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Cover Photo: Fangshan CDC staff is carrying out post-flood disinfection work in Fangshan District, Beijing Municipality, August 4, 2023.

Preplanned Studies

Weekly Weight Gain in Women with Gestational Diabetes Mellitus and Neonatal Birth Weight — China, 2011–2021

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Summary

What is already known about this topic?

Elevated gestational weight gain (GWG) during pregnancy among women diagnosed with gestational diabetes mellitus (GDM) is correlated with an increased instance of large for gestational age (LGA) and macrosomia. However, it remains uncertain whether managing weekly GWG following a GDM diagnosis positively impacts fetal birth weight.

What is added by this report?

Our study found that GWG following GDM diagnosis correlates positively with the risk of LGA and macrosomia among all body mass index (BMI) subgroups, especially for overweight and obese women.

What are the implications for public health practice?

The results of this research highlight the importance of enforcing a more stringent regulation on GWG on a weekly basis for overweight and obese women diagnosed with GDM, particularly when considering neonatal growth.

Neonatal weight serves as a crucial marker of intrauterine development and maternal nutritional health (*1*). Given the potential cumulative impacts of excessive gestational weight gain (GWG) and gestational diabetes mellitus (GDM) on neonatal weight, it may be beneficial to adopt a slower GWG rate (*2*). However, the benefits of maintaining control over weekly GWG following a GDM diagnosis in relation to fetal birth weight remain undetermined. Consequently, we utilized data from various centers nationwide to evaluate the relationship between weekly GWG post-GDM diagnosis (categorized by weight at GDM diagnosis) and the likelihood of large for gestational age (LGA) and macrosomia. Associations between weekly GWG after GDM diagnosis and risks of LGA and macrosomia were assessed using the odds ratio (*OR*) and 95% confidence interval (*CI*).

Based on the Chinese standards for sex- and gestational age-specific birth weight from 2015 (*3*), LGA is identified as a birth weight higher than the 90th percentile for gestational age defined by sex. Macrosomia is identified as a birth weight exceeding 4,000 g (*4*). Body mass index (BMI) at the time of GDM diagnosis was grouped into nine categories using the statistical equidistant grouping method (*5*): BMI>19 kg/m^2; 19 kg/m^2≤BMI<21 kg/m^2; 21 kg/m^2 ≤BMI<23 kg/m^2; 23 kg/m^2≤BMI<25 kg/m^2; 25 kg/m^2 ≤BMI<27 kg/m^2; 27 kg/m^2≤BMI<29 kg/m^2; 29 kg/m^2 ≤BMI<31 kg/m^2; 31 kg/m^2≤BMI<33 kg/m^2; and BMI≥33 kg/m^2. The prevalences of LGA and macrosomia were subsequently calculated for each interval. Utilizing univariate and multivariate logistic regression analyses, we explored the association between weight at GDM diagnosis, weekly GWG post-GDM diagnosis, and the risk factors for LGA and macrosomia. All statistical analyses were performed using SAS statistical software (version 9.4, SAS Institute Inc., Cary, NC, USA), with two-sided statistical tests. A *P* value of less than 0.05 was deemed statistically significant.

This retrospective study relied on data collected from seven regional tertiary hospitals in various provincial level administrative divisions (PLADs) throughout China, including Beijing, Shaanxi, Guizhou, Hebei, Zhejiang, and Shandong. These establishments included Peking Union Medical College Hospital, Beijing Tongzhou District Maternal and Child Health Hospital, Dong E County People's Hospital, Northwest Women and Children's Hospital, the Fourth Affiliated Hospital of Hebei Medical University, Guiyang Maternal and Child Health Hospital, and Wenzhou People's Hospital. All selected facilities had established consistent clinical treatment standards for GDM and were known for the reliability of their data. Female GDM patients' records from 2011 to 2021 were analyzed for this project. All information was extracted from electronic medical records, details of which have been discussed in a previous study (*6*). Subjects' weights, usually not assessed during the 75-g oral glucose tolerance test (OGTT), were documented a week before or after the activity to obtain more comprehensive data. Ultimately, 11,168 women with GDM were considered for this analysis.

Essential data were collected from medical records, which included maternal age, weight prior to pregnancy, week of GDM diagnosis, weight at time of GDM diagnosis, weight before delivery, weeks remaining until delivery, and neonatal birth weight. The diagnostic criteria for GDM are the same as in previous study (*6*).

Study participants self-reported their pre-pregnancy weight. Using these self-reported measurements, pre-pregnancy BMI was calculated using the formula weight (kg) divided by the square of height (m^2). The pre-pregnancy BMI classification criteria remained the same as in previous study. The pregnant women's weight reported a week before or after undergoing the OGTT was marked as the weight at GDM diagnosis. The corresponding BMI was determined by dividing this weight by the square of height (m^2). Pre-delivery weight refers to the measurements taken one week prior to childbirth. The GWG post-GDM diagnosis was computed by deducting the pre-delivery weight from the weight at GDM diagnosis. Lastly, the rate of GWG after the GDM diagnosis, measured in kg/week, represented the GWG from GDM diagnosis to delivery.

Continuous variables are presented as the mean ± standard deviations. Categorical variables are expressed as frequency (percentage) in the descriptive analysis. We used the univariable and multivariable logistic regression models to estimate the effects of weekly GWG and GWG after GDM diagnosis on the occurrence of LGA and macrosomia. BMI of GDM diagnosis was grouped by equidistant grouping method.

The Peking Union Medical College Hospital (PUMCH) Ethics Committee approved this study (NO. JS-2333). Due to the observational nature of the research and the absence of personally identifiable information collection, informed consent was waived, as previously noted elsewhere (*7*). The study, registered under ClinicalTrials.gov Identifier: NCT04421053, adhered to the principles laid out in the Declaration of Helsinki.

Table 1 presents the clinical characteristics of the study participants. Our final analysis included 11,168 women diagnosed with GDM. The mean maternal age was 31.02 years with a standard deviation of 4.38. Of these women, 1,338 (11.98%) delivered infants classified as LGA, while 764 (6.84%) delivered infants with macrosomia. Noteworthy variations were observed in the baseline characteristics of women with GDM within the LGA and macrosomia groups.

A statistically significant increase in the *OR* for fetal growth was observed in individuals grouped by normal weight [LGA: adjusted odds ratio (*aOR*)=2.641, 95% *CI*: 1.926–3.622 and macrosomia: *aOR*=3.299, 95% *CI*: 2.217–4.909]. Notably, increased *OR* was also apparent in the overweight (LGA: *aOR*=2.575, 95% *CI*: 1.734–3.823 and macrosomia: *aOR*=1.998, 95% *CI*: 1.223–3.263) and obese groups (LGA: *aOR*=1.056, 95% *CI*: 1.032–1.082). According to pre-pregnancy BMI, more substantial weekly GWG was associated with a higher risk of LGA and macrosomia. Nonetheless, the *OR* for macrosomia in the obese group was not significant (*aOR*=1.741, 95% *CI*: 0.750–4.043). In addition to this, the *OR* for fetal growth increased significantly in the underweight (LGA: *aOR*=1.140, 95% *CI*: 1.083–1.200 and macrosomia: *aOR*=1.165, 95% *CI*: 1.096–1.239), normal weight (LGA: *aOR*=1.096, 95% *CI*: 1.083–1.110 and macrosomia: *aOR*=1.102, 95% *CI*: 1.086–1.120), overweight (LGA: *aOR*=1.096, 95% *CI*: 1.078–1.114 and macrosomia: *aOR*=1.115, 95% *CI*: 1.093–1.138) and obese groups (LGA: *aOR*=1.056, 95% *CI*: 1.032–1.082 and macrosomia: *aOR*=1.050, 95% *CI*: 1.019–1.082) (Table 2). There was a direct correlation observed between weight at the time of GDM diagnosis and the risk of developing LGA and macrosomia.

The data suggests that with an increase in BMI at the point of GDM diagnosis from less than 19 kg/m^2 to equal to or greater than 33 kg/m^2, the incidence of LGA increased markedly from 1.33% to 24.71%. Simultaneously, the prevalence of macrosomia also rose from 1.33% to 15.21%, as indicated in Figure 1.

Further analysis was conducted on the association between BMI at the time of GDM diagnosis and fetal birth weight. Notable findings indicated that an increased *OR* for LGA (*OR*=1.726, 95% *CI*: 1.431–2.083) was observed when the BMI at GDM diagnosis ranged from 23–25 kg/m^2. The odds ratio for LGA also increased in the subsequent four groups after the reference group, showcasing ratios of *OR*=2.169, 95% *CI*: 1.788–2.631, *OR*=3.003, 95% *CI*: 2.440–3.696, *OR*=4.047, 95% *CI*: 3.161–5.181, and *OR*=3.937, 95% *CI*: 2.860–5.420, respectively.

TABLE 1. Clinical characteristics of study participants.

Characteristic	Overall (11,168) (mean±SD)/*N* (%)	Macrosomia			LGA		
		No (9,207) (mean±SD)/*N* (%)	Yes (1,338) (mean±SD)/*N* (%)	*P* value	No (10,087) (mean±SD)/*N* (%)	Yes (764) (mean±SD)/*N* (%)	*P* value
Age	31.02±4.38	31.02±4.39	31.08±4.38	0.012*	31.03±4.38	30.59±4.26	0.776
Pre-weight (kg)	58.91±8.91	58.48±8.67	63.20±9.21	<0.001†	58.61±8.80	63.08±9.11	<0.001†
Pre-BMI (kg/m^2)	22.70±3.17	22.57±3.12	23.88±3.21	<0.001†	22.61±3.15	23.73±3.15	<0.001†
Underweight (<18.5 kg/m^2)	810 (7.25)	696 (6.23)	44 (0.39)	<0.001†	770 (6.89)	26 (0.23)	<0.001
Normal weight (18.5 kg/m^2≤BMI<23.9 kg/m^2)	6,835 (61.20)	5,763 (51.60)	689 (6.17)		6,326 (56.64)	403 (3.61)	
Overweight (24.0 kg/m^2≤BMI<27.9 kg/m^2)	2,775 (24.85)	2,187 (19.58)	447 (4.00)		2,441 (21.86)	254 (2.27)	
Obese (≥28.0 kg/m^2)	748 (6.70)	561 (5.02)	158 (1.41)		640 (5.73)	81 (0.73)	
Diagnostic week	26.20±1.20	26.20±1.20	26.23±1.18	0.048*	26.21±1.20	26.31±1.16	0.236
Weight at the time of GDM diagnosis (kg)	67.27±9.27	66.71±8.95	72.89±9.27	<0.001†	66.84±9.10	73.31±9.36	<0.001†
BMI at the time of GDM diagnosis (kg/m^2)	25.92±3.28	25.75±3.21	27.55±3.23	<0.001†	25.79±3.25	27.59±3.26	<0.001†
Weight gain after diagnosis of GDM (kg)	4.81±3.20	4.73±3.20	5.45±3.18	<0.001†	4.78±3.18	5.81±3.14	<0.001†
Weekly GWG after the diagnosis of GDM (kg/week)	0.40±0.26	0.39±0.26	0.45±0.25	<0.001†	0.39±0.26	0.46±0.24	<0.001†
Pre-delivery weight (kg)	72.08±9.67	71.44±9.28	78.34±9.66	<0.001†	71.62±9.44	79.12±9.67	<0.001†
Delivery gestational age (weeks)	38.66±1.44	38.68±1.44	38.64±1.30	<0.001†	38.73±1.28	39.19±0.96	0.019*
Total GWG (kg)	13.17±5.20	12.97±5.11	15.15±5.43	<0.001†	13.01±5.09	16.04±5.50	<0.001†
Neonatal weight (g)	3,340±470	3,290±370	4,010±370	<0.001†	3,310±360	4,230±210	<0.001†

Note: The data is expressed as either the mean ± standard deviation or as a number (%). The independent *t*-test was utilized to analyze the difference between the two groups' continuous variables, whereas the Chi-square test was employed to compare the categorical data.

