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Study on the Assessment of Dietary Intake, Gut Health and Immune Status in Rickshaw Drivers Aged 25-45 Years in Mumbai, Maharashtra

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Abstract: Background: Rickshaw drivers form a vulnerable and often overlooked occupational group exposed to multiple health challenges due to prolonged working hours, sedentary behavior, irregular eating habits, and limited access to healthcare. The interrelationship between dietary intake, gut health, and immune status remains underexplored in this segment of urban informal workers. This study aims to assess these domains and explore their associations to inform targeted nutritional interventions.

Methods: A cross-sectional study was conducted among 101 male rickshaw drivers aged 25–45 years in Mumbai, Maharashtra, using convenience sampling. Data collection included a 24-hour dietary recall, Food Frequency Questionnaire (FFQ), Gastrointestinal (GI) Health Assessment Questionnaire, and Immune Status Questionnaire (ISQ), along with self-reported anthropometric and socio-demographic information. Statistical analyses were performed using descriptive statistics, ANOVA, and chi-square tests via SPSS (Version 21).

Results: Mean energy and protein intakes were 1646.23 ± 438.07 kcal and 49.11 ± 14.12 g/day respectively, both significantly below the Recommended Dietary Allowance (RDA). Fiber intake averaged 28.15 ± 9.22 g, reaching approximately 93% of the RDA. The dietary pattern showed frequent consumption of low-nutrient street foods and low intake of diverse whole grains and pulses. GI symptoms were prevalent, indicating compromised gut health in a majority of participants. Immune status was significantly associated with age (p=0.013), marital status (p=0.049), alcohol consumption (p=0.032), and household size (p=0.001), though no significant relationship was found between overall nutrient intake and immune status.

Conclusion: This study highlights notable dietary inadequacies, poor gut health, and compromised immunity among rickshaw drivers in Mumbai. The findings suggest that while dietary intake remains suboptimal, immune health may be more strongly influenced by lifestyle and socio-demographic factors. There is a critical need for comprehensive, community-based interventions that promote dietary awareness and improve gut and immune health among Auto Rickshaw Drivers.

Keywords: Dietary Intake, Gut Health, Immune Status, Auto-Rickshaw Drivers,Nutritional Assessment, Gastrointestinal Symptoms, Mumbai, India.

I. INTRODUCTION

Sustainable transportation is essential for promoting environmentally conscious urban living, and auto-rickshaws constitute a vital component of India's public transport ecosystem. They provide affordable and convenient last-mile connectivity, serving as a lifeline for millions of commuters across cities. However, the occupational environment of auto-rickshaw drivers exposes them to significant health risks. Long working hours, irregular schedules, minimal rest, and constant exposure to air pollution and noise especially due to the vehicle's open design create a high-stress and physically demanding lifestyle (Joshi et al., 2021).

Despite their role in facilitating urban mobility, the health and wellbeing of auto-rickshaw drivers often remain neglected. These drivers routinely face environmental stressors such as whole-body vibration, traffic-related air pollutants, and heat, which are compounded by nutritional inadequacies and lack of access to healthcare (Asma et al., 2019). Digestive disturbances and musculoskeletal discomfort are common due to poor posture, minimal breaks, and inadequate sanitation facilities (Ali et al., 2023; Debbarma et al., 2017).

Nutritional imbalances are a critical concern among this population. Due to time constraints and economic limitations, many drivers consume low-cost street food, which often lacks essential nutrients. Their diets are frequently deficient in macronutrients and micronutrients vital for immune function and metabolic health.

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Over time, such dietary patterns contribute to fatigue, poor digestive function, reduced immunity, and increased risk of non-communicable diseases like diabetes, hypertension, and cardiovascular disorders (Sukumar et al., 2021; Camilo et al., 2018).
Furthermore, constant exposure to environmental pollutants not only compromises respiratory and cardiovascular health but also has implications for gut and immune health. The gut microbiota plays a key role in nutrient absorption, stress response, and immune regulation factors that are directly affected by poor dietary practices and chronic exposure to stress and pollutants (Joshi et al., 2021). However, the unique combination of these risk factors in auto-rickshaw drivers has received limited research attention.
This study aims to examine the association between dietary intake, Gut health, and Immune Status in Rickshaw drivers aged 25–45 years in Mumbai, Maharashtra. Rickshaw drivers in urban areas like Mumbai face unique occupational and lifestyle challenges, including irregular work hours, and poor dietary habits, all of which negatively affect their gut health. Despite their crucial role in the city's transport system, their nutritional and health needs remain largely neglected. Limited research exists on the combined assessment of dietary intake, gut health, and immune status in this group.

