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The dietary diversity and stunting prevalence in minority children under 3 years old: a cross-sectional study in forty-two counties of Western China

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Abstract

As a key indicator of childhood malnutrition, few studies have focused on stunting in relation to various socio-economic factors in which disadvantaged groups face in China. We conducted a community-based cross-sectional study incorporating forty-two rural counties in seven western provinces of China in 2011. In total, 5196 children aged 6–23 months were included. We used Poisson regression to examine risk factors for inadequate minimum dietary diversity (MDD) and stunting status, respectively. Overall, the proportion of children not meeting MDD was 44·5 %. Children aged 6–11 months (adjusted risk ratio (ARR) = 1·39; 95 % CI 1·31, 1·49), with two siblings (ARR = 1·09; 95 % CI 1·02, 1·17), delivered at home (ARR = 1·30; 95 % CI 1·20, 1·41), within Yi (ARR = 1·15; 95 % CI 1·04, 1·28) or Uighur groups (ARR = 1·52; 95 % CI 1·36, 1·71), with an illiterate caregiver (ARR = 2·12; 95 % CI 1·52, 2·96), receiving lowest income (ARR = 1·32; 95 % CI 1·17, 1·50), and with breast-feeding in the last day (ARR = 1·55; 95 % CI 1·44, 1·66) were more likely to have inadequate MDD. Moreover, inadequate MDD was positively associated with stunting (ARR = 1·15; 95 % CI 1·01, 1·31). Other determinants for stunting were age, sex, place of delivery, minority group and income. The stunting prevalence and proportion of inadequate MDD remained high in Western China; to reduce stunting rates of ethnic minorities, further efforts addressing appropriate dietary feeding practices are needed, especially within these groups.

Key words: **Dietary diversity: Complementary feeding: Stunting prevalence: Minority groups**

In past decades, monumental progress has been made on under-5 year child mortality reduction in China. The under-5-children-mortality rate was mitigated by 78 %, from 79·2/1000 live births in 1991 to 10·7/1000 live births in 2015; this improvement led the country to achieve the Millennium Development Goal 4 ahead of schedule[1,2]. In addition to substantial improvement regarding childhood survival status, there has been a significant increase of attention by both the government of China and the global community in regard to achieving early childhood development goals over the past years[3,4]. Globally there are over 250 million children, of that number the 17·43 million that live in China were estimated to be unable to fulfil their full potential due to multiple adversities which can be marked by the lack of adequate nutrition, poor health or stimulation, inadequate nurturing, and perilous environments according to the newly released *Lancet* series[5,6].

Maternal and child nutrition status plays an important role in infant morbidity, early development and even long-term health; childhood stunting is the foundational cause of poor cognition, low adult wages and lost productivity later in life[7]. The 65th World Health Assembly set a target that by the year of 2025, the stunting prevalence of children under 5 years should be mitigated by 50 % as compared with the baseline in 2010 established by the World Health Organization[8]. Globally, approximately 171 million children under the age of 5 years had some sort of stunting that affected their development[9]. Previous studies have shown that the stunting prevalence inequality among different populations is attributed to social, economic and

Abbreviations: MDD, minimum dietary diversity; RR, risk ratio.

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political determinants[7,10]. Among all risk factors, feeding practices has the most direct impact upon childhood stunting. More so, appropriate interventions on the modification of feeding practices has been proved to be effective[11,12].

The significant inequities on under 5-year child survival situations among different regional populations and ethnic minority groups in China have been recognised at the national level[1]. Some regional studies report that the stunting rate among minorities was higher than the Han's, which is the major ethnic group in China[13–16]. In addition to the socio-economic disparities, ethnic minorities have various culture and religious beliefs; therefore, these fundamental roles may dictate their feeding patterns and which may differ from the Han's dietary practices. For example, a previous study within Tibet suggested that unbalanced diets may be linked to a greater stunting prevalence in Tibetan children living at a higher altitude[17]. Moreover, Uygur mothers were unlikely to feed their children breast milk exclusively within the first 6 months; this is due to the traditional belief that breast milk was inadequate for the growth of children[18]. Tibetan mothers were also inclined to introduce water early as following their ethnic tradition[19]. Although some studies have reported breast-feeding practices of the Chinese ethnic minorities, limited studies focused on complementary food diversity of children and the influence of different dietary patterns on the growth of children. To further support interventions on mitigating stunting in poor and remote minority areas, it is first necessary to understand the current prevalence of stunting and its numerous risk factors. Therefore, we conducted a population-based study in forty-two rural counties in the western provinces of China; these areas accounted for most of China's ethnic minorities as well as the most resource limited region in China. Our study methods were designed to identify the association between complementary dietary diversity and infant stunting, especially the impact for children of various ethnic groups and their respective varying dietary patterns.

