LOW MICRONUTRIENT ADEQUACY AND RISING OVERWEIGHT AND OBESITY AMONG READY-MADE GARMENT WORKERS IN BANGLADESH

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ABSTRACT

Background/Objective: The ready-made garment (RMG) sector is key to Bangladesh's economy, significantly contributing to GDP and foreign exchange earnings. However, RMG workers, predominantly women, face critical challenges related to health, nutrition, and productivity. Despite their socio-economic importance, research on their diet quality, nutrient adequacy, and nutritional status remains limited. This study aimed to assess the dietary quality, probability of nutrient adequacy, and nutritional status of RMG workers in Bangladesh. **Methodology:** A cross-sectional study was conducted among 801 RMG workers (333 males and 468 females) employed in two garment industries in Dhaka and Mymensingh. Participants were selected using convenience sampling. Data on socio-demographics, dietary intake, and anthropometry were collected, and nutritional status was assessed using BMI classifications from both WHO and Asian standards. Micronutrient adequacy was evaluated using the probability approach (PA), incorporating estimated average requirement (EAR) values and standard deviations. Descriptive and inferential statistical methods were employed. Multiple logistic regression was used to investigate the influence of socioeconomic factors on workers' micronutrient adequacy. **Results:** Among the 801 RMG workers studied, 58.4% were female, and 90.3% were aged 18-34. Macronutrient distribution indicated excessive carbohydrate intake (67.0% of total energy), while fat intake was often below ideal levels in 43.4% of participants (<15% of total energy). More than half of the RMG workers exhibited inadequate micronutrient intake, with a mean micronutrient adequacy (MPA) score below 0.5. The MPA of micronutrients was significantly higher for RMG workers in Mymensingh (AOR 1.68, p = 0.004) and those aged 25-34 (AOR 1.40, p = 0.049). Calcium consumption among RMG workers was alarmingly low, with most consuming less than 50% of the Estimated Average Requirement (EAR). Similarly, intakes of iron, zinc, riboflavin, and vitamin A were at or below the EAR, indicating a high risk of inadequacies. A concerning overnutrition was observed, with 44% overweight or obese based on Asian BMI standards while it was 24.1% based on WHO BMI standards, with a higher prevalence observed among female workers. **Conclusion:** The study findings highlight the coexistence of overnutrition and micronutrient inadequacy among RMG workers. Targeted nutritional interventions, such as establishing fair-price shops and promoting nutrition education, are recommended to improve food affordability, encourage healthier dietary practices, and enhance workforce productivity.

KEYWORDS: Ready-made garment (RMG) workers, Micronutrient adequacy, Overweight, Obesity, Bangladesh

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Introduction

Bangladesh's economy has grown rapidly in recent decades, largely driven by its Ready-Made Garment (RMG) industry. This sector, under the "Made in Bangladesh" brand, has become a cornerstone of the country's development and a significant contributor to export revenue (Islam, Rakib, and Adnan, 2016). In the 2017-18 fiscal year (FY), the RMG sector generated $30.61 billion in exports, an 8% increase from the previous year, contributing 83.5% of the country's total exports and 11.23% of its gross domestic product (GDP) (EPB, 2018; BBS, 2018). The industry employs approximately 5.1 million workers across 4,621 factories, with women making up 65% of the workforce (BGMEA, 2020). Despite challenges posed by the COVID-19 pandemic, the sector-maintained resilience, achieving $19.9 billion in exports during the first half of FY2021-22, a 28% increase compared to the same period of the previous year (EPB, 2022).

While the RMG industry has propelled economic growth and boosted foreign income, its workers face numerous challenges. Low wages, unsafe working conditions, and limited respect for women's rights are persistent issues. Many workers struggle to afford adequate food, clothing, housing, and medical care (Hasnain, Akter and Sharafat. et al., 2014). This precarious situation adversely impacts workers' health and productivity, with studies highlighting the link between undernutrition and reduced labor efficiency (Faruquee et al., 2014; Ahmed, 2014; Uddin, 2015). Several studies have reported poor nutritional status among RMG workers in Bangladesh. For instance, Hasnain et al. (2014) found that 43.3% of female workers aged 18-35 years were underweight (BMI < 18.5 kg/m²). Similarly, Sultana et al. (2014) revealed that average energy intake among female workers across age groups fell below recommended levels. Other research indicates that low wages and vulnerability prevent workers from achieving food security, leading to insufficient dietary diversity and nutrient deficiencies (Rakib & Rahman, 2016; Riaduzzaman, 2017).

Micronutrient deficiencies are particularly concerning among female workers. A study by Khatun et al. (2013) reported anemia prevalence rates of 77-80%, a condition associated with productivity losses at the national level (Horton & Ross, 2003). Khan and Ahmed (2005) identified significant energy and nutrient deficits in the diets of adolescent RMG workers, with low consumption of protein-rich and micronutrient-dense foods such as eggs, milk, and leafy vegetables. Furthermore, many workers resort to purchasing cheaper, lower-quality food from evening markets (Chowdhury, 2019; Uddin, 2015), exacerbating malnutrition and its associated health risks.

Diet quality plays a critical role in determining nutritional status and overall well-being. Poor dietary practices, characterized by low intake of diverse food groups, have been documented among RMG workers. The Minimum Dietary Diversity for Women of Reproductive Age (MDD-W) indicator, a measure of micronutrient adequacy, showed that only 55% of female RMG workers consumed diets with more than four food groups (FAO, 2016). This dietary insufficiency, coupled with occupational vulnerabilities, contributes to poor physical health, high absenteeism, and reduced productivity (Grimani, Aboagye, & Kwak, 2019).

Despite the growing body of evidence, studies assessing the diet quality, nutrient adequacy, and nutritional status of RMG workers remain limited. This study aimed to investigate the dietary quality, probability of nutrient adequacy, and nutritional status of RMG workers in Bangladesh.

Methodology

Study design and study population

A cross-sectional survey design was adopted to collect sociodemographic, anthropometric, and dietary data of the RMG workers from two industries situated in Dhaka and Mymensingh from September to October 2021. Data was collected through face-to-face interviews from both male and female workers.

Sample size calculation

The study industries were selected purposively based on their conveniences, which stemmed from the easy access and the willingness of the industry authority to participate in the study. The sample size calculation followed a well-established statistical formula, n $= N/1+N\ (e)^2$ (Isreal, 2013) considering the desired level of precision and number of populations. Where, n = sample size, N = population size, and e = the level of precision.