Abbreviation: SD=standard deviation; *N*=number; LGA=large gestational age; BMI=body mass index; GWG=gestational weight gain; GDM=gestational diabetes mellitus.

* P<0.05.

† P<0.001.

TABLE 2. Association between weekly GWG after GDM diagnosis and LGA and macrosomia, stratified by pre-pregnancy BMI status.

Group	Variable	Univariate analysis LGA *OR* (95% *CI*)	Macrosomia *OR* (95% *CI*)	Multivariate analysis LGA *OR* (95% *CI*)	Macrosomia *OR* (95% *CI*)
Overall group	Weekly GWG (kg/week)	2.404 (1.931–2.991)†	2.800 (2.120–3.697)†	2.692 (2.148–3.373)†	2.820 (2.125–3.742)†
	Weight at GDM diagnosis (kg)	1.072 (1.065–1.078)	1.072 (1.064–1.080)	1.073 (1.060–1.080)	1.072 (1.064–1.080)
Underweight (<18.5 kg/m^2)	Weekly GWG (kg/week)	2.583 (0.755–8.835)	5.414 (1.242–23.593)*	3.022 (0.815–11.197)	6.482 (1.288–32.623)*
	Weight at GDM diagnosis (kg)	1.141 (1.084–1.201)†	1.165 (1.097–1.238)†	1.140 (1.083–1.200)†	1.165 (1.096–1.239)†
Normal weight (18.5 kg/m^2≤BMI<23.9 kg/m^2)	Weekly GWG (kg/week)	2.615 (1.928–3.548)†	3.598 (2.449–5.285)†	2.641 (1.926–3.622)†	3.299 (2.217–4.909)†
	Weight at GDM diagnosis (kg)	1.096 (1.083–1.110)†	1.104 (1.087–1.121)†	1.096 (1.083–1.110)†	1.102 (1.086–1.120)†
Overweight (24.0 kg/m^2≤BMI<27.9 kg/m^2)	Weekly GWG (kg/week)	2.932 (2.004–4.290)†	2.653 (1.655–4.253)†	2.575 (1.734–3.823)†	1.998 (1.223–3.263)†
	Weight at GDM diagnosis (kg)	1.097 (1.080–1.115)†	1.119 (1.097–1.142)†	1.096 (1.078–1.114)†	1.115 (1.093–1.138)†
Obese (≥28.0 kg/m^2)	Weekly GWG (kg/week)	2.389 (1.275–4.478)*	1.819 (0.799–4.145)	1.056 (1.032–1.082)*	1.741 (0.750–4.043)
	Weight at GDM diagnosis (kg)	1.057 (1.032–1.082)†	1.050 (1.019–1.082)*	1.056 (1.032–1.082)†	1.050 (1.019–1.082)*

Note: Multivariable analysis was performed by adjusting for maternal age and weight gain at the time of GDM diagnosis or weekly GWG.

Abbreviation: GWG=gestational weight gain; GDM=gestational diabetes mellitus; LGA=large gestational age; BMI=body mass index; *OR*=odds ratio; *CI*=confidence interval.

* *P*<0.05.

† *P*<0.001.

Contrastingly, a decrease in the odds ratio for LGA was documented when the BMI at GDM diagnosis ranged from 19–21 kg/m^2 or 21–23 kg/m^2, with respective ratios of *OR*=0.497, 95% *CI*: 0.310–0.798 and *OR*=0.588, 95% *CI*: 0.446–0.777 (Figure 2A). A parallel trend was apparent in the odds ratio for macrosomia (Figure 2B). The findings thus indicate that the risk of LGA occurrence and macrosomia increases with a higher BMI at GDM diagnosis. These findings are also consistent with the results delineated in Table 2.

In the course of our research, we conducted further analyses to investigate the correlation between the weekly GWG post GDM diagnosis and the associative risks of both LGA and macrosomia. As per representation in Figure 2A, a BMI at GDM diagnosis ranging between 19 and 21 kg/m^2 resulted in a significantly high odds ratio of LGA and macrosomia [(*OR*=1.192, 95% *CI*: 1.071–1.327), (*aOR*=1.182, 95% *CI*: 1.044–1.338)], respectively. Similarly, a BMI range between 23 and 33 kg/m^2 at GDM diagnosis markedly escalated the odds ratio of LGA and macrosomia.

DISCUSSION

Our research suggests that GWG following GDM diagnosis correlates positively with the risk of LGA and macrosomia among all BMI subgroups. Moreover, our findings indicate that the risks of LGA and macrosomia heighten in correspondence to an increase in BMI at the time of GDM diagnosis. These findings underscore the importance of a more stringent oversight of weekly GWG in managing neonatal growth, specifically in women diagnosed with GDM who are classified as overweight or obese.

Women diagnosed with GDM can significantly reduce the risk of macrosomia and LGA by managing their weight. The diagnosis of GDM typically occurs around 24 to 28 weeks of gestation, leaving a relatively short time between diagnosis and delivery. This indicates that GWG rate post-diagnosis may provide a more accurate representation of GWG throughout a GDM pregnancy. One U.S. study reported that a weekly GWG of 1 pound post-diagnosis, adjusted for pre-pregnancy BMI, elevated the risk of adverse outcomes, such as LGA and macrosomia, by approximately 36% to 83% (*8*).

Our study agreed with these findings, showing a clear correlation between weekly GWG post-diagnosis and the risk of LGA and macrosomia. Further, we

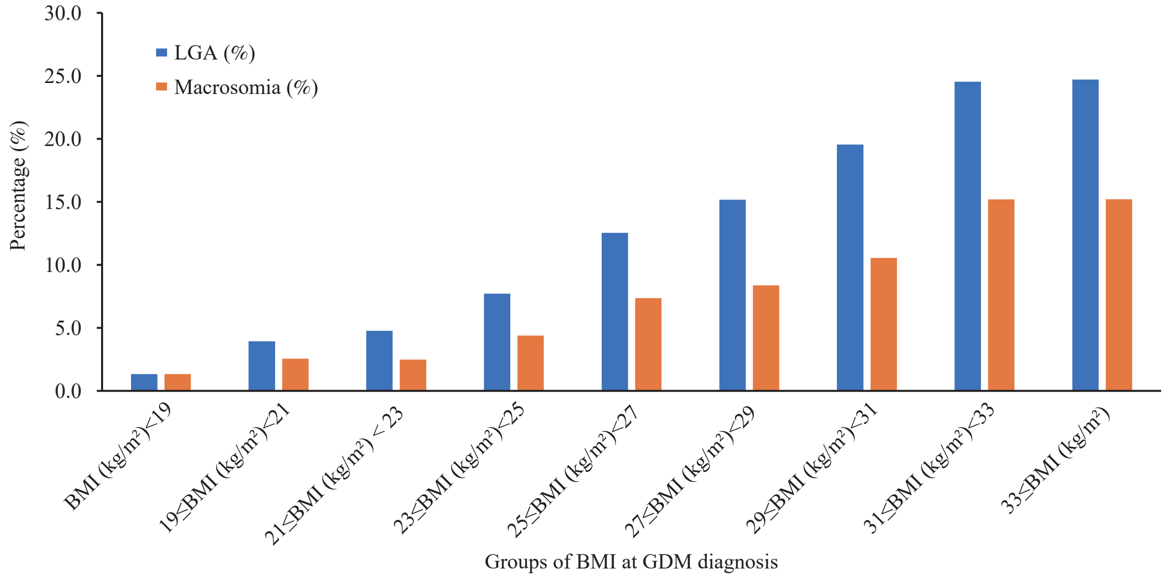

FIGURE 1. Percentage of LGA and macrosomia occurrence in groups stratified by BMI at the time of GDM diagnosis.
Abbreviation: LGA=large for gestational age; BMI=body mass index; GDM=gestational diabetes mellitus.

explored this association in relation to BMI at the time of GDM diagnosis.

Barnes et al. (*9*) performed a retrospective cohort study on pregnant women with excessive GWG prior to GDM diagnosis. They segmented post-diagnosis weight gain into 2-kg units and found a proportional increase in LGA incidence with increased weight gain among GDM patients. This correlates with our findings, but they also examined the impact of excessive weekly GWG post-diagnosis on insulin therapy requirements, an aspect our study did not explore.

In conclusion, clinicians should monitor weekly GWG post-GDM diagnosis closely. It's imperative to conduct interventional studies to understand factors contributing to appropriate GWG, such as diet (*10*), and develop comprehensive weight management guidelines for women with GDM.

Our study stratified participants into nine subgroups aligned to their BMI at GDM diagnosis, to accommodate the cumulative effects of metabolic status and GWG (*11*). A subsequent analysis of the correlation between weight at GDM diagnosis and fetal birth weight revealed a direct correlation.

Clinical vigilance is necessary for overweight and obese pregnant women. These women often exhibit varying degrees of pre-pregnancy insulin resistance and/or chronic inflammation. Pregnancy may only serve as a metabolic stress test. Physiological insulin resistance during gestation can exacerbate pre-existing metabolic abnormalities, resulting in pronounced metabolic shifts in overweight and obese women (*12*). Excessive glucose is converted into stored body fat, giving rise to macrosomia.