Methods

Study design and setting

This study was a cross-sectional baseline survey on feeding practices and child growth in 2011, covering forty-two rural counties in seven western provinces of China (Gansu, Qinghai, Xinjiang, Sichuan, Guizhou, Yunnan and Tibet), as part of maternal and child health (MCH) programme funded by UNICEF and the National Health And Family Planning Commission Of China (NHFPC). Counties were selected by NHFPC and UNICEF as programme counties due to their poor socio-economic development in addition to low MCH performance. Under-5 mortality rates were higher in surveyed counties (up to 21·1/1000 live births) as compared with the national average of 16·4/1000 live births in 2010; the per capita income of 3239 RMB within these forty-two counties were below the national average 5919 RMB in 2010[20]. The Ethical Committee of Peking University Health Science Centre approved this study.

A multistage sampling method was employed to select townships and villages in each county. First, fifteen administrative villages per county and two nature villages per administrative village were selected at random with population proportional to size. Within each selected nature village, ten households with children under 3 years of age were selected according to a full registration list for each village by simple random sampling; the list of children was provided by local village doctors. Random numbers for selection criteria were generated by a random number table, and staff members of this programme completed all the sampling processes. In sparsely populated Tibet, only two or three households with children under 3 years were randomly sampled and selected in each nature village. The youngest children and their caregivers in each selected household were interviewed face-to-face.

Because this study was designed to collect relevant baseline data for a childhood intervention project, we expected to see a decrement in stunting prevalence in the final evaluation. The following formula was used to calculate the sample size:

$$n = 2\overline{pq}\left(Z_\alpha + Z_\beta\right)^2 \Big/ \left(p_1 - p_0\right)^2,\ \overline{p} = \left(p_1 + p_0\right)/2, \overline{q} = 1 - \overline{p}.$$

We used 0·05 as the statistical significance (α) and set the power of the test ($1-\beta$) as 0·8. We assumed the baseline stunting prevalence (p_0) would be 50 % and expected a relative 20 % decrement of stunting prevalence ($p_1 - p_0)/p_0$. Finally, in consideration of a design effect of 2 and with an 80 % response rate, the needed total sample size of children would be 1944 (972:972).

Data collection

A structured questionnaire for caregivers was provided in our survey. Items in the questionnaire were selected from 'Multiple Indicator Cluster Survey' manual published by UNICEF[21]. The dietary intake diversity assessment involved seven foods groups: (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products (milk, yogurt and cheese), (4) flesh foods (meat, fish, poultry and liver/organ meats), (5) eggs, (6) vitamin A-rich fruits and vegetables and (7) other fruits and vegetables. Data on dietary intake for the children 24 h before the survey were obtained through caregivers' recall. The questionnaire also included questions on the socio-economic characteristics of the household (ethnicity, education of the caregivers and income) and on the age, sex, birth order and place of delivery of the children.

Length (for children aged 0–23 months) and height (for children aged 24–35 months) were measured by two anthropometrists in each sampled village. Each measurement was performed twice and the average of both dimensions were used in the analysis. All anthropometrists underwent a systemic standardised anthropometric training before the study and followed the unified anthropometry manuals for consistent results. All village study sites used the same high-precision measuring equipment. Length was measured to the nearest 0·1 cm with the WB-B Length Meter (Wujin Weighing Apparatus Factory). Height was measured to the nearest 0·1 cm with the SH-2B Stadiometer (Wujin Weighing Apparatus Factory). Data collection was monitored for quality control by the Peking University/UNICEF team in fourteen counties and by staff from the local health bureau or the MCH hospitals in twenty-eight counties. All data collected were entered as dual replicates into a database.

Statistical analysis

WHO 2006 Child Growth Standard, length/height-for-age *z* scores (HAZ) was used as an evaluation standard of stunting status as recommended by WHO[22]. All children with *z* score of HAZ below 2 were defined as stunted within our study. The minimum dietary diversity (MDD) was selected from 'Indicators for assessing infant and young child feeding practices' published by WHO in 2008 as a core indicator in our study for accessing complementary feeding practice[23]. WHO guidelines implied that MDD was defined as 'receiving foods from 4 or more food groups 24 h previous to the survey was given'[23]. We also use the term 'inadequate MDD' to refer to children who did not achieve the recommended MDD in the following context.