Industry in Dhaka comprised about 8500 workers, while the Mymensingh industry consisted of 9000 workers, in combination adding up to 17500 workers in total. Therefore, to get a 95% confidence level with a 5% error, a total of 382 subjects per industry is the lowest acceptable number for the study. A total of 764 subjects (382 x 2) were required for this study. Systematic random sampling techniques were used to select the required number of workers on every floor and section of garments. In every production line, the first worker was identified as the starting unit, and after a certain gap, usually 20 workers, the second worker was selected, and so on. At the end of the survey, 801 workers' data was collected due to their availability and responsiveness.

Data collection

Data was obtained through direct (face-to-face) interviews with appropriate safety measures as per COVID-19 policy. A set of two validated structured questionnaires were employed to collect socio-economic and dietary intake data from the workers. Interviews were taken in the factory premises with no presence of industry officials of any level. This was strictly maintained to collect unbiased data from the workers. The data was recorded in a computer-assisted program interface (CAPI) using CSEntry Pro, a survey management tool developed by the Census Board of the USA. The socio-economic characteristics consisted of the following: sex, age, income, education, family size, expenditures. For dietary data collection, a single 24-h recall was administered in 801 subjects. Among them 10% or 80 workers were selected randomly and were interviewed after one week to get two non-consecutive 24-hour dietary recall (Gibson & Ferguson, 2008). Dietary assessment was conducted at their workplace. For better estimation, food samples from each factory were weighted to find out the amount that the respondents consumed during their mid-day meal provision.

Dietary intake assessment

After the interview, the dietary data was cleaned and transformed, and the conversion factor, yield factor, and retention factor were applied where applicable to calculate the raw food intake by the workers. Details on the quantities of raw ingredients used for the preparation of food, cooking methods, the total quantity of cooked food, and its subsequent consumption by factory workers had been obtained from both the workers and those who were responsible for food preparation and distribution in the factories for better estimation. Then, the nutrient composition of the foods consumed by the individuals was computed using the Food Composition Table for Bangladesh (Shaheen, N., Bari, L., & Mannan, M. A. 2013).

Assessment of the probability of nutrient adequacy (MPA)

We calculated the probability of adequacy for each micronutrient using harmonized average requirements (Allen, Carriquiry, and Murphy, 2020). Following the Institute of Medicine guidelines, coefficients of variation and standard deviations for each micronutrient were determined (IOM, 2000). The zinc requirements assumed semirefined diets, reflecting the typical consumption of both unrefined and semirefined food ingredients by rural populations in Bangladesh. For iron, we applied a moderate absorption efficiency of 10% bioavailability, utilizing the full probability method to evaluate adequacy (Allen, Carriquiry and Murphy, 2020). Calcium adequacy was assessed based on the method by Foote et al. (2004), which compares intake levels to the adequate intake (AI). Calcium probability of adequacy was assigned as follows: 0% for intakes below one-fourth of the AI, 25% for intakes between one-fourth and one-half of the

AI, 50% for intakes between one-half and three-fourths of the AI, 75% for intakes between three-fourths and the AI, and 100% for intakes exceeding the AI. The mean probability of adequacy (MPA) for micronutrient intake was computed by averaging the probabilities of adequacy (PAs) for 11 micronutrients: vitamin A, thiamin, riboflavin, niacin, vitamin B-6, folate, vitamin C, calcium, iron, and zinc. The resulting value for PA ranged from 0 to 100%, and an overall mean probability of adequacy (MPA) was calculated by averaging the PA across the ten nutrients. The prevalence of inadequacy was defined by considering MPA below 50% (MPA <0.5) (Román-Viñas et al., 2009). This threshold denotes consumption of 50% to 75% of AI for an individual which helps prevent micronutrient deficiencies. Due to the absence of vitamin B-12 data in the Bangladesh Food Composition Table, it was excluded from the analysis.

Statistical analysis

The data were primarily cleaned in the CSEntry pro software. Using the software-provided data export interface, all the survey data were exported in three formats: excel (.csv), SPSS (.sav), and STATA (*.dta)*. Descriptive as well as inferential statistics were conducted in two software (SPSS & STATA). For normally distributed data, associations were analysed by independent sample t-test, whereas for non-normally distributed data, Mann-Whitney U tests were conducted. A multiple logistic regression analysis was conducted to investigate the effect of socio-economic factors on the MPA of the workers. A $p < 0.05$ was considered a statistically significant level for all tests.

Ethical approval

The nature and purpose of the study were explained in detail to all study participants and written informed consent was obtained from all the study respondents upon agreeing to participate in the study. Ethical approval was obtained from the Institutional Review Board (IRB) of the Institute of Health Economics, University of Dhaka (Ref. No. IHE/IRB/DU/03/2023/Final).

Results

Socioeconomic characteristics of the study participants

Table 1 shows the socio-economic characteristics of study participants (n = 801). Significant gender differences were found in industry location, age, education, income, living status, and household earnings. More females (60.9%) worked in Dhaka, while more males (65.2%) worked in Mymensingh. Females were younger (52.6% aged 18-24) compared to males (56.8% aged 25-34). Males had higher education levels (33.6% with HSC or higher), while females had lower education levels (22.4% up to primary). Income distribution varied, with more males earning >13,000 BDT (41.7% vs. 20.9% of females). More females (92.3%) lived in their own households, while more males (30.0%) lived in a mess. Lastly, males were more likely to live in single-earning households, while females had more double-earning households.

Table 1. Socio-economic characteristics of study participants (n= 801)

Variables	Overall (n=801) %	Male (n=333) %	Female (n=468) %	*p*-value
Industry location				<0.001
Dhaka (Snowtex Outerwear Ltd.)	50.1	34.8	60.9	
Mymensingh (Square Fashion Ltd.)	49.9	65.2	39.9	
Age				<0.001
18-24	43.4	30.6	52.6	
25-34	46.9	56.8	40.0	
≥ 35	9.6	12.6	7.5	
Education				<0.001
Up to Primary	17.0	9.3	22.4	
Secondary Incomplete	35.7	31.2	38.9	
SSC passed	21.7	25.8	18.8	
HSC or Higher	25.6	33.6	19.9	
Personal monthly income (BDT)				<0.001
<9,000	13.6	8.4	17.3	
9,000-11,000	40.3	33.6	45.1	
11,001-13,000	16.5	16.2	16.7	
>13,000	29.6	41.7	20.9	
Living status of the workers				<0.001
Mess or others	17.0	30.0	7.7	
In own Household	83.0	70.0	92.3	
Household members				0.340

≤ 2	44.2	46.8	42.3	
3-5	45.7	42.6	47.9	
≥ 6	10.1	10.5	9.8	
Household earning members				
Single	35.3	55.9	20.7	<0.001
Double	54.9	36.9	67.7	
≥ 3	9.7	7.2	11.5	

Note: *p-* values were derived from chi-square test

Food group consumption pattern among study participants

Table 2 presents the food group consumption patterns among RMG workers, categorized by sex and workdays. Overall, nuts and seeds, milk and milk products, and fruits consumption was very low. Significant differences were found between male and female workers in the consumption of certain food groups. For example, males consumed higher amounts of rice, pulses, and animal-source foods, such as beef, compared to females. Additionally, significant variations in food consumption were observed between working and non-working days. Specifically, workers consumed greater quantities of potatoes, non-leafy vegetables, and pulses on working days than on non-working days.