II. METHODOLOGY

A cross-sectional study was conducted among 101 Auto Rickshaw Drivers aged 25–45 years in Mumbai, Maharashtra, India. Participants were selected using purposive sampling to ensure a diverse representation of dietary habits, and health conditions. The inclusion criteria consisted of rickshaw drivers aged 25-45 years, and people who gave informed consent to participate in dietary recall stress,immune and gut health assessments. Adults aged above 45 years, presence of any severe chronic disease like crohn's disease, ulcerative colitis, Irritable bowel syndrome, and use of tobacco and any other drug abuse were excluded from the study.
Ethical clearance was obtained from the Intersystem Biomedical Ethics Committee (ISBEC) prior to data collection, and written informed consent was secured from all participants to ensure voluntary participation and data confidentiality. Data were collected over four months using a structured online questionnaire, including both self-developed and validated tools.
The tools administered included socio-demographic and lifestyle questionnaires, anthropometric measurements (height, weight, BMI, waist circumference), a 24-hour dietary recall for nutrient intake, food frequency questionnaire (FFQ), Gastrointestinal health assessment questionnaire, and the Immune Status Questionnaire (ISQ). Dietary diversity was assessed based on the number of food groups consumed in the previous 24 hours. Nutrient adequacy was evaluated by comparing macronutrient and micronutrient intake against ICMR-NIN RDA (2020) standards.
Data were analyzed using SPSS (Statistical Package for Social Sciences) software (version 21). Cross tabulations were computed for categorical data according to immune status and compared using the chi-square test. Age, anthropometry, ISQ, gastrointestinal health FFQ and dietary data were compared between very poor, reduced and excellent immunity using ANOVA test. Pearson's Correlation was used to assess correlation of demographic data. $p < 0.05$ was considered to be statistically significant.

III. RESULTS

This section presents the key findings of the study, which assessed dietary intake, gut health, and immune status among rickshaw drivers aged 25–45 years in Mumbai. The analysis includes socio-demographic characteristics, anthropometric measurements, nutrient intake patterns, gastrointestinal symptoms, and immune function. Statistical methods were applied to identify significant differences between groups categorized by immune status and gastrointestinal health. The results provide valuable insights into how lifestyle factors, dietary adequacy, and gastrointestinal functioning collectively influence immune outcomes in this occupational group. These findings highlight critical areas for nutritional intervention and public health strategies targeting auto rickshaw drivers
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TABLE NO. 1 : SOCIO- DEMOGRAPHIC CHARACTERISTICS OF THE STUDY POPULATION

DEMOGRAPHIC CHARACTERISTICS	Frequency (N,%)	Very poor Immunity	Reduced Immune Functioning	Moderate Immunity	F value	P Value
Age						
25-45	101 (100)	8	53	40	4.525	0.013*

DEMOGRAPHIC CHARACTERISTICS	Frequency (N,%)	Very poor Immunity (n=8) (n,%)	Reduced Immune Functioning (n=53) (n,%)	Moderate Immunity (n=40) (n,%)	Pearson Chi -Square	p Value
Marital status						
Prefer not to say	10(100.0)	2(20.0)	6(60.0)	2(20.0)	12.672	0.049*
Divorced	2 (100.0)	0(0.0)	2(100.0)	0(0.0)		
Married	63(100.0)	5(7.9)	26(41.3)	32(50.8)		
Single	26(100.0)	1(3.8)	19(73.1)	6(23.1)		
Occupation of the head of the family						
Elementary Occupation	23 (22.8)	1(12.5)	10(18.9)	12(30.0)	13.187	0.356
Plant and Machine Operators and Assemblers	17 (16.8)	2(25.0)	8(15.1)	7(17.5)		
Craft and Related Trade Workers	13 (12.9)	1(12.5)	5(9.4)	7(17.5)		
Skilled Agricultural and Fishery Workers	28 (27.7)	4(50.0)	18(34.0)	6(15.0)		
Skilled Workers and shop and market sales workers	10 (9.9)	0(0.0)	7(13.2)	3(7.5)		
Clerks	8 (7.9)	0(0.0)	3(5.7)	5(12.5)		
Technicians and associate professionals	2 (2.0)	0(0.0)	2(3.8)	0(0.0)		
Education of the Head of the family						
Illiterate	2 (2.0)	0(0.0)	0 (0.0)	2 (5.0)	10.936	0.205
Primary School Certificate	30 (29.7)	1 (12.5)	13 (24.5)	16(40.0)		
Middle School Certificate	41 (40.6)	4(50.0)	25(47.2)	12(30.0)		