Within our study, thirty-two different ethnic groups were reported and ethnicity was categorised as either Han or other minority groups (Yi, Tibetan, Miao and other ethnics). Additional covariates include sex of children (male and female), age of the child, birth order of children (1, 2, 3 or more), caregiver's education (illiterate, primary school, secondary school, college and above), place of delivery (county hospital, township hospital or at home), income (poorest, poor, middle, richer and richest) and breast-feeding during the previous day (yes/ no).

As the MDD index is generally targeted for infants under the age of 2 years, we restricted our study population to children aged 6–23 months for the final analyses[8]. Socio-economic characteristic distributions were calculated and compared between children within the Han and minority groups using chi-square tests. Socio-economic determinants of inadequate MDD and stunting were examined with Poisson regression; all were weighed for the variation in the sampling distribution of a population of children 6–23 months across counties. Both crude, adjusted relative risks and 95 % CI reports were adjusted for the child's sex, age, birth order, ethnicity of the caregiver, caregiver's education, the place of birth, income, breast-feeding during the previous day and MDD (only for stunting). We also calculated and compared the frequencies of each types of complementary foods consumptions among different ethnic groups and by different age groups. All analyses were conducted using STATA version 13.0.

Results

Samples description

In our survey, a total of 8964 children aged under 5 years were interviewed. The present study included 5196 children aged 6–23 months; among them, 53·1 % were males and 53·8 % were the first baby for their parents. A total of 31·5 % of children's caregivers were illiterate, and 23·8 % children were delivered at their home, as shown in Table 1. Among all children belonging to various proportions of ethnic groups there were 38·0 % Han, 13·8 % Yi, 13·0 % Tibetan, 8·6 % Uighur and 26·5 % belonged to other minority groups. The distributions of various age groups were similar in different ethnic groups ($P = 0{\cdot}234$). Slight differences in child sex distribution showed variation between different ethnic groups ($P < 0{\cdot}05$). For caregiver's education, 68·7 % of the Yi and 58·5 % of the Tibetan groups were illiterate; in contrast, the prevalence of illiteracy was only 22·2 and 3·4 % among the Han and Uighur groups, respectively. Different ethnic groups also showed disparity based on the place of delivery. For example, 19·6 % of the Yi children were delivered at a county level hospital, this proportion was higher in the Tibetan (49·9 %), Uighur (67·2 %) and Han children (73·1 %). Moreover, the income level in Han group had a relatively balanced distribution, whereas the other ethnic groups had more households belonged to the poorest or poor quintiles of income (Han: 37·0 %, Yi: 72·5 %, Tibetan: 50·0 %, Uighur: 48·8 %, $P < 0{\cdot}001$). The Han group also had less of the proportion of breast-feeding during the previous day as compared with other minorities (Han: 37·3 %, Yi: 65·5 %, Tibetan: 40·1 %, Uighur: 55·6 %, $P < 0{\cdot}001$), as shown in Table 1.

Minimum dietary diversity

Table 2 showed the bivariate and multivariate regression output of risk factors associated with an inadequate MDD. Among children within the age groups of 6–23 months in our study, 44·5 % of them did not achieve the MDD. Among all ethnic groups, the Yi minority had the poorest performance with 73·1 % of children not reaching MDD. The Uighur and Tibetan groups also had a relatively high probability of not receiving the MDD in their daily meals, as compared with the Han children. The variations of inadequate MDD differed by age, birth order of children, caregiver's education level, place of delivery, income and breast-feeding during the previous day were also significant. Children aged 6–11 months had a higher proportion of inadequate MDD as compared with older children (58·6 *v.* 36·1 %, adjusted risk ratio (RR) = 1·39). Children with a birth order of being third or greater had a higher proportion of the inadequate MDD in comparison to first born children (65·9 *v.* 38·2 %, adjusted RR = 1·07). Children with illiterate caregivers had the highest probability of inadequate MDD (58·8 %) in comparison with other caregivers with higher education levels. In addition, children from the poorest quintile families who were delivered at home had a significant positive association with poor performance on dietary diversity, with adjusted RR of 1·32 and 1·30, respectively. No significant difference of dietary diversity was found between male and female children.

