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Demographic variations and temporal trends in prenatal use of multiple micronutrient supplements in Beijing, 2013–2017

Haiyang Bian[1,2], Youchi Tang[3], Yubo Zhou[1,2], Hongtian Li[1,2,*] and Jianmeng Liu[1,2,*]
[1]Institute of Reproductive and Child Health, National Health Commission Key Laboratory of Reproductive Health, Peking University Health Science Centre, Beijing, China: [2]Department of Epidemiology and Biostatistics, School of Public Health, Peking University Health Science Centre, Beijing, China: [3]Chaoyang District Maternal and Child Health Care Hospital, Beijing, China

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Abstract

Objective: To provide updated information about demographic variations and temporal trends in the prenatal use of multiple micronutrient (MMN) supplements in the metropolitan areas of China.
Design: Descriptive analysis of routine prenatal healthcare data between 2013 and 2017.
Setting: Chaoyang District, Beijing, China.
Participants: A total of 197 346 pregnant women who attended their first prenatal care visit and provided information about MMN supplementation during the periconceptional period.
Results: Of these pregnant women, 60·6 % reported consuming prenatal MMN supplements. In multivariate-adjusted models, there were significant gradients of age, education and parity in prenatal MMN supplementation, with the highest likelihood of MMN use among the oldest, the most highly educated and nulliparous women ($P_{\text{for trend}} < 0{\cdot}001$). Compared with that among unemployed women, prenatal MMN supplementation was more common among the employed, especially those engaged in business (adjusted relative risks (95 % CI): 1·08 (1·06, 1·10)) and management (1·10 (1·08, 1·12)). The proportion of prenatal MMN supplementation was 57·0 % in 2013, which increased to 63·5 % in 2017 ($P_{\text{for trend}} < 0{\cdot}001$). The trends varied by age, education and parity ($P_{\text{for heterogeneity}} < 0{\cdot}001$), whereas no significant difference was observed in trends across subgroups of ethnicity or occupation. The greatest magnitude increase in MMN supplement use occurred in women of age < 25 years (annual percent change: 5·7 %), less than high school education (9·6 %), parity ≥ 2 (6·8 %) or unemployment (6·1 %).
Conclusion: Approximately two-thirds of women consumed prenatal MMN supplements during the periconceptional period in the central area of Beijing and the proportion increased over time, indicating a need to evaluate the effectiveness and safety and to develop a guideline for relatively well-nourished women.

Keywords
Pregnant women
Dietary supplements
Socio-economic status
Multivitamins

Micronutrients play an essential role in reducing the risks of adverse pregnancy outcomes[1], such as low birth weight[2], birth defects[3] and preterm delivery[4]. The health effects of micronutrient status in early life may even track to adulthood and be linked to lifelong health and well-being[5,6]. To meet the demands of fetal growth and prepare for subsequent delivery and lactation, a series of physiological and metabolic changes occur in a woman's body, which might result in a more frequent micronutrient deficiency during pregnancy[7].

Prenatal multiple micronutrient (MMN) supplementation, considered by many as a complement for dietary micronutrient shortfalls, is not universally recommended by the WHO due to the uncertain risk–benefit profile[8–10]. Although meta-analyses have documented the effects of maternal MMN supplementation on preventing low birth weight and small-for-gestational-age births, virtually all the studies were limited to populations with undernourishment[11]. Notably, these health effects of MMN supplementation could be modified by maternal

*Corresponding authors: Email liujm@pku.edu.cn; lihongtian@pku.edu.cn

nutritional status[12,13]. A study in China suggested that MMN supplementation did not improve infant survival and birth outcomes among women with no or mild anaemia[14]. Given the lack of compelling evidence on the effectiveness of MMN for well-nourished population and the increasing risks of excessive intake of iron and folate[15] and fetal overgrowth[16,17], the benefits and harms need to be weighed before the MMN supplementation is recommended to the well-nourished population.

With the rapid development of China's economy, the labour force has been moving from rural areas to cities, particularly to super cities with strong economic vitality. One of the prerequisites for providing rational nutrition advice to pregnant women with sufficient food supply is a better understanding of the current situations in prenatal dietary supplement use. Most previous studies in China focused on the rates and determinants of periconceptional folic acid supplementation provided as a free service by Chinese government[18–21]. Prenatal MMN supplements, which are bought spontaneously by the women, have not received as much attention. To address this gap, we utilised data collected from Chaoyang District, a high-income district in the capital of China, from 2013 through 2017, to quantify the demographic variations and temporal trends in prenatal use of MMN supplements.