High school certificate	25 (24.8)	3(37.5)	12 (22.6)	10 (25.0)		
Intermediate or Diploma	3 (3.0)	0 (0.0)	3(5.7)	0(0.0)		
Total monthly income of the family						
≤ 6174	35(34.7)	2 (25.0)	18 (34.0)	15(37.5)	1.228	0.873
6,175-18,496	48(47.5)	4(50.0)	27 (50.9)	17 (42.5)		
18,497-30,830	18(17.8)	2(25.0)	8 (15.1)	8(20.0)		
Interpretation						
11-15- Lower Middle	25(24.8)	2 (25.0)	15 (28.3)	8 (20.0)	2.753	0.600
5-10- Upper Lower	68(67.3)	6(75.0)	35 (66.0)	27 (67.5)		
<5- Lower	8(7.9)	0(0.0)	3(5.7)	5(12.5)		
how many people live in your household						
1-2	28(27.7)	2 (25.0)	20(37.7)	6 (15.0)	23.284	0.001*
3-4	55(54.5)	2(25.0)	21(39.6)	32(80.0)		
5-6	15(14.9)	3(37.5)	11(20.8)	1(2.5)		
7 or more	3(3.0)	1(12.5)	1(1.9)	1(2.5)		
what is your living situation						
Living Alone	8(7.9)	0(0.0)	7(13.2)	1(2.5)	7.483	0.112
Nuclear Family	46(45.5)	3(37.5)	27(50.9)	16(40.0)		
Joint Family	47(46.5)	5(62.5)	19(35.8)	23(57.5)		

Residential area do you live in						
Urban Area	18(17.8)	1(12.5)	6(11.3)	11 (27.5)	4.242	0.120
Rural Area	83(82.2)	7(87.5)	47(88.7)	29(72.5)		
consume smoke cigarettes or use other tobacco products						
Yes	34(33.7)	6(75.0)	15(28.3)	13(32.5)	7.294	0.121
Occasionally	44(43.6)	1(12.5)	24(45.3)	19(47.5)		
No	23(22.8)	1(12.5)	14(26.4)	8(20.0)		
Do you consume alcohol						
Yes	22(21.8)	5(62.5)	12(22.6)	5(12.5)	10.524	0.032*
Occasionally	44(43.6)	2(25.0)	21(39..6)	21(52.5)		
No	35(34.7)	1(12.5)	20(37.7)	14(35.0)		

Frequency Percentage (N, %), p <0.05*

The demographic characteristics of all the participants revealed that 7.9% demonstrated very poor immunity, 52.5% with reduced immune functioning, and 39.6% with moderate immunity. A statistically significant association was observed between age and immune status (p = 0.013), suggesting that age may influence immune resilience. Marital status also showed a significant association (p = 0.049), with married individuals generally showing better immune profiles compared to their single or divorced counterparts. Household size (p = 0.001) and alcohol consumption (p = 0.032) were also significantly associated with immune status. Larger households and frequent alcohol use correlated with poorer immunity, while no significant relationships were found with occupation, education, income, or tobacco use.

TABLE NO. 2 : Comparison of Anthropometric Measurement between ISQ Groups

Variable	Very poor immunity (Mean± SD) (n=8)	Reduced immune functioning (Mean± SD) (n=53)	Moderate immunity (Mean± SD) (n=40)	F value	p value
Height (cm)	159.63 ± 12.130	158.23 ±10.129	160.25±6.931	0.567	0.569
Weight (kg)	67.625 ±17.5250	63.792 ± 11.8230	60.575 ± 11.0567	1.507	0.227

BMI(kg/m2)	26.750 ± 6.99735	25.5057± 4.25791	23.6375 ± 4.53950	2.591	0.080
Waist Circumference (cm)	79.00 ± 7.3679	78.377 ± 4.6995	77.150 ± 5.7537	0.766	0.468

Anthropometric assessment revealed that while there were no statistically significant differences in height, weight, BMI, or waist circumference across immune groups, a consistent trend was observed where individuals with moderate immunity had lower BMI and body weight compared to those with reduced or very poor immunity. This trend suggests a possible inverse relationship between body fat and immune status, although there was statistical significance.

