Public Health Nutrition: 24(7), 1869–1876 doi:10.1017/S1368980020003237

Dietary diversity and mental health in preschoolers in rural China

Shaoping Li[1], Kevin Chen[2,3], Chengfang Liu[1,*], Jieying Bi[4], Zhenya He[5], Renfu Luo[1], Yanying Yu[2] and Zimeiyi Wang[3]

[1]China Center for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, Beijing 100871, People's Republic of China: [2]China Academy for Rural Development, Zhejiang University, Hangzhou, Zhejiang Province, People's Republic of China: [3]International Food Policy Research Institute, East and Central Asia Office, Beijing, People's Republic of China: [4]Agricultural Information Institute of Chinese Academy of Agricultural Sciences, Beijing, People's Republic of China: [5]Faculty of Business and Economics, The University of Hong Kong, Hong Kong, People's Republic of China

Submitted 8 November 2019: Final revision received 29 July 2020: Accepted 13 August 2020: First published online 14 December 2020

Abstract

Objective: To investigate the prevalence of mental health problems among preschoolers in rural China and examine the relationship between dietary diversity and mental health.

Design: A cross-sectional survey analysis was performed. Child mental health was assessed with the Strengths and Difficulties Questionnaire (SDQ). Child dietary diversity was assessed with the dietary diversity score (DDS), which was calculated based on nine food groups using a 24-h recall method. Data were analysed using unadjusted and adjusted logistic regression models.

Setting: Two nationally designated poverty counties in Hunan Province of China.

Participants: Preschoolers (*n* 1334) aged 3–5 years, preschools (*n* 26).

Results: Of 950 preschoolers with data on both dietary diversity and mental health, 663 (70 %) were classified as having at least one kind of mental health problem. The prevalences of emotional symptoms, conduct problems, symptoms of hyperactive/inattention, peer relationship problems and poor prosocial behaviour were 39, 27, 23, 12 and 26 %, respectively. Male preschoolers showed higher risks of having mental health problems than their female counterparts on each SDQ subscale except for conduct problems. Moreover, a higher DDS was significantly associated with a lower likelihood of having symptoms of hyperactivity/inattention, peer relationship problems and prosocial behaviour problems after adjustment for confounders (preschoolers' age, gender, cognitive ability, parental migration status, primary caregiver's education and household socio-economic status).

Conclusions: The prevalence of mental health problems was high among preschoolers in rural China. Improving child dietary diversity might be an important strategy to consider in the design of interventions to improve child mental health.

Keywords
Dietary diversity
Mental health
Preschooler
Rural China

Mental health problems in adults can originate as early as childhood[1]. It is estimated that, globally, mental health problems affect 10–20 % of children and adolescents[2], and they have been found to have a serious impact on children's and adolescents' future life behaviours, such as school dropout, substance abuse, family violence and even suicide[3]. Beyond the impact on individuals, the economic loss (e.g. human capital loss) resulting from mental disorders also results in enormous disadvantages to societal development[4]. Studies also show that, compared with their urban peers, rural children are more likely to suffer from mental problems[5,6]. Therefore, effective and efficient interventions to reduce mental health problems in rural children are urgently needed[7].

Diet has been shown in many studies to be an essential factor that may affect mental health[8,9]. In a systematic review, children and adolescents with healthy dietary patterns or consumption of a high-quality diet were found to

*Corresponding author: Email cfliu.ccap@pku.edu.cn

have lower levels of depression or better mental health[10]. One study showed that children with high scores for a 'varied Norwegian' eating pattern were less likely than those with low scores to have indications of any psychiatric disorders and hyperactivity-inattention disorders[11]. The role of the Mediterranean dietary pattern with regard to the prevention of depressive disorders has also been reported[12]. Dietary diversity, an integrated indicator for measuring nutrition adequacy and diet quality[13–15], refers to the intake of various food items from different food groups[15]. In the past few years, several studies have identified the association of dietary diversity with anxiety and depressive symptoms among adult women[16–18]. To the best of our knowledge, however, few studies have examined the relationship between dietary diversity and mental health in children.

The present study aimed to fill the gap mentioned above. To do so, the prevalence of mental health problems among preschoolers in rural China was investigated. Then, the association between dietary diversity and mental health in preschoolers was examined.