Table 2. Food group consumption pattern among study participants (grams/day) by sex and working days

Food groups	Overall Median (IQR)	Sex		*p*-value	Workdays		*p*-value
		Male Median (IQR)	Female Median (IQR)		Non-working days Median (IQR)	Working days Median (IQR)	
Cereals	369.6 (369.6, 394.3)	369.6 (369.6, 422.7)	369.6 (354.5, 384.6)	<0.001	369.6 (314.4, 391.2)	369.6 (369.6, 394.6)	0.076
Rice	369.6 (311.6, 369.6)	369.6 (333.3, 371.6)	369.6 (285.5, 369.6)	0.001	369.6 (254.1, 369.6)	369.6 (346.5, 369.6)	0.003
Wheat	0.0 (0.0, 33.5)	0.0 (0.0, 46.9)	0.0 (0.0, 30.0)	0.974	0.0 (0.0, 50.0)	0.0 (0.0, 30.0)	0.010
Potato	57.0 (26.0, 93.2)	59.6 (26.0, 97.4)	55.0 (26.0, 89.7)	0.318	39.0 (0.0, 90.3)	59.6 (27.0, 93.2)	0.012
Vegetables	157.6 (95.0, 246.7)	159.0 (90.8, 255.1)	156.6 (95.6, 236.9)	0.811	109.4 (44.5, 203.6)	166.9 (99.1, 252.5)	<0.001
Non-leafy vegetables	118.5 (57.0, 191.4)	124.9 (57.0, 191.4)	111.3 (57.6, 188.7)	0.680	68.1 (0.0, 131.0)	135.2 (65.0, 195.8)	<0.001
Leafy vegetables	0.0 (0.0, 49.7)	0.0 (0.0, 46.2)	0.0 (0.0, 54.0)	0.970	0.0 (0.0, 64.4)	0.0 (0.0, 46.5)	0.280
Pulses	18.0 (11.0, 30.6)	18.0 (12.4, 39.0)	15.0 (7.5, 25.5)	<0.001	7.2 (0.0, 24.8)	18.0 (12.4, 33.0)	<0.001
Masoor	16.2 (8.1, 25.0)	18.0 (11.3, 30.0)	15.0 (2.4, 24.6)	0.002	0.0 (0.0, 15.0)	18.0 (12.4, 26.9)	<0.001
Nuts and seeds	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.225	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.007
Milk and milk products	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.041	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.018
Fats and oil	19.0 (15.0, 26.0)	20.0 (16.0, 30.0)	18.0 (15.0, 25.0)	0.038	19.0 (12.5, 24.0)	19.0 (16.0, 28.0)	0.067
Soyabean	18.0 (15.0, 26.0)	20.0 (15.0, 30.0)	18.0 (15.0, 24.5)	0.053	19.0 (12.5, 24.0)	18.0 (15.6, 27.0)	0.102
Animal source food	130.0 (88.0, 186.6)	130.0 (93.0, 191.0)	130.4 (80.0, 181.5)	0.122	167.7 (107.0, 262.5)	125.0 (86.3, 174.7)	<0.001
Beef	0.0 (0.0, 0.0)	0.0 (0.0, 35.0)	0.0 (0.0, 0.0)	0.004	0.0 (0.0, 38.0)	0.0 (0.0, 0.0)	0.026
Chicken	0.0 (0.0, 45.0)	0.0 (0.0, 50.0)	0.0 (0.0, 41.8)	0.708	0.0 (0.0, 103.6)	0.0 (0.0, 35.0)	0.012
Eggs	19.0 (0.0, 39.2)	0.0 (0.0, 38.0)	30.0 (0.0, 39.2)	0.081	0.0 (0.0, 25.0)	33.1 (0.0, 39.2)	<0.001
Fish	55.0 (24.0, 100.0)	58.9 (24.8, 100.0)	53.4 (22.5, 99.7)	0.403	60.8 (17.6, 117.0)	55.0 (24.0, 97.0)	0.325
Spices	51.8 (36.0, 71.0)	52.0 (36.0, 69.0)	51.5 (36.0, 71.9)	0.557	60.2 (41.1, 83.6)	50.2 (35.2, 67.0)	<0.001

Onion	36.0 (24.0, 51.0)	35.0 (23.0, 48.7)	37.2 (25.1, 57.0)	0.022	43.5 (28.5, 65.3)	35.7 (23.2, 48.7)	<0.001
Chilies	10.9 (8.0, 14.6)	11.0 (8.2, 15.0)	10.0 (7.6, 13.8)	0.135	10.0 (6.2, 14.8)	10.9 (8.2, 14.0)	0.040
Fruits	0.0 (0.0, 54.0)	0.0 (0.0, 45.5)	0.0 (0.0, 55.0)	0.439	0.0 (0.0, 58.5)	0.0 (0.0, 51.8)	0.113
Sugar	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	<0.001	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.013
Miscellaneous	0.0 (0.0, 16.0)	0.0 (0.0, 25.0)	0.0 (0.0, 4.5)	<0.001	0.0 (0.0, 30.0)	0.0 (0.0, 15.0)	0.001

Note: IQR= Inter quartile range; *p* values from independent sample t-test/Mann-Whitney U test

Energy and macro-nutrient intake

Table 3 shows the energy and macronutrient intake of RMG workers, categorized by sex and working days. Male workers reported significantly higher energy, protein, fat, and carbohydrate intakes than females (p < 0.001). On working days, intakes of protein, fat, and carbohydrates were significantly lower compared to non-working days (p < 0.05), whereas energy intake did not differ significantly (p = 0.586).