Methods

Setting

Chaoyang District, lying between the city centre and the suburbs, occupies 470 km^2 within the urban area of Beijing, China. The population of this typical Chinese super city district was approximately 3·7 million, and the gross domestic product per capita was over $20 000 in 2017[22]. Like other cities in China, maternal and child health care services are provided by community healthcare centres (CHC) in sub-districts and hospitals. Specifically, pregnant women are suggested to complete the first antenatal care and pregnancy risk assessment at a CHC before 12 weeks of gestation[23]. At the same time, a profile regarding the pregnancy is created in the information system, which is a prerequisite for reserving the following antenatal care and labour and delivery services at a hospital. Because the rate of institutional delivery in Beijing has been close to 100 % since 2010[24], almost all pregnant women who decided to give birth within Chaoyang District over the study period had undergone at least one antenatal care visit at the district's CHC.

Data sources

The Chaoyang District Maternal and Child Health Registry Information System, our primary data source, consists of four modules: antenatal and perinatal care, labour and delivery, registration of birth and child health care. Data are collected and uploaded to the system by physicians from all CHC and hospitals in Chaoyang District. The Chaoyang District Maternal and Child Health Care Hospital is responsible for the data management and quality supervision. Data for the current analysis were derived mainly from two registers regarding antenatal and perinatal care. Since 2010, the Antenatal Register has been used to record individual-level data on maternal demographics, reproductive history and physical examination. In 2012, the Perinatal Register was established to collect additional information, including folic acid supplementation. To improve the integrity of the demographic characteristics, we used records in the Birth Register to impute missing values.

Prenatal multiple micronutrient supplement use and other key variables

Pregnant women were asked whether they had taken any supplements containing folic acid before and during their current pregnancy when they underwent the first antenatal care visit at the CHC. Women indicating use were further asked either folic acid alone or MMN was taken. MMN was defined as a supplement containing folic acid and a variety of other vitamins and minerals. In practice, MMN can be described as a 'multivitamin', 'multiple vitamins and minerals', 'multivitamins/multiminerals', 'vitamin complex', etc. If a pregnant woman could not exactly determine the type of supplements, she was required to show physicians the packaging or instructions of the supplement. When a woman used folic acid and MMN simultaneously, physicians would often suggest her using only one of them. Considering that compliance would influence the preventive effect of folic acid supplementation on neural tube defects[3], two metrics of pattern of use were inquired as well: the starting time and the frequency of supplementation. Women started taking supplements before the last menstrual period were categorized into preconceptional use; otherwise, they were classified into late use. Regular use was defined as taking supplements daily for more than 80 % of the days during the whole period of supplementation (between the first day of use and the day of the interview)[25]. Other variables were obtained from the Antenatal Register, including maternal age at conception (estimated by date of mother's birth and the last menstrual period) (< 25, 25–29, 30–34, 35–39, ≥40 years), education level (< high school, high school, bachelor's degree, postgraduate, unknown), ethnicity (Han, Manchu, other, unknown), occupation (unemployed, sales and service, professional, business, management, other, unknown), parity (0, 1, ≥ 2), and year of conception (according to the last menstrual period).

Since women need to buy their own MMN supplements and online shopping is prevalent among people of reproductive age in China, we conducted a survey on a Chinese online retail platform to understand more about the MMN supplements predominantly sold on the Chinese market.

A combination of search terms – 'pregnant women' and 'multivitamin' (in Chinese) – was used. We extracted brand name, price, ingredient and dosage from the label declarations of the products. For comparison purposes, we calculated the total daily intake of each nutrient using the ingredients of each tablet multiplied by the number of tablets that should be taken per day. Similarly, daily cost was calculated based on the price and daily dosage, assuming individuals were in full compliance with the instructions.