Method

The baseline data of a preschool nutrition pilot programme were used, which were collected in September 2018 as part of launched by the government of Xiangxi Prefecture, with support from the World Food Program. The baseline survey was carried out in two nationally designated poverty counties (Longling County and Yongshun County) in Xiangxi Prefecture, Hunan Province, in central-southern China. Because the baseline survey was conducted before any intervention associated with the pilot programme was implemented, the intervention can be ignored here. The sample included twenty-six preschools, which were randomly sampled from fifteen townships across the two project counties. Of these preschools, ten were located in Longling County, and the remaining sixteen were located in Yongsun County. Within each sample preschool, all children aged 3 or 5 years were included in the sample. Primary caregivers of the children (mostly grandparents or parents) were asked in advance to complete the questionnaire and interview in person. A total of 1334 caregivers of preschoolers were surveyed at baseline. In analysis, those preschoolers with missing data for dietary intake, mental health problems or other confounding variables were excluded. In total, 384 caregivers were excluded from the study and 950 (71 %) were included for further analysis.

The mental health of preschoolers was assessed with the parent-reported Mandarin Language Strengths and Difficulties Questionnaire (SDQ)[19]. As a reliable and valid behavioural screening questionnaire[19–21], the SDQ has been extensively used by researchers and clinicians in their studies worldwide, such as in Europe[22,23], the Middle East[24], Australia[25], China[3] and USA[26]. The questionnaire contains twenty-five items to assess emotions, behaviours and relationships among young children[19]. Specifically, there are five subscales within the SDQ, namely, emotional symptoms, conduct problems, symptoms of hyperactivity/inattention, peer relationship problems and prosocial behaviour. Each subscale includes five items. The score of each subscale ranges from 0 to 10, with higher scores indicating more problems, except for the prosocial behaviour subscale, for which a lower score indicates more problems. Each SDQ subscale was further divided into three categories according to the categories described in an earlier study from China[21]: 'normal', 'borderline' and 'abnormal'. The cut-off values to differentiate the three categories are shown in Table 1. Children with any of the problems listed in the SDQ are categorised in either the 'borderline' or 'abnormal' group.

According to the Guidelines for Measuring Household and Individual Dietary Diversity provided by the Food and Agriculture Organization of the United Nations[27], children's dietary diversity was assessed with the dietary diversity score (DDS) based on nine food groups. Detailed food group classification and example food items in each group were reported in a previous study[28]. Specifically, trained enumerators used two questionnaires to collect detailed information on dietary intake among children. A 24-h recall method was used in both questionnaires. One questionnaire asked primary caregivers what their children had eaten at home as well as what food they had eaten at restaurants or other shops over the past 24 h. The other questionnaire asked preschool kitchen managers what the children had eaten at the preschools over the past 24 h. As such, detailed information on the food consumption of each child both at home and at preschool over the past 24 h was collected, which allowed us to measure the children's total dietary consumption within the past 24 h. The DDS was calculated by counting the number of food groups that a child had consumed in the past 24 h without consideration of a minimum quantity requirement for any food group. Each individual food item in each food group consumed by a child earned one point for the child's DDS, but different individual food items consumed in the same group were not counted repeatedly. Therefore, the DDS ranged from 0 to 9.

Table 1 Cut-offs of the Strengths and Difficulties Questionnaire subscales*

Mental health problems	Normal range	Borderline range	Abnormal range
Emotional symptoms	0–3	4	5–10
Conduct problems	0–2	3	4–10
Symptoms of hyperactivity/inattention	0–6	7	8–10
Peer relationship problems	0–4	5	6–10
Prosocial behaviour problems	10–6	5	4–0

*Adapted from Du *et al.*[21].

Information on factors that might potentially confound the relationship between DDS and mental health was also collected in the questionnaire by trained enumerators. In the examination of the associations, the following factors were adjusted: children's age, gender, left-behind status, BMI, time spent on TV/mobile (<60 min *v.* >60 min), parental education level (junior high school or below *v.* senior high school or above), primary caregiver's education level (junior high school or below *v.* senior high school or above) and household socio-economic status (SES). Considering that measuring SES in poor settings can be difficult and inaccurate due to income instability or reporting bias[29], the possession of durable goods from a list of thirteen items was recorded to represent the SES of each household. Household SES was divided into three categories: lowest tertile, middle tertile and highest tertile. Moreover, child cognitive function was measured using two indexes from the Wechsler Preschool and Primary Scale of Intelligence, Fourth Edition: working memory index and verbal comprehension index. Both the working memory index and verbal comprehension index were categorised into 'normal', 'borderline' and 'abnormal'.