Table 3. Energy and macronutrient intake among study participants by sex and working days

Nutrients	Overall Median (IQR)	Sex		*p*-value	Workdays		*p*-value
		Male Median (IQR)	Female Median (IQR)		Non-working days Median (IQR)	Working days Median (IQR)	
Energy (kcal)	1949.0 (1843.2, 2112.8)	2030.0 (1913.1, 2196.1)	1901.0 (1804.7, 2029.7)	<0.001	1955.2 (1817.0, 2175.9)	1948.4 (1852.4, 2102.2)	0.586
Protein (g)	65.1 (59.5, 72.1)	68.2 (63.2, 75.3)	62.7 (57.3, 69.3)	<0.001	67.9 (61.3, 78.3)	64.6 (59.4, 71.3)	<0.001
Fat (g)	33.0 (29.1, 38.3)	34.5 (30.5, 39.6)	32.1 (28.3, 36.6)	<0.001	34.8 (30.2, 40.2)	32.9 (29.0, 37.3)	0.032
Carbohydrate (g)	327.7 (314.1, 347.3)	339.4 (324.3, 366.0)	320.0 (309.0, 334.8)	<0.001	322.1 (307.2, 346.7)	328.3 (315.3, 347.3)	0.040

Note: IQR= Inter quartile range; *p* values from independent sample t-test/Mann-Whitney U test

Distribution of energy from macronutrients

Table 4 presents the distribution of energy intake from macronutrients among the study participants. The findings indicate that carbohydrates are the primary source of energy, contributing 66.9% of the total energy intake. A majority of participants (66%) consumed carbohydrates above the recommended range (45 to 65% of total energy). Protein and fat intake remained within the recommended range for most participants, with 77.2% and 54%, respectively. However, 43.4% of the participants consumed the recommended level of fat less than 15%. Additionally, for all three macronutrients, there is a significant difference in consumption between working and non-working days.

Table 4. Percent of energy intake from macronutrients by study participants

Macronutrients	Share of total energy (%)	Ranges of intake, %	% Population	Male (n=333) %	Female (n=468) %	*p*-value	Non-working days (n=128) %	Working days (n=670) %	*p*-value
Carbohydrates	66.9	<45	0.4	0.0	0.6	0.291	0.0	0.4	<0.001
		45%-65%	33.6	34.8	32.7		50.0	30.5	
		>65%	66.0	65.2	66.7		50.0	69.1	
Protein		<5%	0.0	0.0	0.0	0.386	0.0	0.0	<0.001
	13.7	5%-15%	77.2	78.7	76.1		60.2	80.4	

		>15%	22.8	21.3	23.9		39.8	19.6	
Fat	16.7	<15%	43.4	44.1	42.9	0.388	31.3	45.8	0.009
		15%-35%	54.9	55.0	54.9		66.4	52.7	
		>35%	1.6	0.9	2.1		2.3	1.5	

Note: The adequacy of macronutrient intake was assessed by comparing the percentage of energy derived from three macronutrients to the AMDR established by the ICMR (2020); AMDR cutoffs: Carbohydrate (45-65%), Protein (5-15%), Fat (15-35%); ICMR = Indian Council of Medical Research; AMDR = Acceptable Macronutrient Distribution Ranges

Micronutrient intake among study participants

Table 5 highlights significant differences in micronutrient intake among study participants. Iron intake was higher in males than females ($p < 0.001$), while calcium intake was significantly higher on workdays compared to non-working days ($p = 0.045$). Vitamin A intake was higher in females than males ($p = 0.004$), and vitamin B12 intake was higher on workdays than on non-working days ($p = 0.007$). Additionally, significant variations were observed in riboflavin, niacin, and vitamin B6 intake.

Table 5. Micronutrient intake among the study participants

Nutrients	**Overall**	**Sex**		***p*-value**	**Workdays**		***p*-value**
		Male	**Female**		**Non-working days**	**Working days**	
Calcium (mg)	319.7 (233.0, 418.5)	311.0 (228.8, 417.0)	325.9 (236.9, 421.8)	0.277	339.8 (241.8, 473.2)	313.7 (229.4, 412.7)	0.045
Iron (mg)	9.3 (8.3, 10.8)	10.0 (8.8, 11.6)	8.8 (8.0, 10.0)	<0.001	9.7 (8.2, 11.5)	9.2 (8.3, 10.7)	0.133
Magnesium (mg)	326.6 (296.8, 368.9)	334.3 (303.6, 384.2)	320.4 (291.7, 359.2)	<0.001	330.4 (295.7, 376.3)	325.5 (297.3, 368.1)	0.416
Phosphorus (mg)	1000.2 (915.8, 1112.1)	1037.0 (941.6, 1155.5)	975.8 (897.4, 1078.2)	<0.001	1048.9 (932.8, 1202.8)	991.4 (913.8, 1100.8)	0.003
Potassium (mg)	1847.0 (1694.5, 2074.8)	1914.9 (1750.3, 2174.7)	1802.9 (1647.8, 2019.3)	<0.001	1884.2 (1692.6, 2151.7)	1844.8 (1696.8, 2063.8)	0.311
Sodium (mg)	187.9 (163.0, 228.5)	198.0 (173.5, 243.0)	180.5 (155.8, 219.7)	<0.001	191.4 (167.6, 255.6)	187.3 (162.9, 223.9)	0.062
Zinc (mg)	10.4 (9.7, 11.5)	10.8 (10.1, 12.1)	10.2 (9.5, 11.1)	<0.001	10.6 (9.6, 12.2)	10.4 (9.7, 11.5)	0.202
Copper (mg)	2.0 (1.9, 2.2)	2.1 (1.9, 2.3)	2.0 (1.8, 2.2)	<0.001	2.0 (1.8, 2.2)	2.0 (1.9, 2.2)	0.428
Vitamin A, RAE (mcg)	171.1 (148.0, 206.1)	162.8 (139.7, 196.3)	178.6 (151.3, 213.8)	0.004	170.4 (140.9, 218.5)	171.3 (148.1, 204.2)	0.847
Retinol (mcg)	48.7 (31.8, 57.4)	46.6 (28.6, 54.6)	51.5 (34.2, 59.5)	<0.001	47.6 (32.1, 60.2)	49.3 (31.1, 57.2)	0.847
Vitamin E (mg)	1.3 (1.2, 1.4)	1.3 (1.2, 1.4)	1.3 (1.2, 1.4)	<0.001	1.3 (1.2, 1.4)	1.3 (1.2, 1.4)	0.173
Thiamine(mg)	0.7 (0.7, 0.8)	0.7 (0.7, 0.8)	0.7 (0.7, 0.8)	0.081	0.8 (0.7, 0.9)	0.7 (0.7, 0.8)	0.262
Riboflavin (mg)	17.0 (15.9, 18.0)	17.3 (16.0, 18.3)	16.8 (15.7, 17.8)	0.246	17.5 (16.0, 19.0)	17.0 (15.9, 17.8)	0.015
Niacin EQ (mg)	1.6 (1.4, 1.8)	1.7 (1.5, 1.8)	1.5 (1.4, 1.7)	<0.001	1.6 (1.4, 1.9)	1.6 (1.4, 1.7)	0.003