Statistical analyses

The proportion of prenatal MMN supplement use represented the percentage of women using prenatal MMN supplements among all pregnant women included in the study. The proportion of preconceptional and regular MMN use was the percentage of women who started to use MMN supplements regularly before pregnancy among all MMN users. Modified Poisson regression models with robust error variance were applied to evaluate the independent associations between the binary outcomes (use or not; preconceptional and regular use or not) and the demographic characteristics, including age, education, ethnicity, occupation, parity and year of conception. The multivariable models provided adjusted relative risks (aRR) and corresponding 95 % CI[26]. Except for ethnicity adjusted relative risks and occupation, the characteristics were treated as continuous independent variables to test the linear trends in proportions across different subgroups. Likewise, the calendar year of conception was treated as a continuous independent variable to examine temporal trends, and the annual percentage change was obtained. Differences in temporal trends between subgroups were investigated by adding an interaction term of the calendar year of conception and the corresponding characteristics. All analyses were performed using SPSS 20.0, and two-tailed tests with $P < 0{\cdot}05$ indicated statistical significance.

Results

Characteristics of the study sample

A total of 204 870 records between 2013 and 2017 were initially identified through the Perinatal Register. After excluding 7005 records that failed to link with other registers and 519 records with incomplete information on supplement use, 197 346 (96·3 %) women were included in the present analysis. The mean (SD) age and week of gestation at the first antenatal care of the study population were 30·2 (4·3) years and 11·1 (6·9) weeks, respectively. The majority of women were Han (93·7 %), had a college degree (77·4 %) and were primiparous (69·9 %). The occupations of the participants were relatively diverse, and the top three were as follows: sales and service (22·0 %), professional (19·9 %) and business (17·9 %) (Table 1).

The proportion of prenatal multiple micronutrient supplement use and its pattern

Among the 197 346 pregnant women, 119 638 (60·6 %) reported to have consumed prenatal MMN supplements during the periconceptional period. The behaviour of MMN supplementation was associated with several maternal characteristics (Table 1). Pregnant women with older age, lower parity, higher level of education and employment were more likely to use MMN. After multivariable adjustments, age and educational gradients were observed ($P_{\text{for trend}} < 0{\cdot}001$), with the highest MMN use proportion among the oldest (≥ 40 years) and the most highly educated (postgraduate). The use of MMN was broadly uniform across ethnicities. Prenatal MMN use was more common among working women, especially for those engaged in business (aRR (95 % CI): 1·08 (1·06, 1·10)) and management (aRR: 1·10 (1·08, 1·12)). Nulliparous women (aRR: 1·22 (1·17, 1·27)) and mothers who had given birth once prior (aRR: 1·12 (1·07, 1·17)) were more likely to use MMN than those who had two or more previous births.

Over the same period, among women who reported prenatal MMN use, the proportion of preconceptional and regular use was 59·3 % (Table 1). The distribution of this behaviour across different subgroups was in line with MMN supplement use. Specifically, women who were older, better educated, employed or had fewer parity had better compliance.

Trends in prenatal multiple micronutrient supplement use

The proportion of prenatal MMN use in 2013 was 57·0 %, which increased to 63·5 % in 2017 (annual percent change: 1·5 % (1·2 %, 1·7 %)). Figure 1 shows the trends in prenatal MMN use by demographic characteristics. The results of the interaction test revealed diverse trends within the subgroups defined by age, education and parity ($P_{\text{for heterogeneity}} < 0{\cdot}001$) (Additional File 1). However, no statistically significant difference was observed in trends by ethnicity and occupation ($P_{\text{for heterogeneity}}$: 0·767 and 0·425, respectively). Women groups that had a lower proportion of supplement use in the base year, had a larger change in use over the course of the study period. Specifically, the proportion increased quickly from 41·9 to 56·1 % among pregnant women less than 25 years old, with an annual percent change of 5·7 % (4·5 %, 7·0 %). Women with a lower level of education also became more willing to choose MMN supplements, with annual percent increases of 9·6 % (8·3 %, 11·0 %) for women with a less than high school education, and 3·7 % (2·8 %, 4·7 %) for women who just finished high school. Consistent with this finding, increasing trends were also observed among mothers who had given birth two or more times, and among unemployed women, with corresponding annual percent changes of 6·8 % (3·2 %, 10·4 %) and 6·1 % (5·2 %, 7·0 %), respectively (Additional File 1).