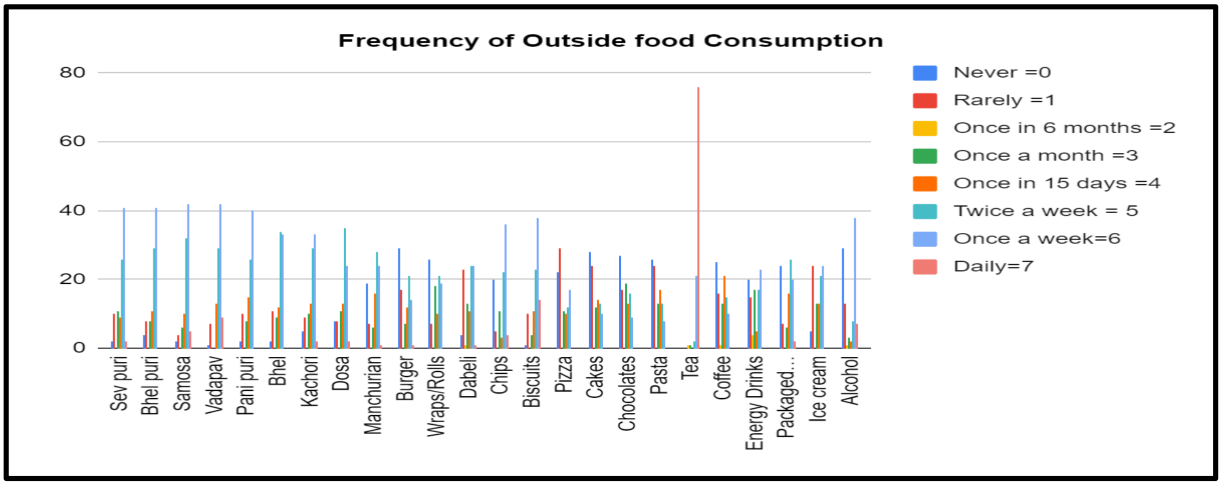

FIGURE 1 Frequency of Outside Food Consumption of the Study Participants.

The study revealed poor dietary patterns among rickshaw drivers, marked by low intake of green leafy and root vegetables, minimal fruit consumption, and a reliance on starchy vegetables like potatoes. Antioxidant-rich foods such as beetroot, carrots, and citrus fruits were rarely consumed, which may weaken immunity and increase inflammation. Street food consumption was extremely high, tea was consumed daily by 75.2% of participants, and snacks like vada pav, samosa, sev puri, and bhel puri were eaten weekly by a majority. These foods, often nutrient-poor and unhygienically prepared, were more common among those with poor immunity. Western fast foods like burgers and pizza were consumed infrequently, likely due to cost and preference. Biscuits and chips were common snacks, while sugary drinks and alcohol also showed notable consumption. Overall, the dietary habits reflect a high dependence on processed and fried foods with limited intake of balanced, nutrient-dense meals, contributing to poor gut and immune health.

TABLE NO. 3 Correlation between ISQ and Nutrient intake in study participants

Variable	Very poor immunity (Mean± SD) (n=8)	% RDA	Reduced immunity (Mean± SD) (n=53)	% RDA	Moderate immunity (Mean± SD) (n=40)	% RDA	F value	p value
Energy (kcal)	1621.13 ± 453.084	76.8	1611.09 ± 348.454	76.3	1705.33 ± 514.662	80.8	0.567	0.569
Protein (g)	45.38 ± 11.686	84.03	50.30 ± 13.246	93.15	51.03 ± 17.432	94.5	0.478	0.621
CHO (g)	242.38 ±	99.66	225.11 ±	93.15	250.30 ± 82.612	97.85	1.611	0.205

	86.274		50.171					
Fats (g)	40.13 ± 13.109	89.12	47.58 ± 21.520	106.3	45.80 ± 24.245	96.68	0.409	0.665
Fiber (g)	28.75 ± 7.086	95.83	27.06 ± 8.668	90.2	28.63 ± 11.657	95.43	0.327	0.722

Mean ± Standard Deviation, p < 0.05*

Table no. 3 presents the comparison of mean nutrient intake across immune status groups with very poor, reduced, and moderate immunity. Mean energy intake was similar across groups, ranging from 76.3% to 80.8% of the RDA, with no statistically significant difference (p = 0.569). Protein intake showed an increasing trend from the very poor (84.03% RDA) to moderate immunity group (94.5% RDA), but was not significant (p = 0.621). Carbohydrate intake remained above 90% of RDA in all groups, with the highest intake in the moderate immunity group, though the difference was also non-significant (p = 0.205). Fat intake varied from 89% to 106% of RDA, with the highest intake in the reduced immunity group (p = 0.665). Fiber intake was relatively high across all categories, ranging from 90.2% to 95.83% of RDA, with no significant differences (p = 0.722).