Vitamin B6 (mg)	322.4 (306.0, 344.3)	332.8 (322.2, 361.0)	308.9 (301.0, 338.4)	<0.001	315.7 (302.9, 339.9)	324.5 (306.5, 345.7)	0.021
Folate (mcg)	62.3 (49.7, 76.4)	63.4 (50.7, 77.2)	60.8 (49.0, 75.6)	<0.001	58.4 (43.0, 78.9)	62.5 (50.8, 75.6)	0.011
Vitamin C (mg)	4.5 (4.2, 4.9)	4.6 (4.3, 5.0)	4.5 (4.1, 4.8)	0.054	4.5 (4.1, 5.0)	4.5 (4.2, 4.9)	0.072
Vitamin B12 (mcg)	1.7 (1.3, 2.2)	1.7 (1.2, 2.2)	1.7 (1.3, 2.2)	0.238	1.9 (1.3, 2.5)	1.7 (1.3, 2.1)	0.007

Note: Data presented as median (IQR), IQR= Inter quartile range

Contribution of food groups to selected micronutrients

Figure 1 shows the contribution of different food groups to the daily supply of selected macronutrients and micronutrients among female workers. Cereals and carbohydrates played a dominant role in the intake of energy (64.5%) and carbohydrates (84.6%), while pulses and legumes contributed significantly to protein intake (40.5%). Vegetables and fish, meats, and eggs contributed notably to the intake of folate, vitamin A, iron, and calcium, whereas edible oils and fats provided the largest share of fat (61.4%). This pattern was almost similar among the male RMG workers (Figure 2).

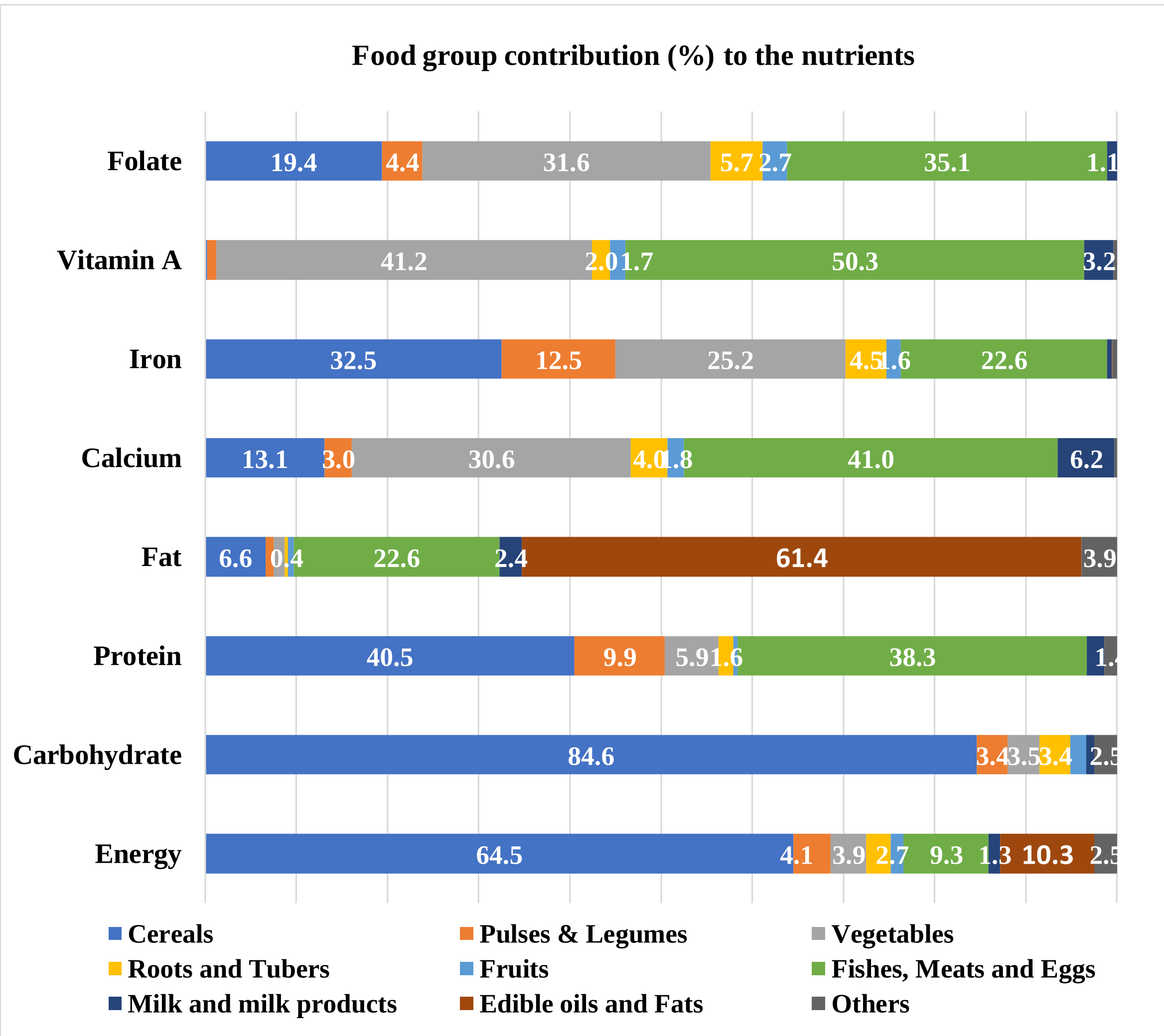


Figure 1. Contribution of food groups to the daily intake of selected macronutrients and micronutrients among female workers (n = 468)