More research is needed to delve into the association between weekly GWG and neonatal growth patterns while mitigating the influence of pre-GDM weight gain.

The present study possesses distinct strengths. Primarily, the sample size selected is robust. Analysis was performed on the data collected from seven hospitals spread across various regions in China, thus providing a comprehensive representation of GWG among GDM affected women in the country. Second, our research probed the correlation between weekly GWG post GDM diagnosis and neonatal birth weight, an aspect not extensively explored by prior studies, which mostly focused on overall GWG. Third, we segmented the study participants into nine groups based on their BMI computed at the time of GDM diagnosis. The subgroup analysis, taking into account weight gain prior to GDM diagnosis, enhances the reliability of our findings.

Nevertheless, this study is not without limitations. Markedly, the primary treatment for GDM is lifestyle adjustment, however, dietary records were not included in the analysis, which may affect the results. Furthermore, certain social determinants such as education level or smoking habits were not available, potentially acting as confounding factors. Lastly, as this is a retrospective cohort study, recall bias could pose a challenge. Hence, it is recommended that future

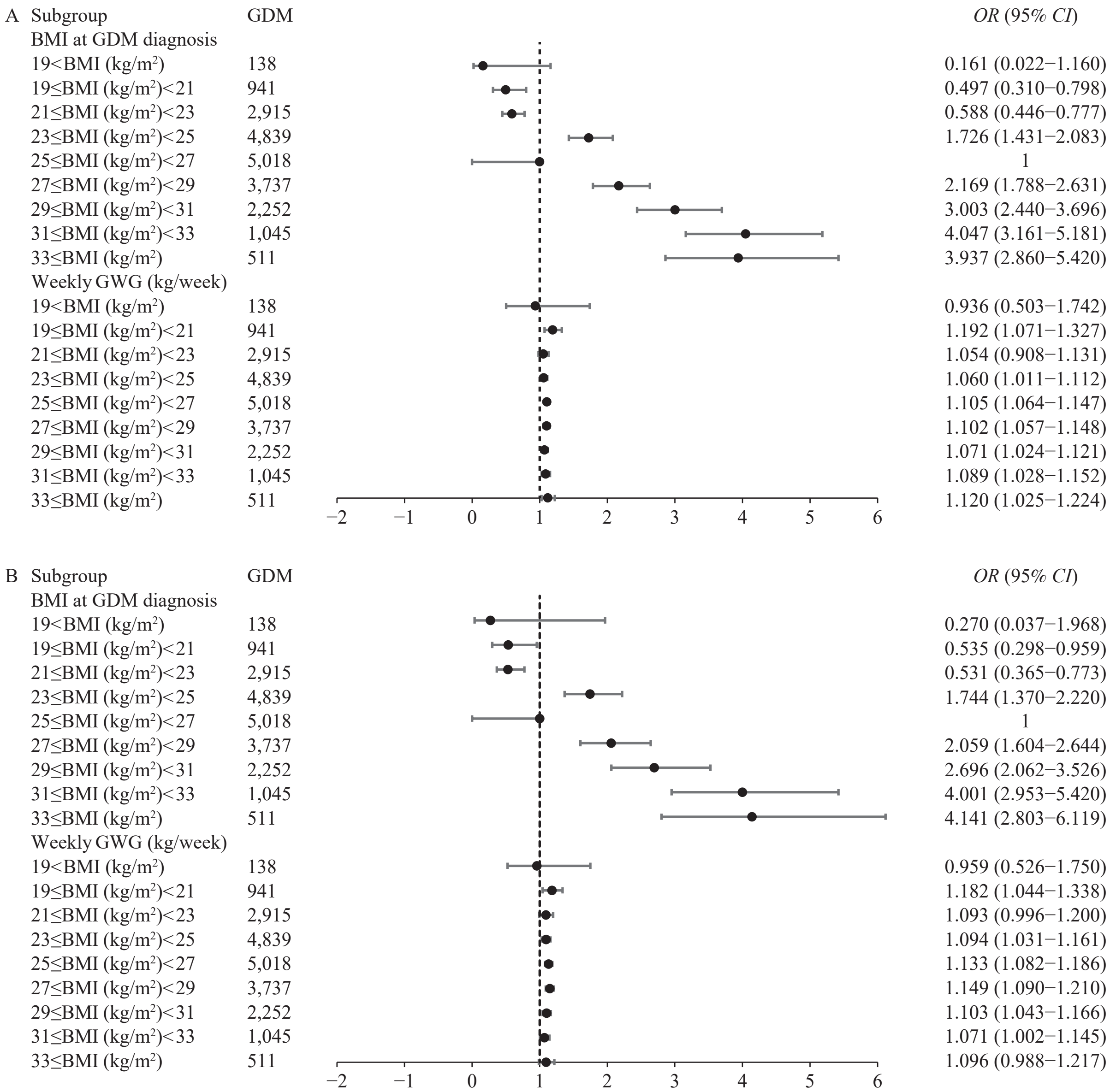

FIGURE 2. Association between various BMI groups at the time of GDM diagnosis, post-diagnosis gestational weight gain, and the risks of LGA and macrosomia.
Abbreviation: GDM=gestational diabetes mellitus; BMI=body mass index; GWG=gestational weight gain; *OR*=odds ratio; *CI*=confidence interval.

prospective cohort studies consider these factors while assessing the connection between weight gain after GDM diagnosis and neonatal birth weight.

In summary, the findings from our data imply a positive correlation between excessive weight gain following GDM diagnosis and increased risks for LGA and macrosomia, particularly in overweight and obese women with GDM. Tighter guidelines for weight gain rate may confer safety and benefits for the population with gestational diabetes.

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REFERENCES

1. Pathirathna ML, Sekijima K, Sadakata M, Fujiwara N, Muramatsu Y, Wimalasiri KMS. Impact of second trimester maternal dietary intake on gestational weight gain and neonatal birth weight. Nutrients 2017;9(6):627. http://dx.doi.org/10.3390/nu9060627.
2. Chiou YL, Hung CH, Liao HY. The impact of prepregnancy body mass index and gestational weight gain on perinatal outcomes for women with gestational diabetes mellitus. Worldviews Evid Based Nurs 2018;15(4):313 – 22. http://dx.doi.org/10.1111/wvn.12305.
3. Zhu L, Zhang R, Zhang SL, Shi WJ, Yan WL, Wang XL, et al. Chinese neonatal birth weight curve for different gestational age. Chin J Pediatr 2015;53(2):97 – 103. http://dx.doi.org/10.3760/cma.j.issn.0578-1310.2015.02.007. (In Chinese).
4. Obstetrics Gynecology. Macrosomia: ACOG Practice Bulletin Summary, Number 216. Obstet Gynecol 2020;135(1):246 – 8. http://dx.doi.org/10.1097/AOG.0000000000003607.
5. Henderson RA, Jarvis C, Clayton T, Pocock SJ, Fox KAA. 10-Year mortality outcome of a routine invasive strategy versus a selective invasive strategy in non-ST-segment elevation acute coronary syndrome: the British heart foundation RITA-3 randomized trial. J Am Coll Cardiol 2015;66(5):511 – 20. http://dx.doi.org/10.1016/j.jacc.2015.05.051.
6. Lyu JL, Sun Y, Ji YL, Liu NN, Zhang SH, Lin H, et al. Optimal gestational weight gain for women with gestational diabetes mellitus - China, 2011-2021. China CDC Wkly 2023;5(9):89 – 193. http://dx.doi.org/10.46234/ccdcw2023.034.
7. Hong M, Liang F, Zheng Z, Chen HM, Guo Y, Li KR, et al. Weight gain rate in the second and third trimesters and fetal growth in women with gestational diabetes mellitus: a retrospective cohort study. BMC Pregnancy Childbirth 2022;22(1):424. http://dx.doi.org/10.1186/s12884-022-04762-4.
8. Harper LM, Tita A, Biggio JR. The institute of medicine guidelines for gestational weight gain after a diagnosis of gestational diabetes and pregnancy outcomes. Am J Perinatol 2015;32(3):239 – 46. http://dx.doi.org/10.1055/s-0034-1383846.
9. Barnes RA, Wong T, Ross GP, Griffiths MM, Smart CE, Collins CE, et al. Excessive weight gain before and during gestational diabetes mellitus management: what is the impact? Diabetes Care 2020;43(1):74-81. http://dx.doi.org/10.2337/dc19-0800.
10. The International Weight Management in Pregnancy (i-WIP) Collaborative Group. Effect of diet and physical activity based interventions in pregnancy on gestational weight gain and pregnancy outcomes: meta-analysis of individual participant data from randomised trials. BMJ 2017;358:j3119. http://dx.doi.org/10.1136/bmj.j3119.
11. Cheng ZH, Wei YM, Li HT, Yu HZ, Liu JM, Zhou YB. Gestational diabetes mellitus as an effect modifier of the association of gestational weight gain with perinatal outcomes: a prospective cohort study in China. Int J Environ Res Public Health 2022;19(9):5615. http://dx.doi.org/10.3390/ijerph19095615.
12. Kampmann U, Knorr S, Fuglsang J, Ovesen P. Determinants of maternal insulin resistance during pregnancy: an updated overview. J Diabetes Res 2019;2019:5320156. http://dx.doi.org/10.1155/2019/5320156.

Preplanned Studies

A Large-Scale Cross-Sectional Study on Mental Health Status Among Children and Adolescents — Jiangsu Province, China, 2022

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Summary

What is already known about this topic?

The prevalence of mental health disorders among children and youth in China stands at 17.5%, a figure that has been gradually escalating over recent years. This surge has led to substantial psychological distress and financial strain for both families and the wider society.

What is added by this report?

This study boasts an expansive geographical scope by covering the Jiangsu Province extensively and utilizing a substantial sample size. An investigation was conducted on the prevalence and risk factors, which included family type and health behaviors, of depressive, anxiety, and stress symptoms.

What are the implications for public health practice?

The mental health status of children and adolescents should be of great concern to the government. Therefore, it is important that public health measures are implemented to mitigate the development of depressive symptoms. These measures may include regular screening procedures and the implementation of proven interventions.