Further analysis on types of complementary foods found that 91·2 % of children received grains, roots and tubers during the previous day of survey, as shown in Fig. 1. More than half of children received dairy products (57·4 %), flesh foods (54·2 %), vitamin A-rich fruits and vegetables (57·1 %) and other fruits and vegetables (57·9 %), respectively. Only 34·3 % of children had eggs intake and only 15·9 % of children received legumes and nuts. When comparing variation of these types of complementary foods by ethnic groups as compared with other, it was found that the Yi group had a lower consumption of every kind of complementary foods, especially dairy products (Yi *v.* Han = 19·5 *v.* 62·9 %, $P < 0{\cdot}001$), eggs (Yi *v.* Han = 25·1 *v.* 43·6 %, $P < 0{\cdot}001$), vegetables and fruits (Yi *v.* Han = 41·6 *v.* 71·8 %, $P < 0{\cdot}001$). The Uighur ethnic also showed similar results with most types of complementary foods intake; the only exceptions were for flesh foods (68·5 %), and non-vitamin A-rich fruits and vegetables (61·6 %). Tibetan children tend to have a greater

Table 1. Socio-demographic characteristics among children aged 6–23 months with Han and ethnic groups in forty-two counties in Western China (2011) (Numbers and percentages)

	Total		Han		Yi		Tibetan		Uighur		Other			
	5196		1977		718		674		448		1379			
Characteristics	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	χ^2	*P*
Age of child (months)													5·563	0·234
6–11	1938	37·3	706	35·7	271	37·7	253	37·5	162	36·2	546	39·6		
12–23	3258	62·7	1271	64·3	447	62·3	421	62·5	286	63·8	833	60·4		
Sex of child													10·362	<0·05
Male	2747	53·1	1066	54·2	356	49·6	333	49·4	236	53·2	756	55·1		
Female	2429	46·9	901	45·8	362	50·4	341	50·6	208	46·8	617	44·9		
Birth order of child													817·350	<0·001
1	2698	53·8	1163	60·5	194	27·1	372	55·4	219	53·4	750	57·9		
2	1640	32·7	623	32·4	188	26·3	239	35·6	137	33·4	453	35·0		
≥3	675	13·5	135	7·0	333	46·6	60	9·0	54	13·2	93	7·2		
Caregiver's education													1180·136	<0·001
Illiteracy	1632	31·5	438	22·2	492	68·7	394	58·5	15	3·4	293	21·3		
Primary	1452	28·0	590	29·9	155	21·6	181	26·9	103	23·1	423	30·7		
Secondary	1950	37·6	885	44·8	69	9·6	73	10·8	315	70·6	608	44·2		
College and above	152	2·9	61	3·1	0	0·0	26	3·9	13	2·9	52	3·8		
Place of delivery													1624·145	<0·001
County hospital	3135	61·7	1408	73·1	140	19·6	332	49·9	291	67·2	964	71·7		
Township hospital	714	14·6	282	14·6	21	2·9	77	11·6	123	28·4	238	17·7		
At home	1208	23·8	237	12·3	554	77·5	256	38·5	19	4·4	142	10·6		
Postpartum visit													258·694	<0·001
Yes	2072	42·8	843	45·7	112	16·9	269	43·2	151	36·3	697	53·9		
No	2767	57·2	1002	54·3	549	83·1	354	56·8	265	63·7	597	46·1		
Income													369·375	<0·001
Poorest	1234	23·9	373	19·0	303	42·9	155	23·0	85	19·0	318	23·1		
Poor	1157	22·4	352	18·0	209	29·6	182	27·0	133	29·8	281	20·4		
Middle	967	18·7	369	18·8	95	13·5	154	22·8	97	21·7	252	18·3		
Richer	989	19·2	448	22·9	60	8·5	98	14·5	86	19·2	297	21·6		
Richest	815	15·8	418	21·3	39	5·5	85	12·6	46	10·3	227	16·5		
Breast-feeding during the previous day													189·362	<0·001
Yes	2148	44·4	683	37·3	442	65·5	250	40·1	238	55·6	535	41·8		
No	2692	55·6	1150	62·7	233	34·5	373	59·9	190	44·4	746	58·2		

intake of dairy products in comparison to other ethnic groups (Tibetan *v.* Han = 75·1 *v.* 62·9 %, $P < 0·001$), but generally have a lower intake of legumes and nuts (Tibetan *v.* Han = 12·3 *v.* 26·4 %, $P < 0·001$), eggs (Tibetan *v.* Han = 25·9 *v.* 43·6 %, $P < 0·001$), fruits and vegetables (Tibetan *v.* Han = 52·5 *v.* 69·8 %, $P < 0·001$). After stratification by age groups, the consumption of all types of foods by different ethnic groups were higher among children aged 12–23 months as compared with children aged 6–11 months, except for the consumption of dairy products within the Yi and Uighur groups. Moreover, the Han children showed higher consumption rates of nearly every types of food and had more children achieved MDD than other ethnicities, in both the 6–11 and 12–23 months groups.