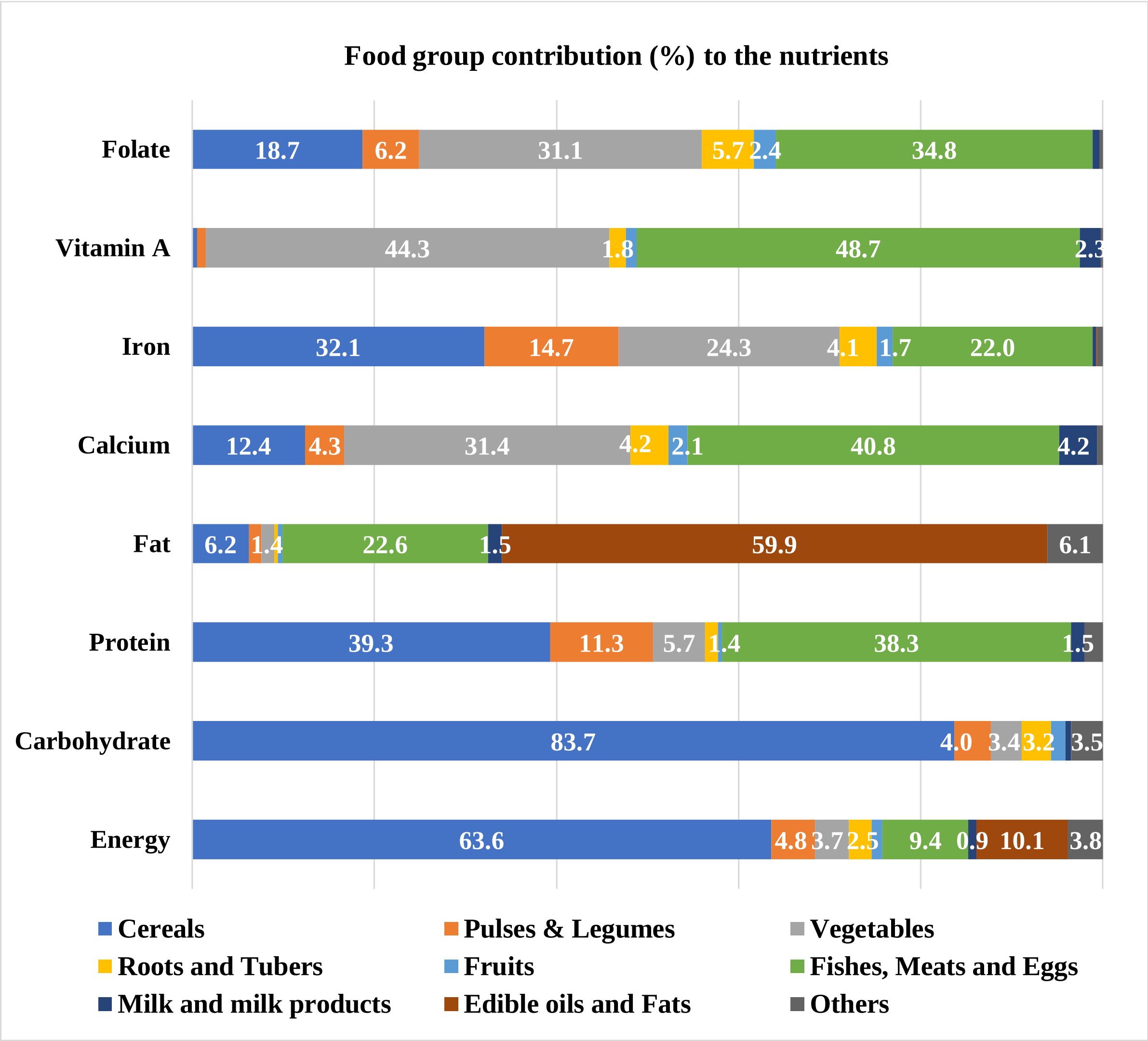
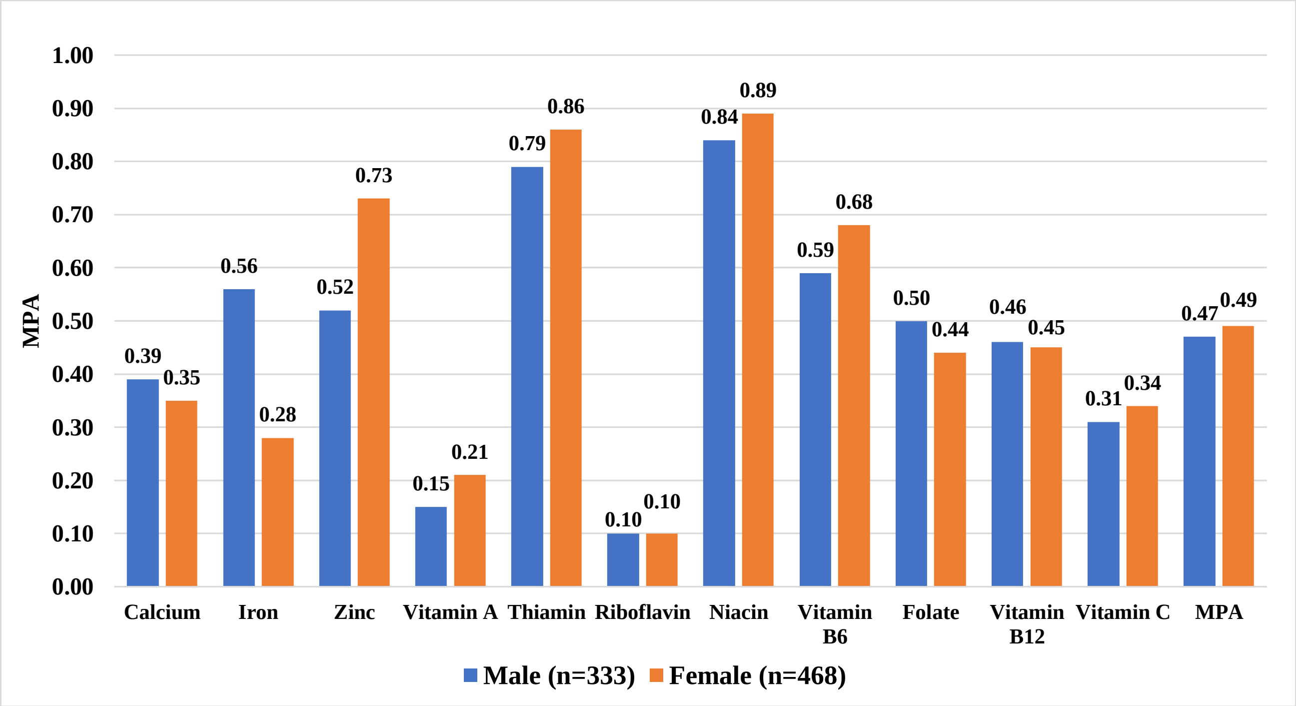


Figure 2. Contribution of food groups to the daily intake of selected macronutrients and micronutrients among male workers (n = 333)

Mean probability of micronutrient adequacy

Figure 3 illustrates the MPA for various micronutrients among RMG workers, segmented by gender. Males showed a higher PA for calcium (0.39) compared to females (0.35), while iron and zinc had low PA values across both genders, with females showing slightly lower adequacy for zinc (0.28) and iron (0.52). Overall, the findings suggest that less than half of the participants consumed adequate micronutrients.



Note. MPA= Mean Probability of Adequacy

Figure 3. Mean probability of adequacy of micronutrients among the study participants

Nutritional status of the workers

Figure 4 illustrates the nutritional status of RMG workers based on the World Health Organization (WHO) and Asian BMI classifications. According to the Asian BMI classification, 44% of workers were classified as overweight or obese, with a higher prevalence observed among female workers compared to males (46.6% vs. 40.2%). While the prevalence was low based on WHO BMI classification (24.1%) overweight or obese, with female workers again showing a higher prevalence than their male counterparts (26.5% vs. 20.7%).