Statistical methods

Wald tests were used to test differences between male and female preschoolers in all measured correlates. Logistic regression models were used to estimate odds, with 95 % CI, of the prevalence of mental health problems across the socio-demographic subgroups (DDS, age, gender, ethnicity, BMI for age *z*-score, cognitive function, time spent on TV/mobile, parental education level, left-behind status, primary caregiver's education level and household SES). Adjusted logistic regression models were used to the estimate odds, with 95 % CI, of the prevalence of mental health problems across the sociodemographic subgroups that were significant in the unadjusted logistic regression models. Significance levels were set at a two-tailed *P*-value ≤0·05 for all tests. All analyses were performed using Stata/se 15.1 (Stata Corporation).

Results

No statistically significant difference in DDS, SDQ score or other confounders (preschoolers' age, gender, cognitive ability, parental migration status, primary caregiver's education or household SES) between children who were included in the present analysis and those who were excluded was found. Our main analytical sample included 950 preschoolers for analysis and there were slightly more males (50·4 %) than females (49·6 %) (see Table 2). The mean ages of the male and female participants were 4·02 (1·00) and 4·15 (0·99) years, respectively. There were no significant gender differences found in this study for age, BMI for age *z*-score, cognitive test performance, time spent on TV/mobile, left-behind status, parental or primary caregivers' education and household SES. The mean DDS for boys and girls were 5·79 (SD 1·20) and 5·81 (SD 1·27), respectively, indicating that there was no significant difference in the intrahousehold food allocation between boys and girls. A total of 663 (70 %) children in our sample had at least one mental health problem. The prevalence of mental health problems in the overall sample population was 39 % for emotional symptoms, 12 % for peer relationship problems, 23 % for symptoms of hyperactive/inattention, 27 % for conduct problems and 26 % for poor prosocial behaviour. Our study results indicated that boys were more likely than girls to have emotional problems, symptoms of hyperactivity/inattention and peer relationship problems and less likely to show prosocial behaviour.

In the univariable analyses (see Table 3), 5-year-olds were less likely to have any of the problems listed in the SDQ subscales than younger children. Female gender was associated with a lower likelihood of conduct problems and symptoms of hyperactivity/inattention and a higher likelihood of prosocial behaviour. In addition, those who had poor performance on the working memory index and verbal comprehension index had a higher possibility for the presence of mental health problems than those who performed well. Moreover, left-behind children were more likely to have emotional symptoms than those who were taken care of by both parents at home, but they had fewer conduct problems than non-left-behind children. The results also revealed that children whose primary caregivers had higher education levels tended to be less likely to have emotional symptoms. Interestingly, the results indicated that children from households in the highest SES tertile were more likely to have peer relationship problems than those from households in lower SES tertiles.

The univariable analysis showed significant differences in dietary diversity based on the presence or absence of mental problems, except for emotional problems and conduct problems (see Table 3). In the unadjusted analysis, children with medium and high DDS were less likely to have symptoms of hyperactivity/inattention than children with low DDS. Similarly, children with high DDS were also less likely to have peer relationship problems and prosocial behaviour problems than children with low DDS.

Adjusting for additional confounding variables did not alter our findings. The association between DDS and mental health problems was similar in the unadjusted model and adjusted model (see Table 3). However, the associations of mental health problems with left-behind status were no longer statistically significant in the adjusted model.

Discussion

The mean DDS for a sample of preschoolers in rural China was 5·80 (SD 1·23), which is relatively low compared with