Mental health disorders in childhood and adolescence often indicate a long-term and recurring disease course that extends into adulthood, causing significant psychological distress and financial strain for families and society. An increasing trend in the prevalence of these disorders has been noted in recent years, making them a significant public health concern in China (*1*). Li et al. reported that the general prevalence of mental disorders among children and adolescents in China was 17.5%, and 18.8% in Jiangsu Province. Notably, Jiangsu Province, one of the nation's most developed regions located in eastern China, is renowned for its high-quality education. This research intends to examine the mental health status of children and adolescents in Jiangsu Province in order to inform and guide prevention and intervention strategies. This cross-sectional study was carried out from September to November 2022, encompassing 123,005 students, aged 6–18 years, from all 13 cities (84 counties), and 499 schools across Jiangsu Province. Diligent public health surveillance of children's and adolescents' mental health can offer essential data on prevalence trends and health behavior variances in different populations. This information is crucial for proposing early identification and targeted interventions for high-risk groups (*2*).

This cross-sectional study, conducted in 2022, was aligned with the "Surveillance for Common Disease and Health Risk Factors Among Students" program. Participants were students aged 6–18 years, drawn from all 13 cities (encompassing 84 counties) and 499 schools in Jiangsu Province. The sampling approach utilized a cluster randomized method, selecting two primary schools, two middle schools, and two high schools from each county. Within these institutions, two classes per grade level were targeted, and all members of the chosen classes were invited to participate, yielding at least 80 survey participants per grade.

Survey participants completed an online questionnaire in multimedia computer classrooms resulting in the accumulation of 123,005 valid responses, representing a 97.7% effective rate. Inclusion criteria required participants to be residents of Jiangsu Province, studying there, and willing to take part in the research. The exclusion criteria were: acute or severe illnesses impacting the ability to cooperate with the investigation, or an incomplete electronic questionnaire submission.

The questionnaire was segmented into two sections. The first solicited sociodemographic information which included variables such as age, gender, grade, family type, parental education level, accommodation status, and residential area. Resident students were defined as those who lived in a school dormitory more than three days per week. Single-parent family was denoted as living exclusively with one parent. Current smoking and drinking behaviors were described as the consumption of alcohol or smoking of cigarettes within the past 30 days.

The second part of the questionnaire appraised the participants' mental health status over the preceding week. Evaluation tools used included the Center for Epidemiology Studies Depression (CES-D) scale and the Depression Anxiety Stress Scale (DASS-21). It also scrutinized health behaviors related to smoking and drinking.

This study utilized the CES-D to evaluate the prevalence of depressive symptoms. Responses were graded on a four-point Likert scale, with higher accumulated scores indicating severe depressive symptoms. The Chinese version of the CES-D scale has been employed and verified for its reliability in previous studies involving Chinese cohorts (*3*). A CES-D score of 20 or higher was utilized to determine the presence of depressive symptoms.

The DASS-21 was used to gauge three negative emotional states: depression, anxiety, and stress. As the depressive symptoms were already appraised using CES-D, the study employed only two subscales or 14 items of the DASS-21 to evaluate the participants' symptoms of anxiety and stress. Responses were calculated on a four-point Likert scale. Each subscale's total score was determined by doubling the sum of its seven items. High scores indicated severe negative emotions. The presence of anxiety symptoms was determined with scores above 7, while indications of stress symptoms were ascertained with scores exceeding 14 (*4*).

The Cronbach's alpha for both the CES-D and DASS-21 were 0.866 and 0.914, respectively, pointing to substantial internal validity.

Categorical variables are presented in percentages, while continuous variables are furnished as Mean ± SD. The statistical evaluations were executed using IBM SPSS Statistics (version 25, IBM SPSS Inc., Chicago, USA), and the Chi-square test served to juxtapose the prevalence of symptoms linked to depression, anxiety, and stress across different variables. Factors associated with depressive symptoms were evaluated a priori, drawing on clinical significance, established scientific knowledge, as well as predictors spotlighted in previously published articles. With univariate logistic regression, variables of statistical significance were incorporated into a multivariate logistic regression in a subsequent step to assess the correlations between depressive symptoms and the explanatory variables, utilizing R software (version 4.2.2; The R Foundation for Statistical Computing, Vienna, Austria). In this study, a *P*-value of less than 0.05 was accepted to signal statistical significance.

This study incorporates 123,005 eligible questionnaires. Among the respondents, 64,785 (52.7%) identified as males and 58,220 (47.3%) as females; 34.9% were primary school attendees, 32.9% were middle school students, and 32.2% were high school pupils. It was found that 14.6% exhibited depression symptoms, 8.0% exhibited evidence of anxiety, and 27.4% demonstrated signs of stress (Table 1). The Chi-square test disclosed a statistically significant discrepancy in the prevalence of depression, anxiety, and stress-related symptoms ($P<0.001$) across distinct academic phases. A higher incidence of these symptoms was observed among female students, upper-grade students, current smokers or alcohol users, and individuals from single-parent households. Multivariable logistic regression results indicated that the potential risk factors for depressive symptoms include being female [odds ratio (*OR*)=1.39, 95% confidence interval (*CI*): 1.35–1.44], a high school student (*OR*=1.98, 95% *CI*: 1.88–2.07), residing in a single-parent household (*OR*=1.12, 95% *CI*: 1.08–1.17), current smoking (*OR*=2.40, 95% *CI*: 2.14–2.68), and current alcohol consumption (*OR*=3.18, 95% *CI*: 3.06–3.30) (Table 2).

DISCUSSION

This study explored the occurrence of symptoms relating to depression, anxiety, and stress in children and adolescents across Jiangsu Province via a large-scale cross-sectional survey. The findings reveal that mental health issues remain a significant public health concern among the juvenile population in Jiangsu. A total of 14.6% of participants in the study demonstrated depressive symptoms, a figure in alignment with the data reported in the "Report on National Mental Health Development (2021–2022)" (*5*). When compared to other provinces, the occurrence rate of depressive symptoms among children and adolescents in Jiangsu is notably lower than that in Shandong Province (36.0%) (*6*), Henan Province (20.0%) (*7*), and Anhui Province (18.6%) (*8*). These discrepancies might be due to the lower economic status of these provinces. Previous research has concluded that

TABLE 1. Characteristics of the participants.

Factor	Primary school students (*N*=42,971)	Middle school students (*N*=40,439)	High school students (*N*=39,595)	Total (*N*=123,005)	*P* value
	Mean±SD/*N* (%)	Mean±SD/*N* (%)	Mean±SD/*N* (%)	Mean±SD/*N* (%)	
Age	10.7±0.9	13.8±0.9	16.7±0.9	13.7±2.6	<0.001
Gender					0.049
Male	22,505 (52.4)	21,499 (53.2)	20,781 (52.5)	64,785 (52.7)	
Female	20,466 (47.6)	18,940 (46.8)	18,814 (47.5)	58,220 (47.3)	
Depressive symptoms					<0.001
No	39,257 (91.4)	34,172 (84.5)	31,605 (79.8)	105,034 (85.4)	
Yes	3,714 (8.6)	6,267 (15.5)	7,990 (20.2)	17,971 (14.6)	
Anxiety symptoms					<0.001
No	40,312 (93.8)	36,799 (91.0)	36,043 (91.0)	113,154 (92.0)	
Yes	2,659 (6.2)	3,640 (9.0)	3,552 (9.0)	9,851 (8.0)	
Stress symptoms					<0.001
No	34,659 (80.7)	29,313 (72.5)	25,327 (64.0)	89,299 (72.6)	
Yes	8,312 (19.3)	11,126 (27.5)	14,268 (36.0)	33,706 (27.4)	
Region					<0.001
Urban	21,277 (49.5)	20,118 (49.7)	29,391 (74.2)	70,786 (57.5)	
Rural	21,694 (50.5)	20,321 (50.3)	10,204 (25.8)	52,219 (42.5)	
Resident students					<0.001
No	42,281 (98.4)	35,122 (86.9)	22,047 (55.7)	99,450 (80.9)	
Yes	690 (1.6)	5,317 (13.1)	17,548 (44.3)	23,555 (19.1)	
Single-parent family					<0.001
No	36,529 (85.0)	33,726 (83.4)	33,167 (83.8)	103,422 (84.1)	
Yes	6,442 (15.0)	6,713 (16.6)	6,428 (16.2)	19,583 (15.9)	
Paternal education					<0.001
≤12 years	27,067 (63.0)	32,423 (80.2)	32,026 (80.9)	91,516 (74.4)	
>12 years	15,904 (37.0)	8,016 (19.8)	7,569 (19.1)	31,489 (25.6)	
Maternal education					<0.001
≤12 years	27,485 (64.0)	33,467 (82.8)	33,356 (84.2)	94,308 (76.7)	
>12 years	15,486 (36.0)	6,972 (17.2)	6,239 (15.8)	28,697 (23.3)	
Current smoking					<0.001
No	42,762 (99.5)	39,948 (98.8)	38,930 (98.3)	121,640 (98.9)	
Yes	209 (0.5)	491 (1.2)	665 (1.7)	1,365 (1.1)	
Current drinking					<0.001
No	39,614 (92.2)	33,956 (84.0)	28,291 (71.5)	101,861 (82.8)	
Yes	3,357 (7.8)	6,483 (16.0)	11,304 (28.5)	21,144 (17.2)	

Abbreviation: SD=standard deviation; *N*=number.

children residing in areas with economic hardship are more prone to develop adverse emotional states, including hostility, interpersonal tension, depression, anxiety, maladaptation, and psychological imbalances (*9*).

Past research indicates a correlation between health risk behaviors, social relationships, education, and mental health in children and adolescents. Li et al. (*10*) suggested that females are more prone to depression than males, a claim supported by the findings of our study. We observed that senior students exhibited more depressive symptoms, potentially due to the

TABLE 2. Multivariable Logistic regression analysis for symptoms of depressive, anxiety, and stress.