Stunting

As shown in Table 3, the overall prevalence of stunting in surveyed areas was 17·8 %. The prevalence of stunting among children aged 12–23 months is nearly twice as much in comparison with children aged 6–11 months (21·8 *v.* 11·1 %, adjusted RR = 2·10). Young males appear to have a higher prevalence of stunting in comparison with their female counterparts (20·8 *v.* 14·3 %, adjusted RR = 1·44). Based on the multivariate analysis, elder aged males delivered at home and from a poor family with a low income were found to be significantly associated with the child's stunting. In addition, there were significant statistical associations between individual ethnic groups and stunting. The Yi, Tibetan and Uighur's children had 1·25, 1·29 and 1·72 times greater risk of stunting in contrast to children from the Han minority, respectively. Table 3 also examined the association between MDD and stunting. After adjusting for all other factors, children who did not achieve the MDD had a 1·15 times greater risk of stunting in comparison with those who received the recommended dietary intake. The gap of stunting prevalence among different ethnic groups was large. For the Han group, only 14·9 % children were stunted, whereas the prevalence for the Yi, Tibetan and Uighur children were 26·5, 20·3 and 24·6 %, respectively.

Discussion

Timely and adequate management of complementary diets are necessary for infants aged 6 months and older; breast-feeding exclusively is insufficient to fulfil a child's nutrition requirements. However to date, socio-economics situations have been known to limit dietary diversity among children in China, especially for those who reside in poorer western regions. Our research showed that 44·5 % of children aged 6–23 months in

Table 2. Relative risks of inadequate minimum dietary diversity among children aged 6–23 months in forty-two counties of Western China (2011) (Percentages, relative risks and 95 % confidence intervals)

Characteristics	*N*	*n*	%	95 % CI	Crude RR	95 % CI	Adjusted RR*	95 % CI
Overall	5169	2868	44·5	43·2, 45·9				
Age of child (months)								
6–11	1933	801	58·6	56·4, 60·8	1·62	1·52, 1·71	1·39	1·31, 1·49
12–23	3236	2067	36·1	34·5, 37·8	1		1	
Sex of child								
Male	2732	1503	45·0	43·1, 46·9	1·01	0·95, 1·08	1·03	0·97, 1·09
Female	2418	1350	44·2	42·2, 46·1	1		1	
Birth order of child								
1	2682	1658	38·2	36·3, 40·0	1		1	
2	1637	865	47·2	44·7, 49·6	1·23	1·15, 1·32	1·09	1·02, 1·17
≥3	671	229	65·9	62·3, 69·5	1·72	1·60, 1·85	1·07	0·98, 1·16
Caregiver's education								
Illiteracy	1630	672	58·8	56·4, 61·2	2·86	2·08, 3·93	2·12	1·52, 2·96
Primary	1445	820	43·3	40·7, 45·8	2·10	1·53, 2·89	1·72	1·24, 2·40
Secondary	1932	1249	35·4	33·2, 37·5	1·72	1·25, 2·37	1·47	1·06, 2·05
College and above	151	120	20·5	14·1, 27·0	1		1	
Ethnic group								
Han	1973	1284	34·9	32·8, 37·0	1		1	
Yi	717	193	73·1	69·8, 76·3	2·09	1·94, 2·25	1·15	1·04, 1·28
Tibetan	674	329	51·2	47·4, 55·0	1·46	1·33, 1·61	1·09	0·99, 1·21
Uighur	438	197	55·0	50·4, 59·7	1·57	1·42, 1·74	1·52	1·36, 1·71
Others	1367	865	36·7	34·2, 39·3	1·05	0·95, 1·15	0·99	0·90, 1·09
Place of delivery								
County hospital	3118	1984	36·4	34·7, 38·1	1		1	
Township hospital	736	423	42·5	39·0, 46·1	1·16	1·06, 1·28	1·02	0·93, 1·13
At home	1206	404	66·5	63·8, 69·2	1·82	1·71, 1·94	1·30	1·20, 1·41
Income								
Poorest	1230	531	56·8	54·1, 59·6	1·86	1·66, 2·08	1·32	1·17, 1·50
Poor	1147	560	51·2	48·3, 54·1	1·67	1·49, 1·88	1·33	1·18, 1·51
Middle	962	559	41·9	38·8, 45·0	1·37	1·20, 1·56	1·17	1·03, 1·33
Richer	983	636	35·3	32·3, 38·3	1·15	1·01, 1·32	1·05	0·91, 1·20
Richest	813	565	30·5	27·3, 33·7	1		1	
Breast-feeding during the previous day								
Yes	2136	835	60·9	58·8, 63·0	1·95	1·83, 2·09	1·55	1·44, 1·66
No	2680	1846	31·1	29·4, 32·9	1		1	

* Adjusted for all the variables in Table 2.