Table 2 Characteristics of the study participants by gender (*n* 950)*

Characteristics	Category	Male (*n* 479)		Female (*n* 471)		*P*
		n	%	*n*	%	
Dietary diversity score	Low (1–4)	75	15·66	67	14·23	0·302
	Medium (5–6)	265	55·32	261	55·41	
	High (7–9)	139	29·02	143	30·36	
Age (years)	3	236	49·27	200	42·46	0·151
	5	243	50·73	271	57·54	
Ethnicity	Han	64	13·36	49	10·40	0·172
	Non-Han	415	86·64	422	89·60	
BMI for age *z*-score	(–2,2)	451	94·15	452	95·97	0·179
	≥2, or ≤–2	28	5·85	19	4·03	
WMI	Normal	369	77·04	376	79·83	0·540
	Borderline	84	17·54	71	15·07	
	Abnormal	26	5·43	24	5·10	
VCI	Normal	331	69·10	324	68·79	0·947
	Borderline	96	20·04	98	20·81	
	Abnormal	52	10·86	49	10·40	
Time spent on TV/mobile	<60 min	163	34·03	169	35·88	0·763
	≥60 min	316	65·97	302	64·12	
Parental education level	Junior high school or below	364	75·99	361	76·65	0·917
	Senior high school or above	115	24·01	110	23·35	
Left-behind status	Both parents at home	140	29·23	137	29·09	0·672
	At least one parent emigrated	339	70·77	334	70·91	
Primary caregiver's education level	Junior high school or below	441	92·07	422	89·60	0·168
	Senior high school or above	38	7·93	49	10·40	
Household SES	Lowest tertile	156	32·57	153	32·48	0·700
	Middle tertile	153	31·94	164	34·82	
	Highest tertile	170	35·49	154	32·70	
Emotional problems	No	286	59·71	296	62·85	0·043
	Yes	193	40·29	175	37·15	
Conduct problems	No	337	70·35	357	70·35	0·308
	Yes	142	29·65	114	24·20	
Symptoms of hyperactivity/inattention	No	358	74·74	373	79·19	0·037
	Yes	121	25·26	98	20·81	
Peer relationship problems	No	413	86·22	420	89·17	0·012
	Yes	66	13·78	51	10·83	
Prosocial behaviour problems	No	334	69·73	371	78·77	0·025
	Yes	145	30·27	100	21·23	

WMI, working memory index; VCI, verbal comprehension index; SES, socio-economic status.
*Sample with complete data on both diet and mental health problems. A total of 1334 caregivers of preschoolers were surveyed at baseline. Those preschoolers with missing data for dietary intake, mental health problems or other confounding variables were excluded. In total, 384 caregivers were excluded from the study and 950 (71 %) were included for further analysis.

the results from other studies among Chinese children[30,31]. The prevalence of mental health problems was 70 % among these children, which is much higher than previous estimates in China[32] and other countries[33,34]. DDS was significantly associated with several mental health problems, including symptoms of hyperactivity/inattention, peer relationship problems and poor prosocial behaviour, after adjustment for confounders.

A potential reason why the mean DDS in this study was lower than that in previous studies is the higher cost and limited accessibility of a diverse diet[35] given the geographical disadvantages of our sampling areas. Similarly, given the poor access to social and educational facilities in the sample areas, the high prevalence of mental health problems among the sample children might be explained by their exposure to negative environmental stress[36]. Older children had a lower risk of each SDQ subscale problem than their younger peers, which was consistent with the results of a study showing that younger children had a higher prevalence of psychological and behavioural problems than older children[37]. A potential reason for the age difference might be that younger children are not as good as older children in dealing with such problems[37]. Child cognitive ability was found to be negatively associated with the risks of mental health problems, which is similar to the finding that having a cognitive delay may place children at risk of having behaviour problems[38]. Other socio-economic risk factors for mental health problems among the study population included left-behind status, primary caregiver education and household SES. Children who had at least one parent who had emigrated were at high risk of having emotional symptoms and conduct problems. The findings from a similar Chinese study showed that left-behind children had more symptoms of hyperactivity and less prosocial behaviour[39]. It is not clear why left-behind status has an impact on different mental health problems in these studies, but the risk of having any kind of mental

Table 3 Dietary diversity and sociodemographic characteristics: association with mental health problems*