TABLE NO. 4 Correlation between ISQ and GI health in study population

Variable	Very poor immunity (Mean± SD) (n=8)	Reduced immune functioning (Mean± SD) (n=53)	Moderate immunity (Mean± SD) (n=40)	F value	p value
Gastric Function	18.75 ±7.421	17.15 ± 9.777	10.68 ± 9.357	6.132	0.003*
GI Inflammation	26.88 ± 10.776	26.81 ± 12.288	18.90 ±14.180	4.498	0.014*
Small Intestine and Pancreas	24.38 ± 10.542	22.64 ± 12.725	11.73 ±11.946	10.026	0.000*
Colon	30.25 ± 12.736	28.11 ±8.824	17.58 ± 13.318	11.576	0.000*

Mean ± Standard Deviation, p < 0.05*

Table no. 4 compares gastrointestinal (GI) health parameters gastric function, GI inflammation, small intestine and pancreas function, and colon health across immune status groups. Statistically significant differences were observed across all domains. Mean gastric function scores were highest in the very poor immunity group (18.75 ± 7.42) and lowest in the moderate immunity group (10.68 ± 9.36) (p = 0.003), indicating better gastric health in participants with stronger immunity. Similarly, GI inflammation scores were significantly higher in those with very poor (26.88 ± 10.78) and reduced immunity (26.81 ± 12.29) than in the moderate group (18.90 ± 14.18) (p = 0.014). Scores for small intestine and pancreas function were also highest in the very poor immunity group (24.38 ± 10.54) and lowest in the moderate group (11.73 ± 11.95) (p < 0.001). Colon health scores followed the same trend, with 30.25 ± 12.74 in the very poor group and 17.58 ± 13.32 in the moderate group (p < 0.001). These results suggest a strong association between immune status and overall GI health.

TABLE NO. 5 Correlation between GI (Section A) and Nutrient intake in study population

Variable	High Score	%RDA	Moderate Score	% RDA	Low Score	% RDA	F value	p value
Energy (kcal) (Mean± SD)	1711.28 ± 627.939	81.10	1562.50 ± 335.401	74.05	1656.03 ± 384.606	78.48	0.563	0.571
Protein (g)	50.50 ±	93.51	45.78 ± 11.471	84.77	51.34 ±	95.07	0.988	0.376

(Mean+ SD)	22.306				13.116			
CHO (g) (Mean+ SD)	252.39 + 89.451	98.32	219.56 + 42.062	93.67	236.72+ 67.094	95.29	1.048	0.355
Fats (g) (Mean+ SD)	42.61 + 27.231	89.63	44.83 + 23.769	103.2	47.71 + 20.151	103.7	0.419	0.659
Fiber (g) (Mean+ SD)	30.39 + 12.848	101.3	23.72 + 5.748	79.06	28.23 + 9.537	94.1	2.304	0.105

Mean ± Standard Deviation, $p < 0.05$*

Table no. 5 examines the association between gastric function scores (high, moderate, and low) and mean nutrient intake among participants. Energy intake was highest in the high score group (1711.28 ± 627.94 kcal, 81.1% RDA), followed by the low (1656.03 ± 384.61 kcal, 78.48% RDA) and moderate groups (1562.50 ± 335.40 kcal, 74.05% RDA), though differences were not statistically significant ($p = 0.571$). Protein intake was highest in the low score group (51.34 ± 13.12 g), while the moderate group had the lowest (45.78 ± 11.47 g), again without significance ($p = 0.376$). Carbohydrate intake was also highest in the high score group (252.39 ± 89.45 g) and lowest in the moderate group (219.56 ± 42.06 g), with no significant association ($p = 0.355$). Fat intake remained fairly consistent across groups ($p = 0.659$). Notably, fiber intake was highest in the high score group (30.39 ± 12.85 g, 101.3% RDA), followed by the low (28.23 ± 9.54 g) and moderate groups (23.72 ± 5.75 g), though the difference did not reach statistical significance ($p = 0.105$).