There was no significant change in preconceptional and regular MMN use within the study period, with proportions

Table 1 Prenatal use of multiple micronutrient (MMN) supplements by demographic characteristics in Chaoyang district, Beijing, 2013–2017

		MMN Supplement Use			Preconceptional and Regular MMN Supplement Use		
	N (%)	n_1	Proportion (%)†	aRR (95 % CI)*	n_2	Proportion (%)‡	aRR (95 % CI)*
Overall	197346 (100.0)	119638	60.6		70882	59.3	
Age (years)							
< 25	15021 (7.6)	7220	48.1	1.00 (Ref.)	2726	37.8	1.00 (Ref.)
25-29	76188 (38.6)	45278	59.4	1.12 (1.10, 1.14)	26368	58.2	1.37 (1.33, 1.42)
30-34	74488 (37.7)	47124	63.3	1.20 (1.18, 1.22)	29596	62.8	1.54 (1.49, 1.59)
35-39	27352 (13.9)	17309	63.3	1.23 (1.20, 1.25)	10584	61.1	1.64 (1.58, 1.69)
≥ 40	4297 (2.2)	2707	63.0	1.25 (1.21, 1.29)	1608	59.4	1.64 (1.57, 1.71)
Educational level							
< High school	17372 (8.8)	7636	44.0	1.00 (Ref.)	2749	36.0	1.00 (Ref.)
High school	22182 (11.2)	11917	53.7	1.18 (1.15, 1.20)	5400	45.3	1.15 (1.11, 1.19)
Bachelor degree	119394 (60.5)	74943	62.8	1.30 (1.27, 1.32)	45795	61.1	1.36 (1.31, 1.40)
Postgraduate	33441 (16.9)	22028	65.9	1.33 (1.30, 1.36)	14994	68.1	1.44 (1.40, 1.49)
Unknown	4957 (2.5)	3114	62.8		1944	62.4	
Ethnicity							
Han	184919 (93.7)	111761	60.4	1.00 (Ref.)	66072	59.1	1.00 (Ref.)
Manchu	5107 (2.6)	3262	63.9	1.03 (1.01, 1.06)	1955	59.9	0.99 (0.96, 1.01)
Other	7032 (3.6)	4408	62.7	1.01 (1.00, 1.03)	2708	61.4	1.01 (0.99, 1.04)
Unknown	288 (0.1)	207	71.9		147	71.0	
Occupation							
Unemployed	17333 (8.8)	11622	51.8	1.00 (Ref.)	5396	46.3	1.00 (Ref.)
Sales and Service	43488 (22.0)	28065	58.6	1.03 (1.01, 1.05)	11071	53.5	1.00 (0.98, 1.03)
Professional	39339 (19.9)	24416	62.1	1.03 (1.01, 1.05)	14965	61.3	1.06 (1.03, 1.08)
Business	35309 (17.9)	20695	64.5	1.08 (1.06, 1.10)	17932	63.9	1.12 (1.09, 1.14)
Management	22544 (11.4)	11666	67.1	1.10 (1.08, 1.12)	8193	70.5	1.20 (1.17, 1.23)
Other	27276 (13.8)	16070	58.9	1.05 (1.03, 1.06)	9055	56.3	1.08 (1.05, 1.10)
Unknown	12057 (6.1)	7104	58.9		4270	60.1	
Parity							
≥ 2	2461 (1.2)	1141	46.4	1.00 (Ref.)	416	36.5	1.00 (Ref.)
1	57011 (28.9)	32599	57.2	1.12 (1.07, 1.17)	15307	47.0	1.17 (1.08, 1.26)
0	137874 (69.9)	85898	62.3	1.22 (1.17, 1.27)	55159	64.2	1.63 (1.51, 1.75)

*Values were mutually adjusted for the characteristics in the table, plus year of conception.
†The proportion of MMN supplements use = (n_1/N)*100 %.
‡The proportion of preconceptional and regular MMN supplement use = (n_2/n_1)*100 %.

of 62·7 % in 2013 and 57·9 % in 2017 ($P_{\text{for trend}} = 0{\cdot}068$). As shown in Fig. 2, the trends in preconceptional and regular MMN use varied by demographics, except for ethnicity and parity ($P_{\text{for heterogeneity}}$: 0·107 and 0·731, respectively). The proportions decreased slightly among younger women, women with a low level of education, unemployed women and women who had given birth two or more times (Additional File 2).