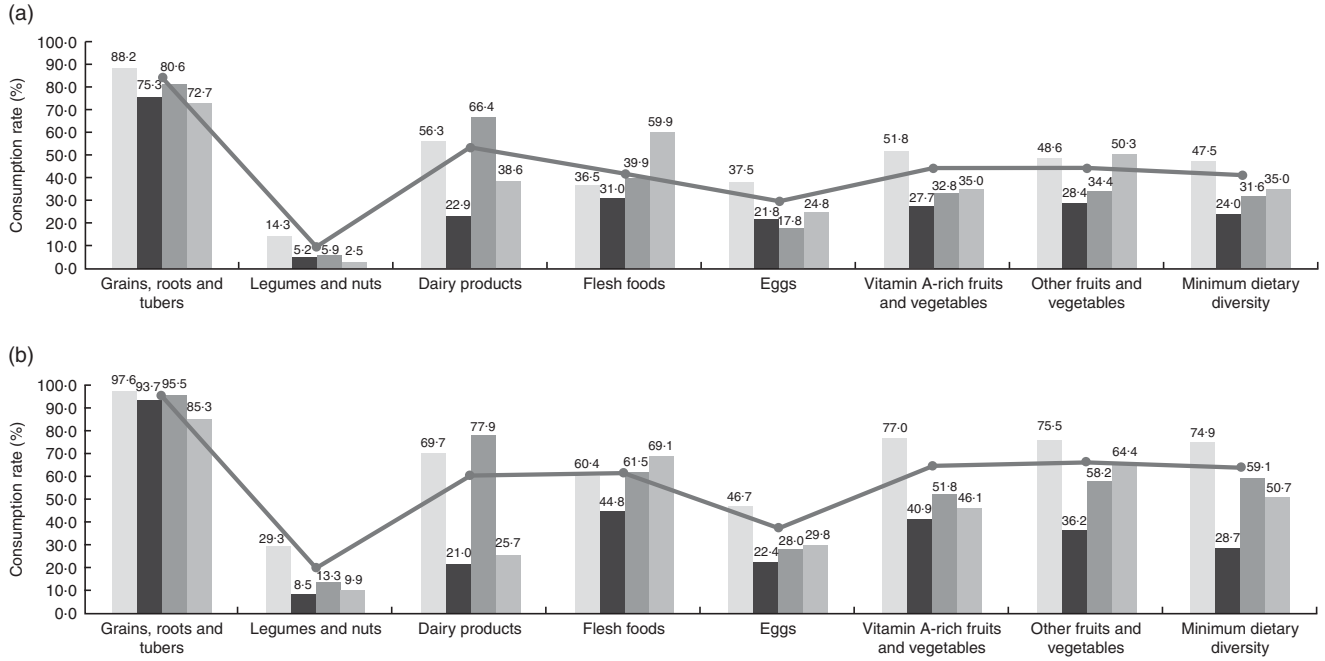

Fig. 1. Comparison of complementary food diversity among children aged (a) 6–11 months and (b) 12–23 months by ethnic groups. □, Han; ■, Yi; ■, Tibetan; ■, Uighur; —●—, total.

Table 3. Relative risks of stunting among children aged 6–23 months in forty-two counties of Western China (2011)
(Percentages, relative risks and 95 % confidence intervals)