TABLE NO. 6 Correlation between GI (Section B) and Nutrient intake in study population

Variable	High Score	% RDA	Moderate Score	% RDA	Low Score	% RDA	F value	p value
Energy (kcal) (Mean+ SD)	1780.00 + 765.374	84.36	1742.40 + 285.502	82.57	1632.98 + 402.349	77.39	0.552	0.578
Protein (g) (Mean+ SD)	45.86 + 22.453	84.92	59.00 + 22.113	109.25	50.04 + 13.752	92.66	1.181	0.311
CHO (g) (Mean+ SD)	260.43 + 97.416	97.54	238.00 + 63.455	91.06	234.48 + 66.272	95.72	0.467	0.628
Fats (g) (Mean+ SD)	40.43 + 24.636	81.76	52.60 + 9.476	108.67	46.39 + 22.404	102.2	0.448	0.640
Fiber (g) (Mean+ SD)	29.86 + 15.678	99.53	28.00 + 8.916	93.33	27.64 + 9.413	92.13	0.164	0.849

Mean ± Standard Deviation, $p < 0.05$*

Table no. 6 presents the association between gastrointestinal (GI) inflammation scores and nutrient intake across three groups: high, moderate, and low inflammation. Energy intake was highest in the high inflammation group (1780.00 ± 765.37 kcal), followed by the moderate (1742.40 ± 285.50 kcal) and low score group (1632.98 ± 402.35 kcal), though the difference was not statistically significant ($p = 0.578$). Protein intake peaked in the moderate inflammation group (59.00 ± 22.11 g), while the high and low groups reported lower values (45.86 ± 22.45 g and 50.04 ± 13.75 g, respectively; $p = 0.311$). Carbohydrate intake remained consistent across groups, with no significant difference ($p = 0.628$). Fat intake was highest in the moderate group (52.60 ± 9.48 g), with the high group consuming the least (40.43 ± 24.64 g), though not statistically significant ($p = 0.640$). Fiber intake was relatively similar across all groups ($p = 0.849$), with the highest intake in the high score group (29.86 ± 15.68 g).

TABLE NO. 7 Correlation between GI (Section C) and Nutrient intake in study population

Variable	High Score	% RDA	Moderate Score	% RDA	Low Score	% RDA	F value	p value
Energy (kcal) (Mean± SD)	1709.93 ± 541.556	81.03	1577.64 ± 334.961	74.76	1646.75 ± 394.949	78.04	0.586	0.558
Protein (g) (Mean± SD)	49.82 ± 19.056	92.25	52.27 ± 12.597	96.79	49.51 ± 13.330	91.68	0.273	0.761
CHO (g) (Mean± SD)	253.00 ± 87.128	98.64	216.27 ± 46.952	91.38	236.08 ± 62.614	95.57	1.822	0.167
Fats (g) (Mean± SD)	45.54 ± 24.562	95.8	45.59 ± 21.926	104.03	47.00 ± 21.059	102.74	0.053	0.949
Fiber (g) (Mean± SD)	28.79 ± 11.262	95.96	25.77 ± 7.770	85.9	28.16 ± 9.803	93.86	0.640	0.529

Mean ± Standard Deviation, $p < 0.05$*

Table no. 7 explores the association between GI health related to small intestine and pancreatic function and nutrient intake, categorized into high, moderate, and low symptom score groups. Energy intake was highest in the high score group (1709.93 ± 541.56 kcal), followed by the low (1646.75 ± 394.95 kcal) and moderate (1577.64 ± 334.96 kcal) groups, though not statistically significant (p = 0.558). Protein intake was fairly consistent across all groups, with the moderate score group reporting slightly higher intake (52.27 ± 12.60 g), but with no significant difference (p = 0.761). Carbohydrate intake was highest in the high score group (253.00 ± 87.13 g), followed by the low and moderate groups, though differences were also not significant (p = 0.167). Fat intake showed minimal variation across groups (p = 0.949), while fiber intake was slightly lower in the moderate group (25.77 ± 7.77 g) compared to the high and low groups, but again not statistically significant (p = 0.529).