	Emotional problems				Conduct problems				Symptoms of hyperactive/inattention				Peer relationship problems				Prosocial behaviour problems			
	Unadjusted OR	95 % CI	Adjusted OR	95 % CI	Unadjusted OR	95 % CI	Adjusted OR	95 % CI	Unadjusted OR	95 % CI	Adjusted OR	95 % CI	Unadjusted OR	95 % CI	Adjusted OR	95 % CI	Unadjusted OR	95 % CI	Adjusted OR	95 % CI
Dietary diversity score																				
Low	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Medium	1·40	1·01, 1·94	1·41	0·98, 2·03	0·98	0·69, 1·38	1·02	0·70, 1·50	**0·58**	**0·36**, **0·92**	**0·57**	**0·34**, **0·94**	0·95	0·49, 1·84	0·83	0·40, 1·72	**0·66**	**0·44**, **0·99**	0·65	0·42, 1·00
High	1·14	0·80, 1·63	1·35	0·91, 2·01	0·87	0·59, 1·28	0·87	0·57, 1·32	**0·48**	**0·27**, **0·86**	**0·23**	**0·15**, **0·34**	**0·69**	**0·50**, **0·91**	**0·40**	**0·20**, **0·82**	**0·32**	**0·16**, **0·67**	**0·29**	**0·12**, **0·73**
Age (years)																				
3	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
5	**0·61**	**0·48**, **0·77**	**0·58**	**0·45**, **0·74**	**0·61**	**0·47**, **0·78**	**0·73**	**0·55**, **0·96**	**0·76**	**0·58**, **0·99**	0·77	0·59, 1·00	**0·58**	**0·41**, **0·83**	0·72	0·49, 1·06	**0·57**	**0·44**, **0·74**	**0·70**	**0·52**, **0·93**
Gender																				
Male	Ref.				Ref.		Ref.		Ref.		Ref.		Ref.				Ref.		Ref.	
Female	1·00	0·81, 1·26			**0·09**	**0·59**, **0·96**	0·77	0·59, 1·01	**0·77**	**0·60**, **0·99**	0·78	0·60, 1·03	0·95	0·69, 1·32			**0·66**	**0·52**, **0·85**	**0·66**	**0·50**, **0·86**
Ethnicity																				
Han	Ref.				Ref.				Ref.				Ref.				Ref.			
Non-Han	1·33	0·92, 1·90			1·16	0·78, 1·70			0·89	0·60, 1·31			1·06	0·63, 1·79			0·80	0·55, 1·15		
BMI for age *z*-score																				
(-2,2)	Ref.				Ref.				Ref.				Ref.				Ref.			
≥2, or ≤−2	1·11	0·65, 1·91			1·52	0·87, 2·63			0·91	0·49, 1·72			1·29	0·62, 2·68			0·79	0·42, 1·49		
WMI																				
Normal	Ref.		Ref.		Ref.		Ref.		Ref.				Ref.		Ref.		Ref.		Ref.	
Borderline	**1·57**	**1·16**, **2·11**	1·38	0·95, 1·98	**1·50**	**1·09**, **2·06**	1·27	0·87, 1·86	1·08	0·77, 1·52			**1·74**	**1·16**, **2·62**	1·37	0·83, 2·26	**1·71**	**1·24**, **2·34**	1·25	0·85, 1·83
Abnormal	1·55	0·93, 2·59	1·54	0·84, 2·80	1·64	0·96, 2·79	1·47	0·81, 2·65	1·24	0·70, 2·18			**2·32**	**1·24**, **4·33**	**2·13**	**1·05**, **4·33**	**1·79**	**1·05**, **3·05**	1·24	0·68, 2·25
VCI																				
Normal	Ref.				Ref.		Ref.		Ref.				Ref.		Ref.		Ref.		Ref.	
Borderline	1·23	0·93, 1·62			**1·37**	**1·01**, **1·85**	1·23	0·88, 1·73	0·98	0·71, 1·35			**1·66**	**1·13**, **2·43**	**1·74**	**1·13**, **2·69**	**1·40**	**1·03**, **1·90**	1·22	0·87, 1·72
Abnormal	1·20	0·83, 1·74			1·59	1·08, 2·33	1·14	0·72, 1·82	1·00	0·65, 1·52			1·35	0·79, 2·28	0·97	0·51, 1·83	**2·05**	**1·40**, **3·00**	**1·67**	**1·06**, **2·63**
Time spent on TV/mobile																				
<60 min	Ref.				Ref.				Ref.				Ref.				Ref.			
≥60 min	0·94	0·75, 1·18			1·12	0·87, 1·44			0·92	0·71, 1·19			1·38	0·97, 1·96			1·09	0·84, 1·41		
Parental education level																				
Junior high school or below	Ref.				Ref.				Ref.				Ref.				Ref.			
Senior high school or above	0·90	0·68, 1·20			0·79	0·58, 1·08			0·97	0·70, 1·34			1·15	0·77, 1·71			0·84	0·61, 1·16		
Left-behind status																				
Both parents at home	Ref.		Ref.		Ref.		Ref.		Ref.				Ref.				Ref.			
At least one parent emigrated	**1·32**	**1·03**, **1·69**	1·29	0·97, 1·71	**0·70**	**0·54**, **0·91**	0·78	0·59, 1·04	0·90	0·69, 1·19			1·06	0·75, 1·52			1·18	0·90, 1·54		
Primary caregiver's education																				
Junior high school or below	Ref.		Ref.		Ref.				Ref.				Ref.				Ref.			
Senior high school or above	**0·54**	**0·35**, **0·84**	**0·53**	**0·32**, **0·88**	1·10	0·72, 1·68			1·17	0·75, 1·83			1·08	0·61, 1·91			0·87	0·55, 1·37		
Household SES																				
Lowest tertile	Ref.		Ref.		Ref.				Ref.				Ref.		Ref.		Ref.			
Middle tertile	0·86	0·66, 1·13	0·88	0·65, 1·18	1·19	0·89, 1·59			1·02	0·75, 1·38			1·11	0·73, 1·69	1·37	0·85, 2·22	0·90	0·67, 1·21		
Highest tertile	**0·64**	**0·49**, **0·84**	**0·68**	**0·50**, **0·92**	0·81	0·60, 1·09			0·96	0·71, 1·31			**1·64**	**1·11**, **2·23**	**2·03**	**1·29**, **3·21**	1·00	0·74, 1·34		