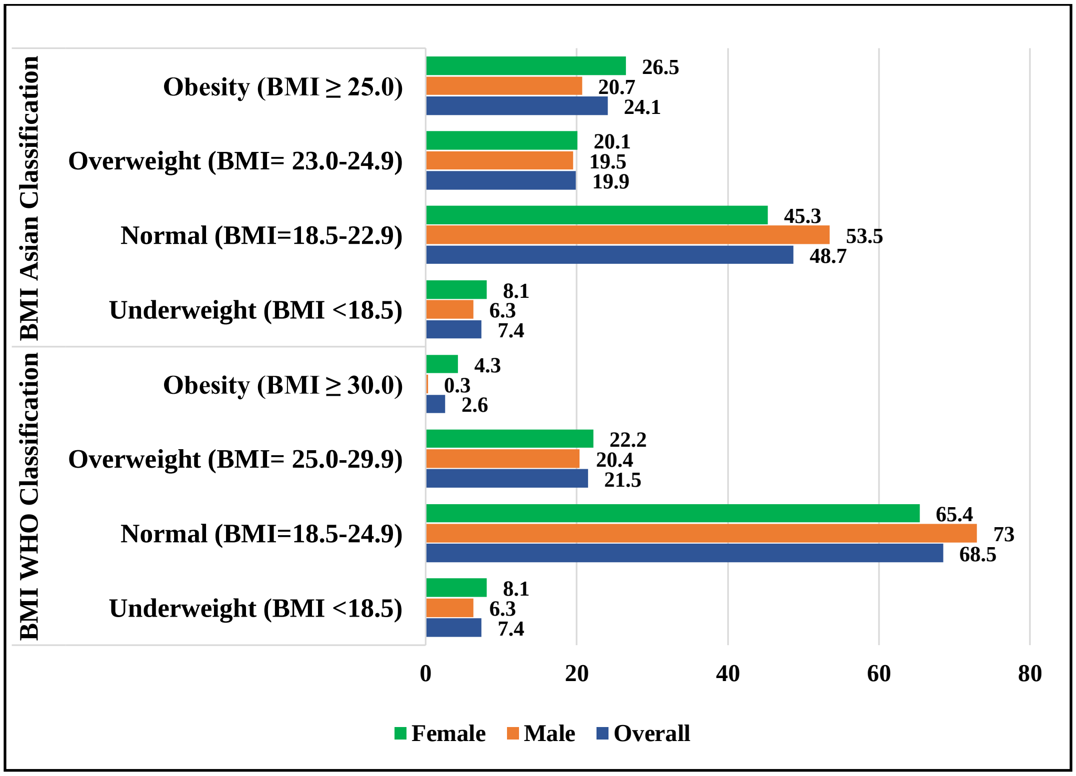


Figure 4. Nutritional status of the RMG workers according to the BMI Asian and WHO classification

The multiple logistic regression analysis (Table 6) reveals that workers from Square Fashion Ltd. (located in Mymensingh region) had a significantly higher likelihood of achieving micronutrient adequacy (MPA > 0.5) (AOR = 1.68, 95% CI: 1.18–2.41, p = 0.004) compared to those from Snowtex Outerwear Ltd. (located in an urban region). The age group of 25–34 years was also significantly associated with higher MPA (AOR = 1.40, 95% CI: 1.00–1.95, p = 0.049) when compared to the 18–24 age group. However, other factors did not show significant associations with micronutrient adequacy after adjusting for potential confounders.

Table 6. Multiple logistic regression analysis of socio-economic factors influencing the mean probability of adequacy (MPA) among the study participants

Variables	Micronutrient Adequacy				
	(%) (MPA > 0.5)	COR (95% CI)	p-value	AOR (95% CI)	p-value
Industry name					
Snowtex Outerwear Ltd. (Dhaka)	42.3	1 (Ref.)		1 (Ref.)	
Square Fashion Ltd. (Mymensingh)	57.7	1.77 (1.34, 2.35)	<0.001	1.68 (1.18, 2.41)	0.004
Sex					
Male	41.5	1 (Ref.)		1 (Ref.)	
Female	58.5	1.01 (0.76, 1.34)	0.963	1.20 (0.86, 1.68)	0.280
Age in years					
18 to 24	40.4	1 (Ref.)		1 (Ref.)	
25 to 34	50.3	1.30 (0.97, 1.74)	0.083	1.40 (1.00, 1.95)	0.049
≥ 35	9.3	1.08 (0.66, 1.78)	0.759	1.14 (0.65, 1.99)	0.649
Living status of the workers					
Mess or others	17.3	1 (Ref.)		1 (Ref.)	
In own Household	82.7	0.96 (0.66, 1.39)	0.821	1.11 (0.65, 1.90)	0.710
Educational status					
Up to Primary	16.8	1 (Ref.)		1 (Ref.)	
Secondary Incomplete	32.7	0.88 (0.58, 1.32)	0.529	0.93 (0.61, 1.43)	0.748
SSC Passed	20.9	0.95 (0.61, 1.50)	0.836	1.05 (0.64, 1.71)	0.843
HSC or Higher Education	29.7	1.37 (0.89, 2.12)	0.157	1.39 (0.86, 2.23)	0.175
Personal Income (BDT)					
<9,000	13.2	1 (Ref.)		1 (Ref.)	
9000 to 11,000	36.5	0.89 (0.57, 1.38)	0.601	0.91 (0.58, 1.43)	0.670
11001 to 13,000	16.2	1.03 (0.62, 1.71)	0.918	0.93 (0.54, 1.60)	0.794
>13,000	34.1	1.40 (0.88, 2.20)	0.153	1.06 (0.62, 1.79)	0.837
Number of Household Members					

≤ 2	45.3	1 (Ref.)		1 (Ref.)	
3 to 5	44.5	0.91 (0.68, 1.22)	0.527	0.90 (0.62, 1.29)	0.561
≥ 6	10.2	0.96 (0.59, 1.56)	0.880	0.83 (0.46, 1.48)	0.528
Numbers of Household Earning Members					
Single	34.3	1 (Ref.)		1 (Ref.)	
Double	54.7	1.04 (0.77, 1.41)	0.780	1.21 (0.81, 1.81)	0.353
≥ 3	11.0	1.33 (0.81, 2.20)	0.265	1.75 (0.93, 3.30)	0.081

Note: COR = Crude Odd Ratios, AOR = Adjusted Odd Ratios

Discussion

This study provides a comprehensive assessment of the dietary quality, probability of nutrient adequacy, and nutritional status of workers from selected RMG factories in Bangladesh. Approximately 44% of workers were categorized as overweight or obese according to the Asian BMI cutoff. Cereals emerged as the primary source of carbohydrates and energy, while pulses and legumes significantly contributed to protein intake. The majority of dietary fat was derived from edible oils and fats. Over half of the respondents demonstrated insufficient micronutrient intake, with a mean micronutrient adequacy (MPA) score falling below 0.5. Notable inadequacies were identified in calcium, iron, riboflavin, folate, and vitamin A. Workers in the Mymensingh region were 1.68 times more likely to achieve micronutrient adequacy than those in the Dhaka region.