TABLE NO. 8 Correlation between GI (Section D) and Nutrient intake in study population

Variable	High Score	% RDA	Moderate Score	% RDA	Low Score	% RDA	F value	p value
Energy (kcal) (Mean± SD)	1497.36 ± 467.823	70.96	1968.89 ± 624.462	93.31	1639.58 ± 379.263	77.70	3.594	0.031*
Protein (g) (Mean± SD)	42.00 ± 13.728	77.77	62.11 ± 23.582	115.01	50.29 ± 13.007	93.12	5.457	0.006*
CHO (g) (Mean± SD)	216.36 ± 51.545	96.32	296.22 ± 104.353	100.3	233.17 ± 62.794	94.8	4.453	0.014*
Fats (g) (Mean± SD)	37.00 ± 15.522	88.95	58.11 ± 29.898	106.25	46.59 ± 21.579	102.3	2.626	0.077
Fiber (g) (Mean± SD)	26.07 ± 9.034	86.9	34.44 ±15.092	114.8	27.36 ± 9.034	91.2	2.428	0.09

Mean ± Standard Deviation, $p < 0.05$*

Table no. 8 outlines the association between colon health status and nutrient intake across participants grouped into high, moderate, and low symptom severity scores. A statistically significant difference was observed in energy intake ($p = 0.031$), with the moderate score group reporting the highest intake (1968.89 ± 624.46 kcal, 93.31% RDA), followed by the low (1639.58 ± 379.26 kcal, 77.70% RDA) and high (1497.36 ± 467.82 kcal, 70.96% RDA) groups. Protein intake also varied significantly across groups ($p = 0.006$), with the moderate group consuming the highest amount (62.11 ± 23.58 g, 115.01% RDA), followed by the low (50.29 ± 13.01 g, 93.12% RDA) and high score (42.00 ± 13.73 g, 77.77% RDA) groups.

IV. DISCUSSION

The findings of the study provide critical insight into how demographic, anthropometric, dietary, and gastrointestinal (GI) health variables are associated with immune function among rickshaw drivers aged 25–45 years.

Significant associations were observed between age, marital status, household size, and alcohol consumption with immune status. Younger, married individuals living in nuclear families and those who abstained from alcohol showed better immune function. These factors align with existing literature indicating that psychosocial stability and healthy lifestyle choices support stronger immune responses (Kumar et al., 2022).

Although education, income, and occupation did not show significant relationships with immunity, these factors indirectly contribute to health through access to nutritious food, healthcare, and sanitation. The high prevalence of low education and low-income status is consistent with findings from other occupational studies involving informal laborers (Devi et al., 2021). From an anthropometric perspective, although BMI and weight were not significantly associated with immune status, the descending trend in BMI and body weight from the very poor to moderate immunity groups is noteworthy.

Nutrient intake patterns revealed suboptimal energy and protein intake, especially among those with poorer immunity. Though the differences were not statistically significant, protein intake increased with improving immunity, reaffirming the role of protein in immune cell function (Calder et al., 2020). Fiber intake remained relatively high across all groups, which supports gut health and immune modulation (Makki et al., 2018; Wypych et al., 2017).

Analysis of street food consumption patterns revealed a high reliance on energy-dense, nutrient-poor foods such as vada pav, samosas, and bhel puri. This dietary pattern could contribute to gut inflammation, dysbiosis, and compromised immunity, especially in individuals with very poor immune function. Such findings reflect the economic constraints and occupational lifestyle of rickshaw drivers.

GI health emerged as a key correlate of immune function. GI inflammation, gastric function, small intestine, and colon health scores were significantly worse among participants with poor immunity. These findings are supported by previous research showing that gut inflammation and dysbiosis impair nutrient absorption and immune regulation (Mitra et al., 2022; Kulkarni et al., 2024). In particular, colon symptom scores were significantly associated with energy, protein, and carbohydrate intake, highlighting the interplay between diet and GI function. Participants with moderate colon symptoms reported higher nutrient intake, possibly due to early dietary intervention or greater health awareness.

Though no significant associations were observed between GI scores and fat or fiber intake, the trends suggested better nutrient intake in individuals with moderate GI symptoms, supporting the idea that adaptive dietary responses may emerge in response to symptoms. Finally, the broader context of occupational stress, air pollution, and irregular work hours must be acknowledged, as these factors contribute to both GI and immune dysfunction (Kaul et al., 2019). Therefore, any dietary or health-based interventions should be complemented by improvements in occupational conditions, hygiene practices, and mental health support.