WMI, working memory index; VCI, verbal comprehension index; SES, socio-economic status.
Bold values represent they are statistically significant.
*Adjusted means for sociodemographic variables that were significant in the unadjusted logistic regression models.

health problem may vary for children exposed to distinct environmental stressors.

The presence of mental health problems was higher among boys than girls, which is consistent with a study in Sichuan, China[32], and studies among children at similar ages but from other cultures[35,36]. Male preschoolers were shown to be more vulnerable to emotional symptoms, symptoms of hyperactivity/inattention, peer relationship problems and poor prosocial behaviour, which is partially consistent with studies showing that boys have a higher risk of having conduct problems and symptoms of hyperactivity/inattention[35,36]. However, the results from a previous study showed no indications of gender differences at preschool age[40], which contradicted our findings.

Recent studies have mainly focused on the relationship between dietary patterns or quality and mental health problems[22,23]. For example, a British study linked an unhealthy dietary pattern (e.g. junk food consumption) with hyperactivity among children[22]. Another Germany study indicated that higher diet quality was related to fewer emotional symptoms and symptoms of hyperactivity/inattention[23]. These findings all provide evidence that dietary diversity, as a key element of a healthy diet and a proxy of diet quality, has an independent impact on mental health. Regarding the association between DDS and mental health problems, there are many potential biological mechanisms by which a varied diet promotes mental health in children[41]. First, dietary diversity may reflect diet quality and nutritional adequacy among children[42], which have been linked with mental health issues. For example, the intake of multiple nutrients, such as Zn, folate and Mg, is related to fewer depressive disorders[43]. Second, a poor diet may negatively impact human biological functioning, including oxidative processes, immune response and levels of salient brain proteins, all of which might elicit mental health problems[42].

This study makes a notable contribution. To the best of our knowledge, this study is the first to examine the relationship between dietary diversity and child mental health. Existing studies have paid much attention to the role of diet quality or a healthy diet in promoting mental health, while few studies have focused on the role of dietary diversity. This study provided evidence that a varied diet is related to a lower likelihood of symptoms of hyperactivity/inattention, peer relationship problems and prosocial behaviour problems among young children and thus is very likely to be taken into account for designing interventions.

However, our study has several limitations. First, the causal relationship between the DDS and mental health could not be determined because of the cross-sectional design. Since children with behavioural problems tend to consume less varied diets, especially diets with fewer servings of fruits and vegetables[25], the possibility of reverse causality cannot be excluded. Second, information about some potential confounders, such as child physical activity, total energy intake, household food security and family financial stress, was not obtained due to data unavailability or difficulty for measurement. Therefore, the relationship between DDS and mental health problems in the present study might have been driven by these confounding effects.

Conclusion

The prevalence of mental health problems was relatively high in this study. More attention should be paid to rural, poor areas where children are more likely to have mental illness. Improving child dietary diversity might be an important strategy to consider in the design of interventions to improve child mental health in poor rural areas. The possible causal effect of dietary diversity on child mental health and the mechanism involved should be examined in future prospective studies.

Acknowledgements

Acknowledgements: The authors would like to thank to the staff of the World Food Program China Office at the time the study was performed, especially Mr. Sixi Qu, Ms. Caroline Legros, Ms. Han Jiang and Ms. Jingyi Liu for their role in mobilising the preschool nutrition programme and facilitating the data collection process. *Financial support:* This research was supported by the National Natural Science Foundation of China (grant nos. 71861147003 and 71925009), the IFPRI Research Project (no. 602174.002.001) funded by the World Food Programme and the China Postdoctoral Science Foundation (grant no. 2019M650361). *Conflict of interest:* The authors declare that there are no conflicts of interest. *Authorship:* K.C., C.L., J.B. and R.L. designed the research. S.L. analysed the data and drafted the paper with contributions from Z.H., C.L., Y.Y. and Z.W. All the authors read and approved the final manuscript. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the International Food Policy Research Institute Institutional Review Board (IRB) (DSG-18-0837). Written informed consent was obtained from all legal guardians of children and school staff involved in the study.