Prenatal multiple micronutrient supplements sold on the Chinese market

We identified seven prenatal MMN supplements containing 9–22 micronutrients from the survey. Additional File 3 provides a summary of these products. The average daily cost was $0·6, and the highest daily cost was nearly four times as high as that of the lowest ($1·1 *v.* $0·3). The types of vitamins were similar, but the combinations of minerals varied. Of these MMN products, six provided three types of fat-soluble vitamins (vitamins A, D, and E). In terms of water-soluble vitamins, all products contained vitamin C, of which the daily dosage ranged from 50 to 100 mg; B-complex vitamins were relatively common. The products for the periconceptional period could provide at least 0·4 mg folic acid per day. Although all the products contained Fe, the dosage varied from 4·8 to 60 mg per day. Similarly, the daily amount of Zn available in these products ranged from 5·5 to 25 mg.

Discussion

In this descriptive analysis involving nearly 200 000 urban pregnant women in China, 60·6 % reported using prenatal MMN supplements during the periconceptional period, and 59·3 % of the MMN users initiated regular supplementation before conception. The proportions of MMN supplementation, as well as compliance with supplementation, varied significantly according to age, education, occupation and parity. Moreover, we observed increasing trends in MMN supplementation from 2013 through 2017, particularly among the groups that had a lower proportion in the base year.

The overall proportion of MMN supplementation in our study was substantially higher than that reported in another study in China (43·5 %)[27] and was as high as reported in some developed countries such as Denmark (54·4 %)[28] and the United States (69·8 %)[29]. In addition to the differences in definitions of MMN and the duration of use, the differences in participants' characteristics (e.g. educational level) may also account for the discordant findings. Another important factor to account for the high proportion