Factor	Depressive symptoms			Stress symptoms			Anxiety symptoms		
	OR	*95% CI*	*P* value	*OR*	*95% CI*	*P* value	*OR*	*95% CI*	*P* value
Academic period									
Primary school	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Middle school	1.69	(1.61, 1.76)	<0.001	1.30	(1.23, 1.37)	<0.001	1.42	(1.37, 1.47)	<0.001
High school	1.98	(1.88, 2.07)	<0.001	1.08	(1.02, 1.15)	0.013	1.87	(1.80, 1.94)	<0.001
Gender									
Male	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Female	1.39	(1.35, 1.44)	<0.001	1.51	(1.44, 1.57)	<0.001	1.40	(1.36, 1.43)	<0.001
Region									
Urban	1.00 (Ref)				*		1.00 (Ref)		
Rural	1.00	(0.97, 1.04)	0.788				1.00	(0.98, 1.03)	0.740
Resident students									
No	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Yes	1.01	(0.96, 1.05)	0.756	0.94	(0.88, 0.99)	0.027	0.99	(0.96, 1.03)	0.576
Single-parent family									
No	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Yes	1.12	(1.08, 1.17)	<0.001	1.11	(1.05, 1.17)	<0.001	1.11	(1.07, 1.15)	<0.001
Paternal education									
≤12 years	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
>12 years	0.95	(0.90, 1.00)	0.056	1.01	(0.94, 1.07)	0.874	0.95	(0.91, 0.99)	0.009
Maternal education									
≤12 years	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
>12 years	0.95	(0.90, 1.00)	0.066	0.99	(0.92, 1.06)	0.695	0.95	(0.91, 0.99)	0.010
Current smoking									
No	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Yes	2.40	(2.14, 2.68)	<0.001	2.01	(1.76, 2.28)	<0.001	1.51	(1.35, 1.69)	<0.001
Current drinking									
No	1.00 (Ref)			1.00 (Ref)			1.00 (Ref)		
Yes	3.18	(3.06, 3.30)	<0.001	3.56	(3.40, 3.73)	<0.001	2.79	(2.71, 2.89)	<0.001

Abbreviation: Ref=reference; *OR*=odds ratio; *CI*=confidence interval.

* Data missing here is due to the univariate logistic regression of anxiety symptoms showing that "region" is not statistically significant (*P* value >0.05), so "region" was not incorporated into a multivariate logistic regression of anxiety symptoms.

stressors associated with more rigorous academic demands and college preparations. Additionally, participants from single-parent households recorded a higher incidence of depressive symptoms. This may be attributed to a communication gap between parents and deficient psychological adjustment capabilities (*11*).

Interestingly, current smoking was linked with a two-fold increase in the likelihood of depressive symptoms among adolescents, in line with Raffetti et al.'s findings (*12*). Moreover, self-identified alcohol consumers in this study had a higher probability of depression compared to non-drinkers. Certain scholars argue that the correlation between depression and unhealthy behaviors, such as smoking and excessive drinking, may point to a coping mechanism rather than a cause. They suggest that the increased incidence of depression in smokers and drinkers may arise from individuals using tobacco and alcohol to manage their mental state (*13*).

Nicotine, present in tobacco, has a stimulant effect on the brain and triggers the release of substances that govern depressive pathways, anxiety, and stress response. Although nicotine may temporarily alleviate depression, stress, and anxiety, its long-term consumption can lead to addiction, increased sensitivity, and a heightened depressive tendency. Similarly, alcohol, a central nervous system depressant, can affect neurotransmitter levels in the brain, leading to mood alterations. However, the causality of the observed associations cannot be definitively established within the confines of this study due to the cross-sectional design's inherent limitations.

This study was subject to several limitations. First, the outcomes cannot be universally applied since the sample was limited to Jiangsu Province and may not accurately represent the entire population. Second, as this was a cross-sectional study, it is not feasible to infer potential causal consequences. Lastly, given this was an internet-based survey, participants' accessibility data was obtained through a sole self-reported question, with no subsequent confirmation processes or extensive resources incorporated into this questionnaire. There is a need for additional longitudinal studies to be carried out in the future.

Childhood and adolescence represent critical stages in an individual's development, characterized by several physical and emotional changes. These changes may potentially disrupt functioning in the family, school, society, and adaptive functioning. It is therefore essential to identify primary indicators of depression and develop effective prevention and intervention measures. This approach is instrumental in promoting the physical and mental well-being of adolescents (*14*).

Monitoring the mental health of children and adolescents plays a critical role in understanding the broader public health impact, increasing awareness about mental health, and pinpointing potential resource allocation needs (*15*). This study's findings can assist public health professionals, policymakers, and educators in early recognition and intervention of mental health issues. Specifically, these findings can support targeting students who are upper-classmen, female, current smokers, alcohol users, or those living in single-parent families, leading potentially to improved long-term health outcomes.

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REFERENCES

1. Weersing VR, Jeffreys M, Do MCT, Schwartz KTG, Bolano C. Evidence base update of psychosocial treatments for child and adolescent depression. J Clin Child Adolesc Psychol 2017;46(1):11 – 43. http://dx.doi.org/10.1080/15374416.2016.1220310.
2. Bitsko RH, Claussen AH, Lichstein J, Black LI, Jones SE, Danielson ML, et al. Mental health surveillance among children — United States, 2013-2019. MMWR Suppl 2022;71(2):1 – 42. http://dx.doi.org/10.15585/mmwr.su7102a1.
3. Sun XY, Li YX, Yu CQ, Li LM. Reliability and validity of depression scales of Chinese version: a systematic review. Chin J Epidemiol 2017;38(1):110 – 6. http://dx.doi.org/10.3760/cma.j.issn.0254-6450.2017.01.021. (In Chinese).
4. Wang K, Shi HS, Geng FL, Zou LQ, Tan SP, Yi Wang, et al. Cross-cultural validation of the depression anxiety stress scale-21 in China. Psychol Assess 2016;28(5):e88 – 100. http://dx.doi.org/10.1037/pas0000207.
5. Fu XL, Zhang K, Chen XF, Chen ZY. Report on national mental health development in China (2021-2022). Beijing: Social Sciences Academic Press (China). 2023. http://find.nlc.cn/search/showDocDetails?docId=-7071672176933469663&dataSource=ucs01&query. (In Chinese).
6. Ma SQ, Ci HT, Lv JC. Depression condition and its influencing factors of adolescent, Shandong. Mod Prev Med 2020;47(5):839 – 43. https://d.wanfangdata.com.cn/periodical/xdyfyx202005018. (In Chinese).
7. Zhang XJ, Tian QF, Hu HH, Cai XM, Jin XX. Depressive symptoms of provincial demonstration middle school students and its relationship with life events in Zhengzhou. Chin J Health Psychol 2017;25(4):491 – 3. http://qikan.cqvip.com/Qikan/Article/Detail?id=672083236. (In Chinese).
8. Liu XY, Wang J, Guo Y, Yang QH, Chen YY, Liu NP, et al. Depressive symptoms and its association with academic achievement and negative attribution style among key senior high school students. Chin J Sch Health 2016;37(11):1655 – 7. https://d.wanfangdata.com.cn/periodical/zgxxws201611017. (In Chinese).
9. Liu FR, Song XQ, Shang XP, Wu MF, Sui ML, Dong YC, et al. A meta-analysis of detection rate of depression symptoms among middle school students. Chin Mental Health J 2020;34(2):123 – 8. https://d.wanfangdata.com.cn/periodical/zgxlwszz202002008. (In Chinese).
10. Li G, Mei JH, You J, Miao JF, Song XY, Sun WZ, et al. Sociodemographic characteristics associated with adolescent depression in urban and rural areas of Hubei Province: a cross-sectional analysis. BMC Psychiatry 2019;19(1):386. http://dx.doi.org/10.1186/s12888-019-2380-4.
11. Ding J, Wan Q, Qian ML, Yin XJ, Wu HP, Ma YY, et al. Correlation between family environment and depressive symptoms among adolescents. Chin J Sch Health 2023;44(5):677 – 81. https://d.wanfangdata.com.cn/periodical/zgxxws202305010. (In Chinese).
12. Raffetti E, Donato F, Triolo F, Andersson F, Forsell Y, Galanti M R. Country differences in the cross-sectional associations between smoking and depressive symptoms in adolescence. Eur J Public Health 2022;32(6):913 – 8. http://dx.doi.org/10.1093/eurpub/ckac155.
13. Wu ZP, Yue Q, Zhao Z, Wen J, Tang LY, Zhong ZZ, et al. A cross-sectional study of smoking and depression among US adults: NHANES (2005-2018). Front Public Health 2023;11:1081706. http://dx.doi.org/10.3389/fpubh.2023.1081706.
14. Klasen F, Otto C, Kriston L, Patalay P, Schlack R, Ravens-Sieberer U. Risk and protective factors for the development of depressive symptoms in children and adolescents: results of the longitudinal BELLA study. Eur Child Adolesc Psychiatry 2015;24(6):695 – 703. http://dx.doi.org/10.1007/s00787-014-0637-5.
15. Caldwell DM, Davies SR, Hetrick SE, Palmer JC, Caro P, López-López JA, et al. School-based interventions to prevent anxiety and depression in children and young people: a systematic review and network meta-analysis. Lancet Psychiatry 2019;6(12):1011 – 20. http://dx.doi.org/10.1016/S2215-0366(19)30403-1.

Commentary

Addressing Environmental Health Challenges for Sustainable Development in China

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On May 5, 2023, the World Health Organization (WHO) declared that the coronavirus disease 2019 (COVID-19) no longer posed a public health emergency of international concern (*1*). As restrictions associated with the epidemic are relaxed and a fresh policy cycle commences, China's economy is expected to serve as a key driver of global economic post-pandemic recovery.

For over four and a half decades, China has witnessed rapid economic growth, positioning itself as the world's second-largest economy. Notably, from 2012 to 2022, the gross domestic product (GDP) of China expanded more than twofold, from 53.9 trillion Chinese yuan (CNY) [approximately 7.58 trillion United States dollars (USD)] to 121.02 trillion CNY (17.93 trillion USD). In the same period, the country had an average annual GDP growth rate of 6.2%, one of the highest globally (*2*).

Alongside this economic growth, China also achieved significant strides in environmental conservation. Specifically, energy consumption per unit of GDP reduced by 8.1%, and CO_2 emissions decreased by 14.1%. Furthermore, from 2018 to 2022, an improvement was observed in water quality in cities at or above the prefectural level, with the percentage of good-quality surface water bodies increasing from 67.9% to 87.9%. Air quality also improved, with the average particulate matter 2.5 ($PM_{2.5}$) concentration decreasing by 27.5% and severe air pollution days declining by over 50% (*2*).

However, simultaneous industrial expansion and rapid urbanization, coupled with an increase in energy consumption and a burgeoning vehicular population, has amplified environmental pollution issues. This situation presents a significant challenge to both socioeconomic development and public health in China, reflecting environmental health challenges often encountered by developing nations.