References

1. Kessler RC, Angermeyer M, Anthony JC *et al.* (2007) Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry* **6**, 168–176.

2. Kieling C, Baker-Henningham H, Belfer M *et al.* (2011) Child and adolescent mental health worldwide: evidence for action. *Lancet* **378**, 1515–1525.
3. Bao P, Jing J, Jin Y *et al.* (2016) Trajectories and the influencing factors of behavior problems in preschool children: a longitudinal study in Guangzhou, China. *BMC Psychiatry*. Published online: 01 June 2016. doi: 10.1186/s12888-016-0864-z.
4. Trautmann S, Rehm J & Wittchen H (2016) The economic costs of mental disorders. EMBO Rep 17, 1245–1249.
5. U.S. Department of Health and Human Services, Health Resources and Services Administration & Maternal and Child Health Bureau (2011) *The Health and Well-Being of Children in Rural Areas: A Portrait of the Nation 2007*. Rockville, Maryland.
6. Liu Z, Li X & Ge X (2009) Left too early: the effects of age at separation from parents on Chinese rural children's symptoms of anxiety and depression. *Am J Public Health* **99**, 2049–2054.
7. Fazel M, Hoagwood K, Stephan S *et al.* (2014) Mental health interventions in schools in high-income countries. *Lancet* **1**, 377–387.
8. O'Connell ME, Boat T & Warner KE (2009) *Preventing Mental, Emotional, and Behavioral Disorders Among Young People: Progress and Possibilities*, Vol. 7. Washington, DC: National Academies Press.
9. Jacka FN, Kremer PJ, Berk M *et al.* (2011) A prospective study of diet quality, mental health in adolescents. *PLoS ONE*. Published online: 21 September 2011. doi: 10.1186/s12888-016-0864-z.
10. Khalid S, Williams CM & Reynolds SA (2016) Is there an association between diet and depression in children and adolescents? A systematic review. *Br J Nutr* **116**, 2097–2108.
11. Oellingrath IM, Svendsen MV & Hestetun I (2014) Eating patterns and mental health problems in early adolescence – a cross-sectional study of 12–13-year-old Norwegian schoolchildren. *Public Health Nutr* **17**, 2554–2562.
12. Sánchez-Villegas A, Delgado-Rodríguez M, Alonso A *et al.* (2009) Association of the Mediterranean dietary pattern with the incidence of depression: the Seguimiento Universidad de Navarra/University of Navarra follow-up (SUN) cohort. *Arch Gen Psychiatry* **66**, 1090–1098.
13. Arimond M & Ruel MT (2004) Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *J Nutr* **134**, 2579–2585.
14. Hatløy A, Torheim LE & Oshaug A (1998) Food variety – a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *Eur J Clin Nutr* **52**, 891–898.
15. Azadbakht L & Esmaillzadeh A (2011) Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Public Health Nutr* **14**, 62–69.
16. Poorrezaeian M, Siassi F, Qorbani M *et al.* (2015) Association of dietary diversity score with anxiety in women. *Psychiatry Res* **230**, 622–627.
17. Poorrezaeian M, Siassi F, Milajerdi A *et al.* (2017) Depression is related to dietary diversity score in women: a cross-sectional study from a developing country. *Arch Gen Psychiatry*. Published online: 16 November 2017. doi: 10.1186/s12991-017-0162-2.
18. Jiang W, Mo M, Li M *et al.* (2018) The relationship of dietary diversity score with depression and anxiety among prenatal and post-partum women. *J Obstet Gynaecol Res* **44**, 1929–1936.
19. Goodman R (1997) The strengths and difficulties questionnaire: a research note. *J Child Psychol Psychiatry* **38**, 581–586.
20. Goodman R (2001) Psychometric properties of the strengths and difficulties questionnaire. *J Am Acad Child Adolesc Psychiatry* **40**, 1337–1345.
21. Du Y, Kou J & Coghill D (2008) The validity, reliability and normative scores of the parent, teacher and self report versions of the Strengths and Difficulties Questionnaire in China. *Child Adolesc Psychiatry Ment Health*. Published online: 29 April 2008. doi: 10.1186/1753-2000-2-8.
22. Wiles NJ, Northstone K, Emmett P *et al.* (2007) 'Junk food' diet and childhood behavioural problems: results from the ALSPAC cohort. *Eur J Clin Nutr* **63**, 491–498.
23. Kohlboeck G, Sausenthaler S, Standl M *et al.* (2012) Food intake, diet quality and behavioral problems in children: results from the GINI-plus/LISA-plus studies. *Ann Nutr Metab* **60**, 247–256.
24. Thabet A, Stretch D & Vostanis P (2000) Child mental health problems in arab children: application of the strengths and difficulties questionnaire. *Int J Soc Psychiatry* **46**, 266–280.
25. Renzaho AM, Kumanyika S & Tucker KL (2010) Family functioning, parental psychological distress, child behavioural problems, socio-economic disadvantage and fruit and vegetable consumption among 4-12 year-old Victorians, Australia. *Health Promot Int* **26**, 263–275.
26. Deater-Deckard K, Wang Z, Chen N *et al.* (2012) Maternal executive function, harsh parenting, and child conduct problems. *J Child Psychol Psychiatry* **53**, 1084–1091.
27. Kennedy G, Ballard T & Dop MC (2013) *Guidelines for Measuring Household and Individual Dietary Diversity*. Rome: Food and Agriculture Organization of the United Nation.
28. Bi J, Liu C, Li S *et al.* (2019) Dietary diversity among preschoolers: a cross-sectional study in poor, rural, and ethnic minority areas of Central South China. *Nutrients*. Published online: 6 March 2019. doi: 10.3390/nu11030558.
29. Morseth MS, Grewal NK, Kaasa IS *et al.* (2017) Dietary diversity is related to socioeconomic status among adult Saharawi refugees living in Algeria. *BMC Public Health*. Published online: 03 July 2017. doi: 10.1186/s12889-017-4527-x.
30. Meng L, Wang Y, Li T *et al.* (2018) Dietary diversity, food variety in Chinese children aged 3–17 years: are they negatively associated with dietary micronutrient inadequacy? *Nutrients*. Published online: 5 November 2018. doi: 10.3390/nu10111674.
31. Jiang H, Zhao A, Zhao W *et al.* (2018) Do Chinese preschool children eat a sufficiently diverse diet? A cross-sectional study in China. *Nutrients*. Published online: 20 June 2018. doi: 10.3390/nu10060794.
32. Qu Y, Jiang H, Zhang N *et al.* (2015) Prevalence of mental disorders in 6–16-year-old students in Sichuan Province, China. *Int J Environ Res Public Health* **12**, 5090–5107.
33. Kovess-Masfety V, Husky MM, Keyes K *et al.* (2016) Comparing the prevalence of mental health problems in children 6–11 across Europe. *Soc Psychiatry Psychiatr Epidemiol* **51**, 1093–1103.
34. Kashala E, Elgen I, Sommerfelt K *et al.* (2005) Teacher ratings of mental health among school children in Kinshasa, Democratic Republic of Congo. *Eur Child Adolesc Psychiatry* **14**, 208–215.
35. Liu J, Shively GE & Binkley JK (2014) Access to variety contributes to dietary diversity in China. *Food Policy* **49**, 323–331.
36. Elberling H, Linneberg A, Olsen EM *et al.* (2010) The prevalence of SDQ-measured mental health problems at age 5–7 years and identification of predictors from birth to preschool age in a Danish birth cohort: the Copenhagen Child Cohort 2000. *Eur Child Adolesc Psychiatry* **19**, 725–735.