Characteristics	*N*	*n*	%	95 % CI	Crude RR	95 % CI	Adjusted RR*	95 % CI
Overall	5073	901	17·8	16·7, 18·8				
Age of child (months)								
6–11	1903	211	11·1	9·7, 12·5	1		1	
12–23	3170	690	21·8	20·3, 23·2	1·96	1·70, 2·26	2·10	1·78, 2·49
Sex of child								
Male	2688	560	20·8	19·3, 22·4	1·45	1·28, 1·64	1·44	1·26, 1·64
Female	2385	341	14·3	12·9, 15·7	1		1	
Birth order of child								
1	2636	438	16·6	15·2, 18·0	1		1	
2	1603	276	17·2	15·4, 19·1	1·03	0·90, 1·18	0·92	0·79, 1·06
≥3	663	164	24·7	21·5, 28·0	1·48	1·27, 1·74	0·98	0·81, 1·18
Caregiver's education								
Illiteracy	1595	344	21·6	19·5, 23·6	2·71	1·56, 4·70	1·75	0·95, 3·24
Primary	1409	258	18·3	16·3, 20·3	2·30	1·32, 4·00	1·72	0·93, 3·16
Secondary	1908	285	14·9	13·3, 16·5	1·87	1·08, 3·26	1·58	0·86, 2·90
College and above	151	12	7·9	3·6, 12·3	1		1	
Ethnic group								
Han	1921	270	14·1	12·5, 15·6	1		1	
Yi	716	190	26·5	23·3, 29·8	1·88	1·60, 2·22	1·25	1·00, 1·58
Tibetan	649	132	20·3	17·2, 23·4	1·44	1·19, 1·74	1·29	1·05, 1·60
Uighur	439	108	24·6	20·6, 28·6	1·75	1·43, 2·13	1·72	1·38, 2·15
Others	1348	201	14·9	13·0, 16·8	1·06	0·89, 1·25	1·10	0·92, 1·32
Place of delivery								
County hospital	3054	447	14·6	14·1, 16·1	1		1	
Township hospital	727	139	19·1	18·3, 22·6	1·30	1·09, 1·55	1·16	0·96, 1·39
At home	1181	295	25·0	25·9, 29·8	1·70	1·49, 1·94	1·23	1·03, 1·47
Income								
Poorest	1196	259	21·7	19·3, 24·0	2·13	1·69, 2·69	1·56	1·19, 2·03
Poor	1134	234	20·6	18·3, 23·0	2·03	1·60, 2·58	1·58	1·22, 2·06
Middle	947	167	17·6	15·2, 20·1	1·74	1·35, 2·23	1·47	1·12, 1·93
Richer	967	148	15·3	13·0, 17·6	1·51	1·17, 1·94	1·38	1·05, 1·82
Richest	800	81	10·1	8·0, 12·2	1		1	
Breast-feeding during the previous day								
Yes	2111	374	17·7	16·1, 19·3	1·03	0·91, 1·17	1·15	0·99, 1·32
No	2617	448	17·1	15·7, 18·6	1		1	
Minimum dietary diversity								
Received	2778	433	15·6	14·2, 16·9	1		1	
Not received	2269	464	20·4	18·8, 22·1	1·31	1·16, 1·47	1·15	1·01, 1·31

* Adjusted for all the variables in Table 3.

the forty-two western counties failed to reach the MDD as defined by WHO. The adverse situation on dietary diversity from our study is similar to other surveys conducted within China's western areas[24,25] and some undeveloped countries[26–28]. But the status was far worse as compared with those from the eastern regions (e.g. 60 % for children aged 6 months and nearly 100 % for children aged 12 months reported in Shanghai received MDD[29]) and central areas (e.g. reported from the poor rural counties in Hunan Province, 73·9 % of the children aged 6–23 months received MDD[30]) in China; this stark difference is indicative of a serious problem involving dietary diversity for children in Western China.

From the multivariable analysis results, socio-economic factors such as caregivers with low education level, low family income and children delivered at home were found to have greater risks of an inadequate MDD; these findings may suggest the importance of education, socio-economic status and access to health care services in relation to proper feeding practice. The sex of children' had insignificant impact on the adequacy of dietary diversity, this observation was consistent with most other studies[24,26,31]. In addition, children with a higher birth order were less likely to have a diversified feeding pattern which may indicate a negligence on a child's individual care when parents have more than one child.

One highlight of our study were the stark differences and similarities observed based on feeding patterns by different ethnicities. First, minority groups showed a greater dietary disparity in comparison with the Han group. Nearly two-thirds of the Han's children met the MDD criteria; this contrasts with the only one-fourth of the Yi's, about half of the Uighur, and Tibetan children who met the similar criteria. Furthermore, we observed that children from various ethnic groups showed different patterns of complementary food in addition to a standardised diet. For all the studied ethnic groups, grains, roots and tubers comprised predominant proportion of their diets, but legumes and nuts are rarely chosen. Due to the high altitude and barren soil, most Tibetans lived on a grazing based lifestyle; therefore, groups within this population rely more on meat and dairy products as a common food source within their diets, rather than vegetable and fruits. Although meat and dairy food can provide protein, abundant energy content, and micro-elements such as Fe and Zn, there is a greater need for

caregivers to be more careful with these sorts of foods and personal hygiene, which may be contaminated at the point of source. The food structure of Uighur children is most comparable with Uighur adults; this would include a greater intake of flesh foods, but less eggs, dairy products, vitamin A-rich fruits and vegetables intake. As previously mentioned meat may provide essential amino acids, additionally the increase of dietary cholesterol as found in eggs and dairy products is noticeable; the high protein and high energetic intake maintained in adult diets may lead to unbalanced growth or development in children. On the other hand, dietary patterns among ethnic groups were also shown to be subject to modification by age groups; older children are more likely to be exposed to a greater diversity of food types in comparison to their younger counterparts. For children under 1 year of age, those in Han group showed a richer diversity of complementary foods types; these children are more likely to achieve MDD earlier than other groups, this observation may account for lower stunting prevalence within this ethnic group.