KEY ENVIRONMENTAL HEALTH ISSUES IN CHINA

In 2022, China emerged as the world's leading consumer of electricity, accounting for 31% of the global demand (*3*). Projections for 2023–2025 anticipate an average annual growth of 5.2%, suggesting that by 2025 China will consume one-third of the world's electricity. Despite the increased uptake of renewable energy sources in recent decades, coal remains a pivotal part of the Chinese electricity landscape, contributing over 62% to power generation in 2022. Furthermore, coal consumption surpassed 4 billion tons, representing more than half of the world's total coal use. Additionally, China's aging population is a burgeoning issue; the country's seventh national population census in 2021 indicated that the proportion of people aged 65 or older reached 190 million (13.50% of the total population), reflecting a 4.63% increase since 2010. This exponential growth in the aging population not only precipitates demographic shifts, but it also significantly impacts socioeconomic and technological changes (*4*). Urbanization trends show a rapid expansion of urban areas, with the number of cities increasing from 223 in 1980 to 687 in 2020. Now, 63.89% of the population resides in urban areas. China's urbanization process continues to evolve as over 10 million individuals transition from rural to urban areas annually (*2*). Lastly, the number of on-road civilian vehicles in China amplified more than threefold, growing from 93 million in 2011 to 319 million in 2022.

Despite the remarkable progress China has made in its economic and social development due to the implementation of reform and opening-up policies, the tension between swift socioeconomic growth, the availability of energy resources, and the ecological environment is becoming increasingly apparent (*5*). Multiple constraints are now impacting China's development, including pressures from ecological protection, limited energy support, and global climate change concerns, all of which are connected to its modernization process. At present, China is the world's leading producer of CO_2 and other greenhouse gases, aggravating worries about climate change and air pollution (*6*).

Even though significant strides have been made by the government to curb environmental pollution and conserve ecosystems, there are substantial improvements that need to happen. For instance, in 2021, out of 339 cities at the prefectural level or higher, 121 (35.7%) failed to meet the National Guidelines for ambient air quality (*7*). Factoring in dust storms, the number of non-compliant cities rises to 146 (43.1%). The average land quality for farming was rated at 4.76 on a scale from 1 (best) to 10 (worst), with 31.24% of land falling into the higher quality (categories 1–3), 46.81% in the middle (categories 4–6), and 21.95% in the low quality (categories 7–10).

In terms of groundwater resources (inclusive of both the Yangtze and Yellow Rivers), among the 3,632 points monitored, 84.9% held Grades I–III water quality (signifying relatively higher quality), while Grades IV, V, and low V (indicating relatively lower quality) accounted for 11.8%, 2.2%, and 1.2% respectively. According to the Blue Book on Climate Change in China 2022, the average land surface temperature in 2021 rose 0.97 °C over the baseline average, making it the highest since 1901 (*8*). This rise in surface temperature in China, at a rate of 0.26 °C per decade, exceeds the worldwide average rate of increase, which sits at 0.15 °C per decade.

PUBLIC HEALTH IMPACTS OF ENVIRONMENTAL POLLUTION AND CLIMATE CHANGE

The deleterious effects of environmental pollution and climate change on public health are increasingly evident. For instance, it was determined that in 2019, air pollution was implicated in roughly 1.85 million fatalities in China, with approximately 1.42 million of these attributable to particulate matter (*9*). The *Lancet* Countdown's 2022 report on health and climate change regarding China revealed escalating health risks stemming from climate change. This is illustrated by the occurrence of record-breaking average national temperatures and a rise in extreme weather events across the country (*10*). In 2021, compared to the average for 1986–2005, Chinese inhabitants faced on average an additional 7.85 heatwave days, leading to an increase of approximately 13,185 heatwave-related deaths. There was a loss of about 33 billion heat-related work hours, amounting to a 1.68% decrease in GDP. From 2017 to 2021, as compared to the 2001–2005 average, elevated temperatures concurrently led to an average increase in wildfire exposure of 60.0%. A rising trend in dengue transmission has been noted since 2000 when compared to prior timeframes. Likewise, China's swift urbanization is yielding substantial impacts on both the environment and public health. Preliminary data indicates significant disparities among distinct urban groups in the realm of cardiovascular disease prevention and mortality risks (*11*).

CHINA IS TACKLING ENVIRONMENTAL HEALTH CHALLENGES SERIOUSLY

China grapples with significant challenges related to environmental pollution and population health protection. As the largest upper-middle income developing country, China's swift economic growth and industrialization complicate efforts to decrease carbon emissions and safeguard ecosystems. Undeniably, China, akin to other nations, carries an ethical right to development. However, increased energy consumption and industrial production inevitably lead to elevated carbon emissions and pollutant creation. The question of how to preserve the environment throughout the modernization process is of pivotal importance, with multiple lower- or upper-middle income developing countries striving to find a suitable solution. Nevertheless, the Chinese government is actively implementing measures aimed at curtailing carbon emissions, managing environmental pollution, and enhancing ecosystem protection.

The State Council executive meeting, held in December 2020, ratified a pollution control regulation aimed at monitoring and controlling pollutant discharge from enterprises and public institutions to maintain a robust ecological environment (*12*). The regulation, effective since March 2021, mandates that all enterprises involved in pollutant discharge secure a pollution discharge permit, with unpermitted discharges prohibited.

In October 2021, the Chinese Government published a white paper, "*Responding to Climate Change: China's Policies and Actions.*" Recognized as the world's largest developing country and a significant contributor to carbon emissions, China announced ambitious goals of reaching peak carbon emissions before 2030 and carbon neutrality prior to 2060 (*13*). The government has prioritized climate change response and has consistently lowered the intensity of its carbon emissions. It has put forth substantial efforts to fulfill its Nationally Determined Contributions (NDCs) and has maximally sought to mitigate climate change. China has embraced green, low-carbon strategies in its economic and social development agenda, striving towards the harmonious coexistence of humans and nature. With China's pursuit of carbon neutrality, aerosol reductions stemming from clean air actions and pollution control policies could potentially have a substantial impact on the climate (*14–18*).

In January 2023, China released another white paper, titled "*China's Green Development in the New Era*" (Table 1). China has firmly endorsed the concept of a global community with a shared future, demonstrating steadfast support for multilateralism. It has proposed both the Global Development Initiative and the Global Security Initiative, widened practical cooperation, and actively engaged in global environmental and climate governance (*19*).

China has aggressively addressed pressing pollution issues with ambitious objectives. For instance, in 2021 the mean concentration of $PM_{2.5}$ in cities at or above the prefectural level registered at 30 μg/m^3, a year-over-year reduction of 9.1% (*7*). Further, the percentage of surface water at or above Grade III rose by 1.5% year-over-year, reaching 84.9%. The emission of CO_2 per unit of GDP is projected to decrease by 18% from 2020 to 2025, illustrating China's acceleration towards a low-carbon energy consumption transition. The share of renewable energy consumption is expected to increase to approximately 20% by 2025. Despite these advancements, China still faces significant challenges in reaching peak carbon dioxide emissions before 2030 and achieving carbon neutrality prior to 2060. Numerous plans, laws, regulations, and policies have been put into action, demonstrating China's unwavering commitment to its "dual carbon goals" — carbon peak before 2030 and carbon neutrality before 2060 — and to advancing towards a greener and healthier nation (Figure 1). China also plans to enact its green transition agenda, increasing its role in bilateral and multilateral green development initiatives, advocating for a fair and equitable global environment governance system, and contributing its unique perspective and efforts to global economic growth (*19*). These endeavors will contribute significantly to global sustainability development and may inspire other developing nations with rapid industrialization to follow suit.

SUMMARY AND OUTLOOK

The significance of environmental protection within the context of modernization is a pertinent concern for numerous nations, especially those undergoing transitional stages. Notably, the Chinese government

TABLE 1. Summary of key regulations implemented in China promoting high-quality and green development over the past decade.

Time	Document title	Content
April 24, 2014	The Revised Environmental Protection Law (Order of the President of the People's Republic of China No. 9)	(i) Protect and improve the environment in the course of socioeconomic development. (ii) Expand the number of items from 47 to 70. (iii) Put into practice on January 1, 2015.
June 27, 2018	Battle for Protecting Blue Sky Three-Year Action Plan (Order of the President of the People's Republic of China No. 22)	(i) The focus should be on controlling air pollution, especially in regions experiencing severe pollution. (ii) Substantially reduce emissions of air pollutants and greenhouse gases within three years. (iii) In comparison to the levels of 2015, there was a decrease in the levels of SO_2 and NOx by 15%, and $PM_{2.5}$ by 18% in 2020.
December 26, 2020	The Yangtze River Protection Law (Order of the President of the People's Republic of China No. 65)	(i) Enhance ecological and environmental protection and restoration efforts in the Yangtze River basin. (ii) Facilitate the rational and effective use of resources. (iii) Safeguard ecological security and ensure harmony between humans and nature.
October 27, 2021	The White Paper on Responding to Climate Change: China's Policies and Actions	(i) China has elevated the response to climate change to a higher level of priority within state governance. (ii) The goal is to reach peak CO_2 emissions prior to 2030, with an aim to attain carbon neutrality by 2060. (iii) China is taking pragmatic actions towards these goals.
January 19, 2023	The White Paper on China's Green Development In the New Era	(i) Promote harmonious coexistence between humans and nature. (ii) Optimize social and economic benefits with minimum resource costs and environmental impacts. (iii) Enhance sustainable and high-quality development.

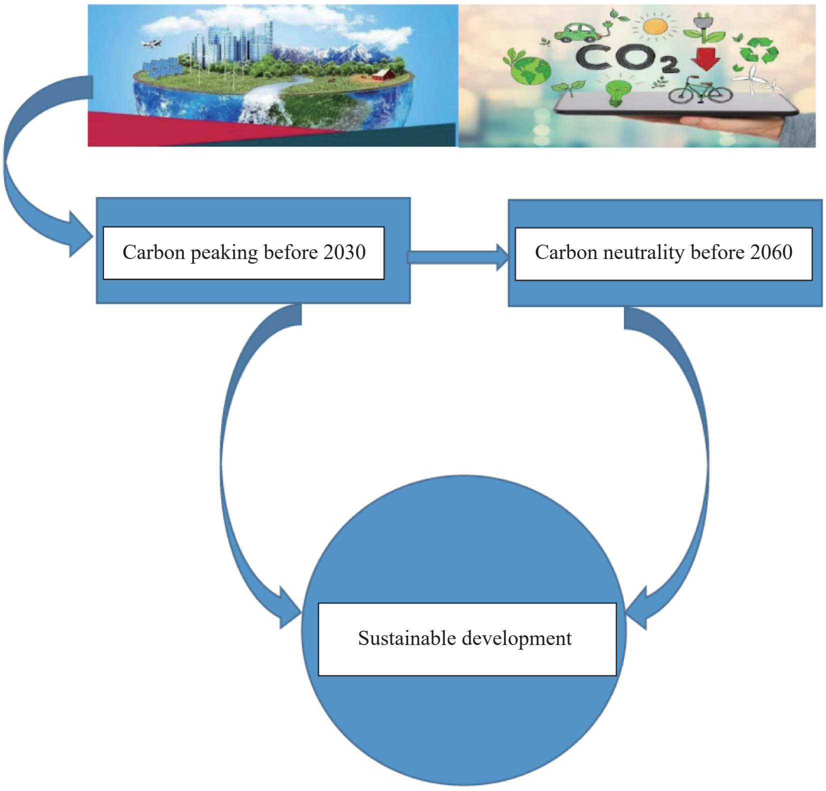

FIGURE 1. Conceptual diagram illustrating green development and "dual carbon" goals.

has implemented proactive strategies aimed at reducing carbon emissions, managing environmental pollution, and augmenting ecosystem protection. Recent enhancements to this positioning include the establishment of various plans, laws, regulations, and policies, indicating China's resolve to enhance its environmental condition and bolster population health. Given the successful implementation of these measures, China's envisioned image as a green, healthy, and sustainable country is likely to make substantial contributions to global socioeconomic development.