Public Health Nutrition

37. Hu H, Lu S & Huang C (2014) The psychological and behavioral outcomes of migrant and left-behind children in China. *Child Youth Serv Rev* **46**, 1–10.
38. Cheng E, Palta M, Kotelchuck M *et al.* (2014) Cognitive delay and behavior problems prior to school age. *Pediatrics* **134**, e749–e757.
39. Fan F, Su L, Gill MK *et al.* (2009) Emotional and behavioral problems of Chinese left-behind children: a preliminary study. *Soc Psychiatry Psychiatr Epidemol* **45**, 655–664.
40. Campbell SB (1995) Behavior problems in preschool children: a review of recent research. *J Child Psychol Psychiatry* **36**, 113–149.
41. O'Neil A, Quirk SE, Housden S *et al.* (2014) Relationship between diet, mental health in children, adolescents: a systematic review. *Am J Public Health*. Published Online: 10 September 2014. doi: 10.2105/ajph.2014.302110.
42. Hatløy A, Torheim L & Oshaug A (1998) Food variety – a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *Eur J Clin Nutr* **52**, 891–898.
43. Jacka FN, Maes M, Pasco JA *et al.* (2012) Nutrient intakes and the common mental disorders in women. *J Affect Disorders* **141**, 79–85.

Public Health Nutrition