Among all the groups studied, the Yi minority showed greatest disparity in nearly every type of food group. One possible explanation for this phenomenon may be due to both limited access to resources and local traditional customs. Most of the Yi people in our study lived in rural mountainous areas with inconvenient traffic infrastructure. The local average household income was low and most residence lived on coarse grains (as other food resources were limited)[32,33]. Lack of sufficient food supplies and proper feeding knowledge, parents may tend to feed their children only with breast milk and grain foods. Further interventions should focus on improving Yi's simple food structure to further develop feeding practice education specifically for this minorities.

Stunting reflects chronic undernutrition during the 'critical window' of growth and development for both infants and young children. The overall stunting prevalence among surveyed subjects living in Western China in our study was 17·8 %; this was higher than the national average prevalence of rural children of 11·2 % and mostly similar to 18·7 % in poor rural areas in 2013[34]. Past evidence has illustrated that a lack of food dietary diversity will accumulate to child's malnutrition status, especially stunting[35–37], these findings have also been confirmed in our multivariate analysis. A study in India has showed a non-significant difference of stunting prevalence between children with medium and low food diversity, however, the difference became significant when comparing children with high and low food diversity[38]. Male's sex was more prevalent in stunting, but this was not observed in complementary food diversity. The high stunting prevalence for male children was consistent with previous studies[7,15,38] and with the high under 5-year mortality rate of boys in China[1]. Education level and income were found significantly associated with MDD, whereas only income was associated with stunting. The significant association between education and stunting in the binary model disappeared after adjusting for MDD and other variables; this indicates that education levels of caregivers may be only the direct causal factor of MDD, but not stunting (education level → MDD → stunting). Other literatures also observed the association between a caregiver's education and stunting when the authors did not adjust for dietary diversity[15,36]. However, the relationship between income and stunting remains significant in both the binary and multivariable models, these observations suggest that income may confound the relationship of MDD and stunting (income → MDD → stunting, income → stunting). In another way, income is an independent risk factor which can be mediated to reduce stunting in children.

In addition, the gaps of stunting prevalence among different ethnic groups was large. Of the three-major minority ethnic groups investigated (Yi, Tibetan, Uygur), these groups showed higher stunting prevalence in comparison to the Han group. In particular, the prevalence of stunting within the Yi group was as high as 26·5 %, which was comparable with the level of Southern Africa[39]. As shown in Table 1, different ethnic groups have variable distributions of children's sex, birth order, caregiver's education, delivery place, postpartum visit, income and breast-feeding status. Among all these factors above, children's sex, birth order, caregiver's education level, place of delivery, income and breast-feeding status are found to be statistically associated with MDD; whereas place of delivery, income and MDD are associated with stunting. Therefore, the disparity among different ethnic groups may be partly accounted for by the inequalities of socio-economic factors and complementary dietary performance among different ethnic groups.

Several limitations of our study should be considered. First, the tool we used to assess dietary diversity of children is 24-h dietary recall; whereas this method is rather convenient for collecting data, this conservative approach may affect our information on the food diversity based on caregiver recall bias. In addition, the types of food consumed by children may vary from day by day, therefore the results of the survey in 24 hs may differ from the actual dietary situation. Second, our study only focused on types of complementary foods, rather than the meal frequency, food quantity, food sanitation or caregiver hygiene; other feeding practice factors which are also key indicators of child growth and may play roles in developing sufficient interventions to reduce stunting prevalence. One important strength of our study is that there is a scarcity of literature that focus on dietary diversity issues in Western China; our novel results may contribute to current evidence of associations between dietary diversity and the stunting of children within western rural areas.

To conclude, our study found that nearly 44·5 % complementary feeding diversity has not met the WHO recommended MDD; an overall 17·8 % stunting rate is existent in the poor counties of Western China. Inadequate MDD was found to be positively associated with childhood stunting. Moreover, different ethnicities showed greater variation in achieving MDD and should be further explored in future research to benefit individual groups as well as the general health of Western China. To halve the stunting prevalence by 2025, further efforts are needed: for regions with limited food sources, supplementary nutrition programmes should be conducted; for these ethnic minority groups, health education for caregivers as well as nutrition interventions focusing on feeding practices in tandem with local culture and food availability improvement should be addressed.

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The authors declare that there are no conflicts of interest.

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