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REFERENCES

1. WHO. Statement on the fifteenth meeting of the IHR (2005) Emergency Committee on the COVID-19 pandemic. 2023. https://www.who.int/news/item/05-05-2023-statement-on-the-fifteenth-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-coronavirus-disease-(covid-19)-pandemic. [2023-5-15].
2. Chinese Government. Government work report. 2023. http://english.www.gov.cn/2023special/GOVTWORKREPORT2023. [2023-5-15]. (In Chinese).
3. International Energy Agency. Electricity market report 2023. 2023. https://www.iea.org/reports/electricity-market-report-2023/executive-summary. [2023-5-15].
4. Cuaresma JC, Lábaj M, Pružinský P. Prospective ageing and economic growth in Europe. J Econ Age 2014;3:50 – 7. http://dx.doi.org/10.1016/j.jeoa.2014.05.003.
5. Wu Q, Tu K. Analysis on the dual constraints of energy and environment to the development of China and countermeasures. Chin Sci Bull 2019;64(15):1535 – 44. http://dx.doi.org/10.1360/N972018-01057. (In Chinese).
6. Intergovernmental Panel on Climate Change. AR6 synthesis report: climate change 2023. 2023. https://www.ipcc.ch/report/sixth-assessment-report-cycle/. [2023-5-15].
7. Ministry of Ecology and Environment of the People's Republic of China. Bulletin of China's ecology and environment 2021. 2022. http://www.gov.cn/xinwen/2022-05/28/content_5692799.htm. [2023-5-15]. (In Chinese).
8. National Bureau of Meteorology. Blue book on climate change in China 2022. 2022. http://www.gov.cn/xinwen/2022-08/10/content_5704792.htm. [2023-5-15]. (In Chinese).

9. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. Lancet 2020;396(10258):1223 – 49. http://dx.doi.org/10.1016/S0140-6736(20)30752-2.
10. Cai WJ, Zhang C, Zhang SH, Bai YQ, Callaghan M, Chang N, et al. The 2022 China report of the *Lancet* Countdown on health and climate change: leveraging climate actions for healthy ageing. Lancet Public Health 2022;7(12):e1073 – 90. http://dx.doi.org/10.1016/S2468-2667(22)00224-9.
11. Zhang XY, Lu JP, Yang Y, Cui JL, Zhang XY, Xu W, et al. Cardiovascular disease prevention and mortality across 1 million urban populations in China: data from a nationwide population-based study. Lancet Public Health 2022;7(12):e1041 – 50. http://dx.doi.org/10.1016/S2468-2667(22)00170-0.
12. The State Council the People's Republic of China. Pollution control regulation to come into effect. 2021. http://english.www.gov.cn/policies/latestreleases/202101/29/content_WS601416dbc6d0f72576944c20.html. [2023-5-18]. (In Chinese).
13. Liu Z, Deng Z, He G, Wang HL, Zhang X, Lin J, et al. Challenges and opportunities for carbon neutrality in China. Nat Rev Earth Environ 2022;3(2):141 – 55. http://dx.doi.org/10.1038/s43017-021-00244-x.
14. Yang Y, Zeng LY, Wang HL, Wang PY, Liao H. Climate effects of future aerosol reductions for achieving carbon neutrality in China. Sci Bull 2023;68(9):902 – 5. http://dx.doi.org/10.1016/j.scib.2023.03.048.
15. Tang R, Zhao J, Liu YF, Huang X, Zhang YX, Zhou DR, et al. Air quality and health co-benefits of China's carbon dioxide emissions peaking before 2030. Nat Commun 2022;13(1):1008. http://dx.doi.org/10.1038/s41467-022-28672-3.
16. Shindell D, Smith CJ. Climate and air-quality benefits of a realistic phase-out of fossil fuels. Nature 2019;573(7774):408 – 11. http://dx.doi.org/10.1038/s41586-019-1554-z.
17. Yang Y, Ren LL, Li HM, Wang HL, Wang PY, Chen L, et al. Fast climate responses to aerosol emission reductions during the COVID-19 pandemic. Geophys Res Lett 2020;47(19):e2020GL089788. http://dx.doi.org/10.1029/2020gl089788.
18. Ma XF, Huang G, Cao JJ. The significant roles of anthropogenic aerosols on surface temperature under carbon neutrality. Sci Bull 2022;67(5):470 – 3. http://dx.doi.org/10.1016/j.scib.2021.10.022.
19. The State Council Information Office the People's Republic of China. Full text: China's green development in the new era. 2023. http://english.scio.gov.cn/whitepapers/2023-01/19/content_85067818.htm. [2023-5-18]. (In Chinese).

Perspectives

Enhancing Public Health Competencies via Action on Salt China — China, 2017–2022

Puhong Zhang[1,#]

The Action on Salt China (ASC) project is a noteworthy collaborative venture between China and UK, with the China CDC serving as a key partner. The objective of this report is to present a case study that demonstrates the significant role of ASC in bolstering the capacity of public health services in China. Furthermore, this study aims to offer valuable references and provoke thoughtful insight for potential international collaborations in the future.

Obstacles Encountered in the Execution of Salt Reduction Strategies

In China, the consumption of salt significantly exceeds the World Health Organization's (WHO) recommended limits, with intake levels twice as high. Prevailing evidence has underscored salt reduction as one of the most economical and practical preventative measures to stave off hypertension and cardiovascular diseases. In recent decades, certain nations such as the UK have successfully created and instituted nationwide salt reduction programs. In China, where consumers add approximately 80% of the salt during meal preparation, considerable strides have been made towards crafting salt reduction strategies and interventions under the umbrella of Healthy China 2030 Actions. However, several obstacles obstruct the comprehensive application of these strategies. One notable hurdle is the inadequate capability of the public health workforce to craft, enforce, and assess intricate interventions aimed at promoting salt reduction across varied settings. This includes a deficiency in necessary competencies and expertise to devise scalable and practical salt-reduction intervention initiatives based on need analysis. Furthermore, there's a crucial necessity for the capacity to effectively execute the package, bolstered by ongoing process evaluations, as well as assessments of effectiveness and health economics. As such, offering continuous education and training for public health workers is critical for them to effectively perform their roles in preventing and controlling noncommunicable diseases.

Opportunities Provided by ASC

ASC is a global health research unit jointly spearheaded by Professor Graham MacGregor and Feng J He of Queen Mary University of London (QMUL) and Professor Puhong Zhang of The George Institute for Global Health, China (TGI China) (*1*). Being funded by the National Institute for Health and Care Research (NIHR) in the UK, ASC has aimed at addressing the public health challenge of excessive salt consumption through a spectrum of capacity building initiatives since its inception in 2017.

ASC was overseen by a senior Steering Committee, presided over by Professor Longde Wang, a member of the Chinese Academy of Engineering and the former Vice Minister of Health. In addition to the principal research institutes of TGI China and QMUL, ASC collaborates with partners such as the China CDC, the Chinese Center for Health Education, the China National Center for Food Safety Risk Assessment, and Beihang University. Further support is provided by regional collaborators in the provinces of Hebei, Heilongjiang, Jiangxi, Hunan, Sichuan, and Qinghai, as well as local partners located in 33 study sites at county and district levels.

ASC convened a multidisciplinary team of researchers with substantial expertise in various public health fields including salt reduction, trial design, community engagement, intervention development, mobile health, project management, data management and analysis, process evaluation, health economic evaluation, and implementation science. Equally important fields covered by the team include health education, communication, policy advocacy, and financial management. These specializations are crucial in building the competencies and skillset required for the successful implementation of effective salt reduction interventions.

Efforts to mitigate copious salt consumption in China, which primarily originates from home/restaurants cooking and pre-packaged food, incorporated six distinct strategies within the ASC (*2*).

These strategies encompassed four cluster randomized controlled trials (RCTs): an application-based intervention study directed at schoolchildren and their families (AIS) (*3*); a home cook-centric intervention study (HIS) (*4*); a restaurant-based intervention study (RIS) (*5–6*), and a comprehensive intervention study (CIS) (*7*). Two national health campaigns were also included: an educational campaign raising awareness about salt consumption (*8*) and a campaign encouraging salt reduction in processed foods, buttressed by research on food sodium content to aid target setting and nutrition labeling (*9–10*). A comprehensive salt reduction intervention package, successfully proven by the aforementioned RCTs, was notably amplified across all six provinces in 2020–2021.

The Endeavors of ASC in the Realm of Capacity Building

The development of capacity remains a fundamental element of the ASC program, dating back to its RCT phase from 2018 to 2019, and continuing through to its expansion phase from 2020 to 2021. A few notable outcomes of the ASC's capacity-building initiatives are outlined as follows:

The four RCTs conducted encompassed numerous stages including trial design, intervention development, implementation, monitoring, and evaluation. As part of this process, extensive professional training was carried out for public health workers stationed at local CDCs. These trainings, which primarily benefited the CDC staff located at the 33 study sites across six provinces, encompassed a comprehensive range of topics. This included salt reduction knowledge and practical skills, nuances of RCT implementation and evaluation, project management essentials, and quality control methods among other topics. The public health workforce also received training in the use of mHealth-based intervention and evaluation tools, equipping them to carry out the RCTs effectively.

A comprehensive intervention package, designed as a principal educational tool for professional trainings, has been developed. This intervention package includes an all-encompassing array of health education materials such as technical manuals, visual aids, digital and conventional training courses, as well as app-based intervention and evaluation instruments. This package has been incorporated into the national resource repositories of the China CDC and CCHE, and is utilized as instructional material for public health professionals nationwide (*11*).