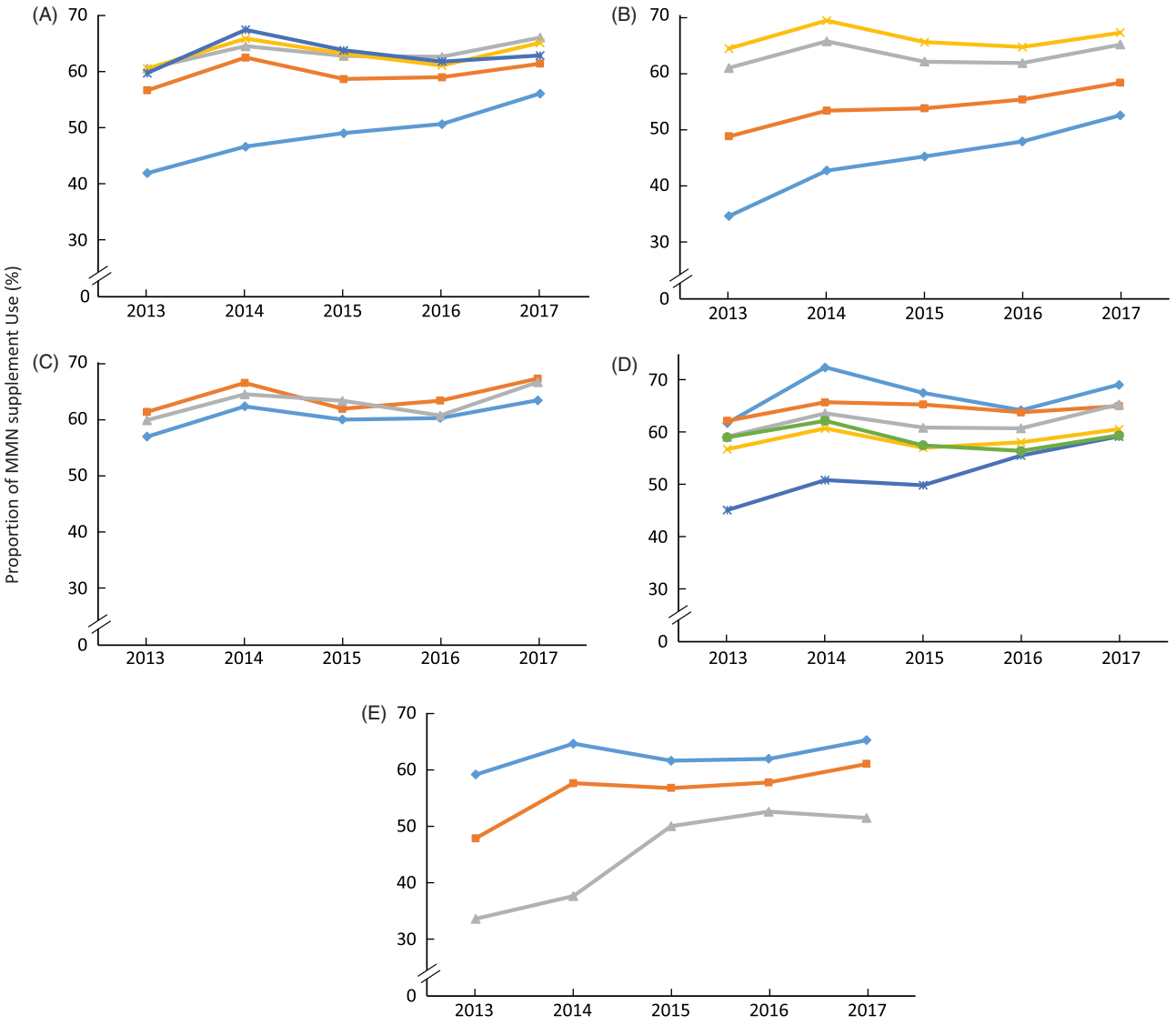

Fig. 1 (colour online) Trends in prenatal use of multiple micronutrient (MMN) supplements by demographic characteristics, in Chaoyang District, Beijing, 2013–2017. (A) Maternal age, (B) educational level, (C) ethnicity, (D) occupation, (E) parity. As estimated by modified Poisson regression model, the annual percentage change in overall proportion of prenatal MMN use was 1·5 % (95 % CI: 1·2 %, 1·7 %) from 2013 to 2017. Interaction test indicated the differences in temporal trends between the subgroups of age, education level and parity ($P < 0·001$).). (A) —◆—, <25; —■—, 25–29; —▲—, 30–34; —×—, 35–39; —✳—, ≥40; (B) —◆—, <high school; —■—, high school; —▲—, bachelor degree; —×—, postgraduate; (C) —◆—, Han; —■—, Manchu; —▲—, other; (D) —◆—, management; —■—, business; —×—, sales and service; —▲—, professional; —✳—, unemployed ; —●—, other; (E) —◆—, 0, —■—, 1; —▲—, ≥2

is that the Chinese government launched a nationwide programme in 2009 to provide periconceptional folic acid alone supplements for rural women to prevent neural tube defects[20]. The free service is gradually being expanded to urban residents by local governments. Urban women planning pregnancy in Beijing have been able to obtain free folic acid supplements since 2011[30]. To facilitate the implementation of this programme, national and local efforts on nutrition education have been made, which promoted public awareness of nutrition before and during pregnancy.

We observed significant demographic variation in prenatal use of MMN supplements, which was consistent with the findings of previous studies focusing on dietary supplements[31–34], MMN[27] and folic acid[18,19,28]. Although we lacked data on household income, the educational gradients and heterogeneity across occupational groups both suggested that MMN supplementation might be related to the socio-economic status (SES). Maternal age at pregnancy was also regarded as an indicator of SES[35]. Especially for this metropolitan female population, pursuing a higher level of education and career development often means delayed childbearing. It is plausible that socio-economically advantaged women pay more attention to 'perfect' nutritional status during pregnancy and are more able to afford the expense of supplements[36]. We identified that parity was independently associated with prenatal MMN supplement use, in accordance with our expectation because nulliparous mothers are usually more anxious about pregnancy. In addition, the SES-driven