Overweight and obesity rates among RMG workers in this study are slightly higher than the national average of 33% (NIPORT, 2023). While this scenario has been reported in previous studies, it might be possible that the sedentary nature of their jobs contributes to this nutritional imbalance, particularly among women (Yeasmin, 2019). The dietary habits of these workers could further explain the discrepancy in nutritional status.

RMG workers exhibited distinct dietary patterns across the week. While participants consumed more food on the working days, their intake of animal-based products and vegetables was notably higher during weekends. This shift in dietary composition resulted in a significantly higher protein and fat intake on weekends, likely contributing to the observed discrepancy in macronutrient consumption without a concomitant change in overall caloric intake, which was approximately 1950 kcal across the study period. Gender-based disparities were evident in dietary consumption patterns, with male workers consistently consuming greater quantities across most food groups than their female counterparts. A similar trend was observed in macronutrient intake.

As previously highlighted, micronutrient inadequacy was widespread among the study population, with over half of the workers exhibiting insufficient micronutrient intake. Of the eleven micronutrients assessed, riboflavin exhibited the highest prevalence of inadequate intake (approximately 90%), followed by vitamin A (82%), vitamin C (68%), calcium (63%), and iron (58%). The high prevalence of inadequate vitamin A, riboflavin, folate, and iron intake, coupled with adequate niacin consumption found in our study, aligns with the findings of previous studies among pregnant and lactating women in

Bangladesh (Arsenault et al., 2013; Nguyen et al., 2018). The observed insufficiency in calcium and riboflavin intake can be attributed to the limited dietary quality, characterized by minimal consumption of milk and dairy products of the population (Mirmiran et al., 2006). In an earlier study, around 50% of the population was found to have zero consumption of animal-based products such as meat and milk (Akheruzzaman et al., 2021). Mirmiran et al. (2006) demonstrated a positive association between dairy product consumption and the adequacy of calcium, phosphorus, zinc, and protein intake. So, the workers should be encouraged and incentivized to consume more dairy products regularly. Consumption patterns of water-soluble vitamins varied significantly by day of the week. Intake of niacin, vitamin B_6, folate, and vitamin B_{12} was substantially higher on weekdays compared to weekends. The predominant sources of these vitamins, cereal-based foods, were consumed more frequently on weekdays, likely explaining this pattern. Conversely, riboflavin and calcium intake, primarily derived from animal-based products, was higher on weekends, aligning with the increased consumption of these foods. Furthermore, significant gender disparities in micronutrient intake were observed. Males consumed higher amounts of most micronutrients (iron, magnesium, phosphorus, potassium, sodium, zinc, copper, niacin, vitamin B_6, and folate) compared to females, except calcium and vitamin A. Given the higher overall caloric intake among males, this group's observed pattern of greater micronutrient consumption is unsurprising.

Micronutrient deficiencies among Ready-Made Garment (RMG) workers, particularly in calcium, iron, riboflavin, folate, and vitamin A, can have a significant impact on both health and productivity. For example, iron deficiency is a leading cause of anemia, which impairs cognitive and physical work capacity, thereby directly reducing productivity (Meyer, 2024). Additionally, vitamin A deficiency weakens immune function, making individuals more vulnerable to infections, which can lead to higher rates of illness and absenteeism (USAID, 2022). Addressing these deficiencies through targeted interventions, such as dietary approaches and supplementation, is essential for improving worker health and sustaining productivity (Magee and McCann, 2019).

To identify factors associated with overall diet quality among RMG workers, we employed a regression model using the MPA as a proxy for dietary adequacy. Though significant consumption variation was observed across weekdays and weekdays, even across genders, in the adjusted model, MPA was significantly associated with the area of residence of indicating workers in Mymensingh had a significantly 68% times higher probability of achieving micronutrient adequacy than the workers of the Dhaka region. Several possible explanations can support the present findings; as Mymensingh was situated on the outskirts of the city area, the overall cost of living was relatively lower there (Roy, 2010). A previous study demonstrated that the food price in rural Mymensingh is considerably lower than in urban Dhaka city (Islam et al., 2023). In rural areas, workers have the advantage of farmgate food. The farmgate prices of food products were lower than those in city areas (BNNC, 2020). Workers might have enjoyed lower food prices than the city dwellers. Affordable cost of living, lower food prices, and higher food availability might be the underlying reasons for the higher probability of micronutrient adequacy in rural workers compared to their urban counterparts.

Several targeted measures should be implemented to address the dual burden of overnutrition and micronutrient inadequacy among RMG workers. Establishing fair price shops (FPS) within factory premises can enhance the affordability and accessibility of healthier dietary options for workers. Additionally, nutrition education programs should be introduced across all sections of the factories to empower workers with the knowledge to make better food choices, even within their limited budgets.

The study has several strengths. The study analyzed data from 801 RMG workers, ensuring robust and generalizable findings. By evaluating both macronutrient and micronutrient intakes, it provided a comprehensive picture of dietary adequacy, with the Probability of Adequacy (PA) method adding precision to the assessment of micronutrient adequacy. Additionally, identifying gender-based disparities in food and nutrient intake highlights critical areas for targeted nutritional interventions. This study's cross-sectional design limits the ability to establish causal relationships between dietary patterns and health outcomes. Additionally, dietary data collected on only two non-consecutive days may not fully represent habitual intake patterns, and the purposive selection of factories restricts the generalizability of findings across the entire RMG sector. Furthermore, the study does not account for seasonal or time-dependent variations in food availability and consumption, which could influence dietary behavior.

Conclusion

The study concludes that overnutrition and micronutrient inadequacy coexist among RMG workers in Bangladesh. Gender disparities in the consumption of both macro- and micronutrients were also evident. RMG workers in the Dhaka region are at a higher risk of micronutrient inadequacy than their counterparts in the Mymensingh region. Area-specific interventions, such as promoting nutrition education and improving affordability and the food environment, should be implemented to reduce the nutrient intake gap among workers and promote healthier dietary practices.

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