Training sessions on measuring dietary salt intake, utilizing the high-accuracy method of 24-hour urinary sodium excretion, have been implemented in field research. The three RCTs namely AIS, HIS, and CIS, have amassed 24-hour urine samples from a total of 6,030 participants (*12*). This cohort included 5,436 adults and 594 schoolchildren, consequently making them the most substantial RCTs in China to employ 24-hour urinary sodium in assessing the efficacy of salt reduction interventions. Furthermore, training concerning process evaluation has been executed in these four RCTs.

In the scale-up phase, an ASC Scale-up platform was established to facilitate routine public health operations. This platform includes features such as an activity planning and design module, an extensive repository of educational materials, an activity recording module, an impact evaluation system, and a performance-based incentives module. These capabilities were leveraged across six provinces. By the end of 2021, over 1,000 salt reduction initiatives were executed, with 350 of these activities gaining recognition for their excellence across these provinces (*13*).

In the broader context of capacity enhancement, numerous engagement initiatives have taken place with multi-sectoral government leaders and policymakers, particularly within the education and health sectors, to facilitate the implementation of salt reduction interventions across various sectors at a policy level. These initiatives have been instrumental in disseminating research findings and advocating for the integration of salt reduction policies into the operations of non-health sectors.

Training workshops have been conducted targeting a variety of stakeholders, including schoolteachers, restaurant chefs, community workers, and members of the media. These individuals play an instrumental role in assisting public health professionals in the implementation of salt reduction interventions in key environments such as schools and restaurants. For instance, within the context of the AIS, training was initially provided to schoolteachers regarding the delivery of interventions, followed up by educational courses for students and salt reduction activities engaging entire families. Likewise, in the RIS, restaurant personnel, such as waiters and chefs, received training on salt reduction knowledge and techniques (*13*).

Partners of ASC have collaboratively developed a cloud-based information system. A variety of WeChat applications, including AppSalt, KnowSalt, FoodSwitch, and the Salt and Health WeChat official account, as well as a mobile phone-based data collection system, have been integrated into this system. These digital resources facilitate capacity building activities, health education, intervention implementation, and project management.

Research training opportunities have been given to public health investigators and researchers in order to enhance their capacities in areas such as data management, analysis, process evaluation, implementation science, and health economic evaluation. Throughout the project timeline, research conducted by ASC has facilitated the academic completion of two doctoral and four master's students.

A series of training activities in financial and project management have been implemented for local CDC staff to enhance their competencies. The focus of these activities includes project planning, budget control, due diligence checks, among other related subjects.

Capacity Strengthening Achievements

The public health workforce associated with ASC program has experienced significant benefits, underscored by several exceptional achievements in capacity strengthening, as detailed below:

The competencies and skills necessary for the creation, implementation, and evaluation of population-based salt reduction interventions have seen significant improvements. The CDC staff who participated in this study have acquired in-depth knowledge and practical experience in conducting RCTs and overseeing salt reduction interventions across a variety of environments. Furthermore, collaboration and communication skills with members from non-health sectors, such as educators, have been enhanced to effectively facilitate public health interventions.

The public health workforce has enhanced its abilities regarding the utilization of mHealth innovations, which bolster the implementation of salt reduction interventions. A noteworthy illustration of this is the employment of the AppSalt platform in healthcare education; it has been deemed effective, feasible, and innovative in ensuring a sustainable decrease in salt consumption among both children and adults (*3*). This application served as the foundation for the EduSaltS project — a salt reduction scaling-up program initiated in over 300 schools in China (*14*).

The research capabilities within the realm of public health have seen substantial enhancements. Researchers and investigators from ASC have successfully published more than 60 scholarly articles in high-impact journals including two BMJ articles for the main results of AIS and HIS (*3*). These publications' critical findings hold substantial implications for policies, procedures, and further research both in China and globally.

Community engagement, advocacy, and social mobilization capacities have been considerably enhanced. For example, the World Hypertension League organized children's art competitions in which numerous schoolchildren participated to commemorate World Hypertension Day from 2020 to 2022. Throughout the duration of the project, consumer awareness campaigns were carried out, encompassing annual events such as World Salt Awareness Weeks and China's Salt Awareness Weeks, among other significant campaign days (*13*).

The capacity for evidence-based policymaking has been significantly enhanced. The ASC program has effectively prepared public health professionals with evidence, enabling them to advocate and lobby for improvements in policies concerning salt reduction. In 2023, the *Chinese Journal of Preventative Medicine* published a crucial policy document titled "Deepening the Action on Salt China — CHRPS Strategies" (*15*). Another influential paper, proposing maximum sodium targets for pre-packaged foods in China was published in the Bulletin of the World Health Organization (*16*). Furthermore, ASC has been instrumental in advocating for revisions to the nutritional labeling standards for pre-packaged and restaurant foods.

Global Health Impact

The findings of ASC have received extensive international dissemination, notably through platforms including WASSH. The school-based salt reduction model proposed by ASC has been acknowledged as a best practice by the Global Alliance for Chronic Diseases (GACD). This recognition culminated in 2021 with a feature within a series of short films produced by BBC Story Works.

Sustainability

The accomplishments and broad network of ASC have catalyzed the inception of several novel research initiatives, including projects like "School-based Education Program to Reduce Salt: Scaling-Up in China (EduSaltS)" (*14*), and "Comprehensive

Workplace Intervention for Cancer Prevention in China (WECAN)" (*17*). Looking ahead, ASC is committed to sustaining its influence and continuing to contribute significantly towards the achievement of the United Nations' Sustainable Development Goals.

Limitations

ASC initiative is presently conducted only in selected regions across six provinces in China. While its technical guidance, training materials, salt reduction instruments, expansion platform, and publications may reach a broader spectrum of staff and areas within China, its current impact remains quite constrained. Consequently, additional efforts should be exerted to amplify its influence within the realm of public health.

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REFERENCES

1. He FJ, Zhang PH, Li Y, MacGregor GA. Action on salt China. Lancet 2018;392(10141):7 – 9. http://dx.doi.org/10.1016/S0140-6736(18)31138-3.
2. Zhang PH, He FJ, Li Y, Li CN, Wu J, Ma JX, et al. Reducing salt intake in China with "Action on Salt China" (ASC): protocol for campaigns and randomized controlled trials. JMIR Res Protoc 2020;9(4):e15933. http://dx.doi.org/10.2196/15933.
3. He FJ, Zhang PH, Luo R, Li Y, Sun YW, Chen FG, et al. App based education programme to reduce salt intake (AppSalt) in schoolchildren and their families in China: parallel, cluster randomised controlled trial. BMJ 2022;376:e066982. http://dx.doi.org/10.1136/bmj-2021-066982.
4. Zhang XC, Hu X, Ma JX, Zhang PH, Li Y, Luo R, et al. Cluster randomised controlled trial of home cook intervention to reduce salt intake in China: a protocol study. BMJ Open 2020;10(5):e033842. http://dx.doi.org/10.1136/bmjopen-2019-033842.
5. Du WW, Wang HJ, Zhang JG, Zhang XF, Wei N, Li Y, et al. Sodium content of restaurant dishes in China: a cross-sectional survey. Nutr J 2022;21(1):10. http://dx.doi.org/10.1186/s12937-022-00762-4.
6. Du WW, Zhang PH, Zhang JG, Li Y, He FJ, Zhang XF, et al. Sodium reduction in restaurant food: a randomized controlled trial in China. Nutrients 2022;14(24):5313. http://dx.doi.org/10.3390/nu14245313.
7. Liu M, Xu JW, Li Y, He FJ, Zhang PH, Song J, et al. A town-level comprehensive intervention study to reduce salt intake in China: cluster randomized controlled trial. Nutrients 2022;14(21):4698. http://dx.doi.org/10.3390/nu14214698.
8. Fan F, Li YH, Li L, Nie XQ, Zhang PH, Li Y, et al. Salt-related knowledge, attitudes, and behaviors and their relationship with 24-hour urinary sodium excretion in Chinese adults. Nutrients 2022;14(20):4404. http://dx.doi.org/10.3390/nu14204404.
9. Song YZ, Li Y, Guo CL, Wang YS, Huang LP, Tan M, et al. Cross-sectional comparisons of sodium content in processed meat and fish products among five countries: potential for feasible targets and reformulation. BMJ Open 2021;11(10):e046412. http://dx.doi.org/10.1136/bmjopen-2020-046412.
10. Li Y, Wang HJ, Zhang PH, Popkin BM, Coyle DH, Ding JM, et al. Nutritional quality of pre-packaged foods in China under various nutrient profile models. Nutrients 2022;14(13):2700. http://dx.doi.org/10.3390/nu14132700.
11. Chinese Center for Health Education. Resource bank for health promotion and health education. 2023. http://www.rbhp.org.cn:81/portal/index.htm. [2023-6-19]. (In Chinese).
12. Li Y, Zhang PH, Wu J, Ma JX, Xu JW, Zhang XC, et al. Twenty-Four-hour urinary sodium and potassium excretion and their associations with blood pressure among adults in China: baseline survey of action on salt China. Hypertension 2020;76(5):1580 – 8. http://dx.doi.org/10.1161/HYPERTENSIONAHA.120.15238.
13. The George Institute for Global Health. Action on salt China. 2023. https://www.actionsaltchina.com/index.html. [2023-6-19]. (In Chinese).
14. Zhang PH, Sun JW, Li YH, Li Y, Sun YW, Luo R, et al. An mHealth-based school health education system designed to scale up salt reduction in China (EduSaltS): a development and preliminary implementation study. Front Nutr 2023;10:1161282. http://dx.doi.org/10.3389/fnut.2023.1161282.
15. Wang LD, Zhang PH, Li Y, Li YH, Zhang B, Wang HJ, et al. Deepening the action on Salt Reduction in China suggestions on strategy and implementation plan. Chin J Prev Med 2023;57(7):1105 – 14. http://dx.doi.org/10.3760/cma.j.cn112150-20221205-01176. (In Chinese).
16. Zhang PH, Zhang JG, Li Y, Dong L, He FJ, Brown M, et al. Sodium content targets for pre-packaged foods, China: a quantitative study and proposal. Bull World Health Organ 2023;101(7):453 – 69. http://dx.doi.org/10.2471/BLT.23.289992.
17. Li Y, Sun KG, Wang BH, Wang N, Luo R, Wang CQ, et al. Comprehensive workplace intervention for cancer prevention in China (WECAN): protocol for a stepped-wedge, cluster-randomised controlled trial. BMJ Open 2023;13(4):e072405. http://dx.doi.org/10.1136/bmjopen-2023-072405.

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