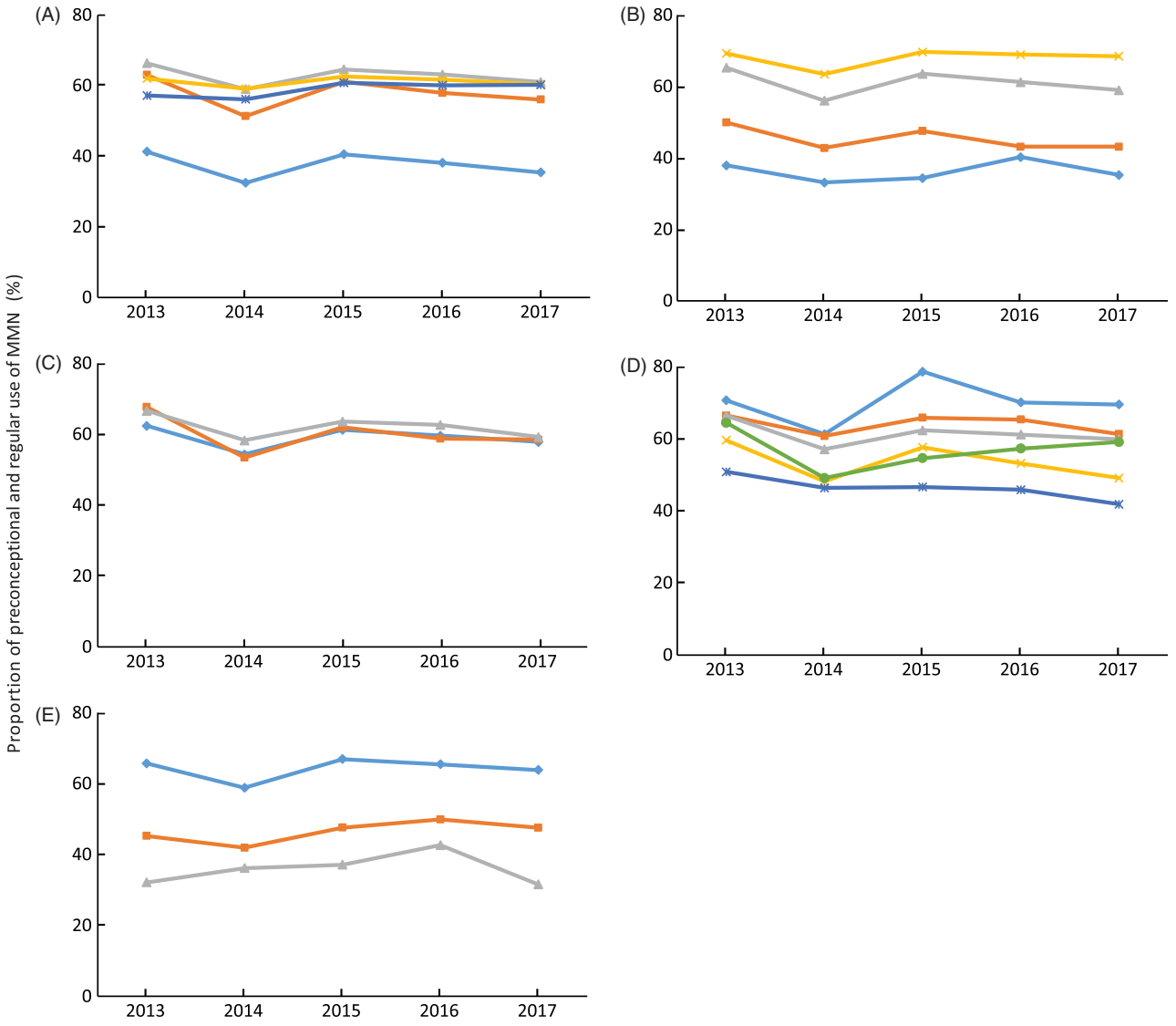

Fig. 2 (colour online) Trends in preconceptional and regular use of multiple micronutrient (MMN) supplements by demographic characteristics in Chaoyang District, Beijing, 2013–2017. (A) Maternal age, (B) educational level, (C) ethnicity, (D) occupation, (E) parity. As estimated by modified Poisson regression model, the annual percentage change in overall proportion of preconceptional and regular use was –0·1 % (95 % CI: –0·4 %, 0·3 %) from 2013 to 2017. Interaction test indicated the differences in temporal trends between the subgroups of age and education level ($P < 0{\cdot}001$). A) ◆, <25; ■, 25–29; ▲, 30–34; ×, 35–39; ✱, ≥40; (B) ◆, <high school; ■, high school; ▲, bachelor degree; ×, postgraduate; (C) ◆, Han; ■, Manchu; ▲, other; (D) ◆, management; ■, business; ×, sales and service; ▲, professional; ✱, unemployed ; ●, other; (E) ◆, 0, ■, 1; ▲, ≥2

hypothesis was supported by the demographic variations in compliance with supplementation.

