- Ma, Y., Gong, W., Ding, C., Song, C., Yuan, F., Fan, J., Liu, A., 2021. The association between frequency of eating out with overweight and obesity among children aged 6–17 in China: a National Cross-sectional Study. *BMC Publ. Health* 21 (1). <https://doi.org/10.1186/s12889-021-11104-0>.
- Madej, K., 2016. *Interactivity, Collaboration, and Authoring in Social Media*. Springer International Publishing.
- Nago, E.S., Lachat, C.K., Lieven, H., Dominique, R., Dossa, R.A., Kolsteren, P.W., 2010. Food, energy and macronutrient contribution of out-of-home foods in school-going adolescents in Cotonou, Benin. *Br. J. Nutr.* 103 (2), 281–288. [10.1017/S0007114509991668](https://doi.org/10.1017/S0007114509991668).
- Nelson, M.C., Story, M., Larson, N.I., Neumark-Sztainer, D., Lytle, L.A., 2008. Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. *Obesity* 16 (10), 2205–2211. <https://doi.org/10.1038/oby.2008.365>.
- Pan, Y., Jiang, G.H., Chang, G., Jing, L.L., 2015. Study on nutrition intervention for different populations in catering industry. *Occup. Health* 31 (22), 3107–3110.
- Perignon, M., Masset, G., Ferrari, G.L., Barré, T., Vieux, F., Maillot, M., Darmon, N., 2016. How low can dietary greenhouse gas emissions be reduced without impairing nutritional adequacy, affordability and acceptability of the diet? A modelling study to guide sustainable food choices. *Publ. Health Nutr.* 1–13.
- Ren, J., Luo, X., Zhao, X., Yang, W., Yang, M., Wang, Y., Yuan, P., 2020. Takeaway food in Chengdu, Sichuan province, China: composition and nutritional value. *Asia Pac. J. Clin. Nutr.* 29 (4), 883–898. [https://doi.org/10.6133/apjcn.202012.29\(4\).0025](https://doi.org/10.6133/apjcn.202012.29(4).0025).
- Roxana, C., Michael, S., Nadine, C., Myduc, T., Saelens, B.E., James, K., 2015. Changes in awareness and use of calorie information after mandatory menu labeling in restaurants in King County, Washington. *Am. J. Publ. Health* 105 (3), 546–553. [10.2105/AJPH.2014.302262](https://doi.org/10.2105/AJPH.2014.302262).
- Song, G., Li, M., Semakula, H.M., Zhang, S., 2015. Food consumption and waste and the embedded carbon, water and ecological footprints of households in China. *Sci. Total Environ.* 529, 191–197. <https://doi.org/10.1016/j.scitotenv.2015.05.068>.
- Steyn, N.P., Labadarios, D., Nel, J.H., 2011. Factors which influence the consumption of street foods and fast foods in South Africa—a national survey. *Nutr. J.* 10 (1), 104. <https://doi.org/10.1186/1475-2891-10-104>.
- Thomala, L.L., 2021. Number of Social Network Users in China from 2017 to 2020 with a Forecast until 2026. Retrieved from. <http://www.cac.gov.cn/>. (Accessed 20 March 2019).
- van Dammen, L., Bush, N.R., de Rooij, S., Mol, B.W., Mutsaerts, M., van Oers, A., Roseboom, T., 2021. A lifestyle intervention randomized controlled trial in obese women with infertility improved body composition among those who experienced childhood adversity. *Stress Health* 37 (1), 93–102. <https://doi.org/10.1002/smi.2976>.
- van Elten, T.M., Karsten, M.D.A., Geelen, A., van Oers, A.M., van Poppel, M.N.M., Groen, H., group, L.I.s., 2018. Effects of a preconception lifestyle intervention in obese infertile women on diet and physical activity; A secondary analysis of a randomized controlled trial. *PLoS One* 13 (11), e0206888. <https://doi.org/10.1371/journal.pone.0206888>.
- Vandelanotte, C., Maher, C.A., 2015. Why we need more than just randomized controlled trials to establish the effectiveness of online social networks for health behavior change. *Am. J. Health Promot.* 30 (2), 74–76. <https://doi.org/10.4278/ajhp.141204-CIT-605>.
- Villinger, K., Wahl, D.R., Boeing, H., Schupp, H.T., Renner, B., 2019. The effectiveness of app-based mobile interventions on nutrition behaviours and nutrition-related health outcomes: a systematic review and meta-analysis. *Obes. Rev.* 20 (10), 1465–1484. <https://doi.org/10.1111/obr.12903>.
- Ward, M.M., Vaughn, T.E., Uden-Holman, T., Doebbeling, B.N., Clarke, W.R., Woolson, R.F., 2002. Physician knowledge, attitudes and practices regarding a widely implemented guideline. *J. Eval. Clin. Pract.* 8 (2), 155–162.
- Xie, J., Xu, Y., Li, H., 2021. Environmental impact of express food delivery in China: the role of personal consumption choice. *Environ. Dev. Sustain.* 23 (6), 8234–8251. <https://doi.org/10.1007/s10668-020-00961-1>.
- Yu, W., 2014. Causes and countermeasures of food waste in China. *Agric. Outlook* 4.
- Zibing, W., Guohong, J., Jing, L., Yi, P., Zhuo, W., W, D., 2015. Study on dining out and nutritional intervention of some residents in Tianjin. *Prevent. Control Chronic Dis. China* 23 (2), 147–149.