V. CONCLUSION

The study emphasizes the multifactorial health burden faced by rickshaw drivers in Mumbai, particularly in relation to dietary inadequacy, compromised gut function and poor immune status. While macronutrient intake was below recommended levels, the real challenge was in food choices dominated by processed, low-nutrient street food and irregular meal patterns. Despite moderate awareness and availability of food, knowledge-action gaps persisted, influenced by occupational demands, lifestyle habits, and lack of targeted education. The absence of strong correlations between nutrient intake and immune function suggests that behavioral and environmental factors have a stronger immediate impact on immune and gut health than diet alone. These insights can inform targeted public health policies and urban workforce wellness programs to improve quality of life among informal sector workers. The study addresses the urgent need for behavior-centered dietary interventions, stress management strategies, and health education programs tailored to the lifestyle of informal occupational groups like rickshaw drivers.

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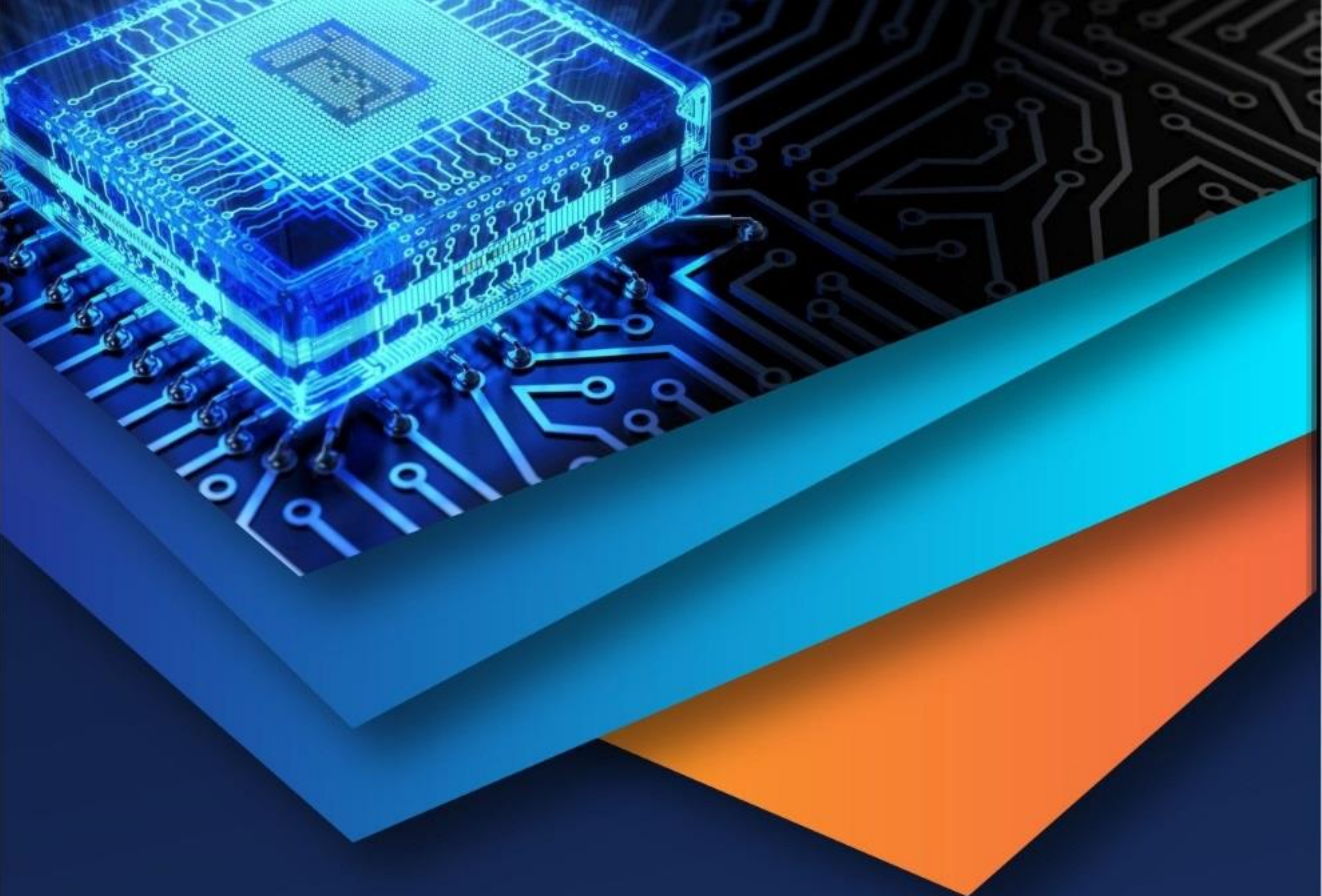

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