To the best of our knowledge, this is the first study demonstrating trends in the use of prenatal MMN supplements in China. The trends varied across subgroups of several demographic characteristics. Compared with that in women with higher SES, a more pronounced increase in MMN supplementation was observed among women with lower SES. Women with higher SES may have gone through a period of rapid growth ahead of the others because individuals with higher SES had better access to information about nutrition as well as sources of supplements. Due to the relatively short study period, we may have failed to capture the growth within higher SES groups, which could be as pronounced as what was has since been observed among the lower SES counterparts.

Although adequate micronutrient intake has been recognised as optimal for both maternal and fetal health[37], most of the high-quality evidence with regard to the short- and long-term benefits of prenatal MMN supplementation come from resource-poor settings[38,39]. Pregnant women in our study may not be a population with a high rate of nutritional deficiencies as WHO's recommendation noted. For instance, the incidence of low birth weight between 2013 and 2017 in a district of Beijing was < 3 %[40], in contrast to 19–32 % in South Asia[41]. On the other hand,

socio-economically advantaged women, who are more likely to have a high-quality diet[42], used prenatal MMN more frequently. More importantly, whether prenatal MMN supplementation has potential adverse impacts on the well-nourished population awaits definitive evidence. In contrast to the current WHO recommendation, the high proportion of prenatal MMN use in both our study and other developed countries[28,29] suggests a need for an evaluation of the impacts of prenatal MMN supplementation among relatively well-nourished women. In addition, the increasing trend of prenatal MMN use over the study period, especially the appreciable increase observed among socio-economically disadvantaged women, indicates that the prenatal supplement use transition (from folic acid only to MMN) may exist or being impending in the larger extent of China. This is because the country is undergoing rapid urbanisation and economic development, and most of the areas are following the path of affluent areas. It is important to raise awareness about this transition and determine women's motivations for prenatal supplement use preferences, which may have implications for optimising the relevant nutritional intervention programme.

The standardised prenatal health care system enables us to leverage data including nearly all pregnant women in a representative area of a Chinese metropolis and minimise the selection bias. Several limitations should be considered. First, given the setting of our study and the characteristics of the participants, the proportion of MMN supplement use observed in our study could possibly be generalised to the central area of Beijing as well as other super cities in China, but may not be generalisable to other settings, in particular to the less developed areas. The SES-related demographic variation and increasing trends in prenatal MMN use, however, might shed light on a larger area of China, since even in Beijing the annual disposal income for urban residents varies considerably from an average of $3687 of the poorest quintile to $15 633 of the richest quintile[43]. Second, we lacked individual-level data on the brands or ingredients of MMN, so we were unable to assess the impacts of different recipes. Third, the MMN products identified from the survey in 2019 may not be fully representative of those available in previous years. Nevertheless, the approval numbers indicated that one product started to sell in 2014, and the other six products were on the market before 2013 (the base year of analysis). Fourth, because the calendar year of conception was used, there might be misclassification of women whose preconceptional use traversed several years. Last, as the interview about MMN supplementation was conducted at the first antenatal care visit, a full picture of the whole pregnancy may not be shown. When a much longer duration of supplementation was taken into account, the proportion of prenatal MMN supplementation following the instruction of products is likely to be lower than what was observed in our study. Although challenges existed in assessing the population-level exposure precisely, this microcosm, not only provided us with a snapshot of the contemporary situation of prenatal MMN supplementation in developed areas of China but also may signal the direction of prenatal dietary supplement use transition in the entire country.

Conclusions

Between 2013 and 2017, approximately two-thirds of women living in a super city of China used MMN supplements during the periconceptional period. Supplementation behaviour was positively related to SES, and it presented increasing trends over time. Given that the impacts of prenatal MMN supplementation beyond under-nourished women remain unknown, these findings indicate a need to evaluate the benefits and risks and develop relevant guidelines concerning MMN consumption among relatively well-nourished pregnant women.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020004905

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