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STUDY ON DIETARY INTAKES, STRESS SCORE AND NUTRITIONAL STATUS IN FOOD DELIVERY RIDERS IN MUMBAI, MAHARASHTRA.

A DISSERTATION SUBMITTED BY
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ABSTRACT

Background:

The rapid expansion of the online food delivery industry has generated a large and growing gig-based workforce operating under precarious conditions. Food delivery riders in India typically work over ten hours a day, six days a week, earning between Rs. 15,000–20,000 per month, often without formal employment benefits or social protection. This workforce faces a unique convergence of occupational hazards — ergonomic risks, environmental exposures, psychological stress from delivery deadlines and traffic congestion, and disrupted eating patterns — all of which heighten vulnerability to poor nutritional outcomes and non-communicable diseases. Evidence indicates that irregular meal timing, meal skipping, and reliance on energy-dense convenience foods are common among workers with unpredictable schedules, and these behaviours have been linked to metabolic disturbances, hormonal dysregulation, and deteriorating mental health. Despite growing literature on burnout, anxiety, and depression in this population, research examining the interplay between dietary intake, stress, meal patterns, and nutritional status among food delivery riders in India remains limited.

Objectives:

To assess anthropometric measurements using weight, height, and BMI; to evaluate the dietary intake of macronutrients and micronutrients using a 24-hour dietary recall; to assess perceived stress levels using the Perceived Stress Scale (PSS-10); to examine meal timing, meal frequency, and eating behaviours using the Meal Pattern Questionnaire (MPQ); to assess general nutrition knowledge using the General Nutrition Knowledge Questionnaire (GNKQ); and to correlate dietary intake, stress levels, and nutrition knowledge among food delivery riders.

Methodology:
A cross-sectional observational study was conducted among 150 male food delivery riders aged 18–35 years, actively working in Mumbai, Maharashtra, for a minimum of three months. Participants were recruited using purposive sampling from delivery hotspots and food outlet clusters across the city. Those with any known chronic illness were excluded. Ethics approval was obtained from the Inter System Biomedical Ethics Committee (ISBEC) prior to data collection, and written informed consent was secured from all participants. Data were collected via a case record form administered through structured interviews, encompassing demographic characteristics, anthropometric measurements (height, weight, BMI classified per WHO standards), 24-hour dietary recall, a semi-quantitative Food Frequency Questionnaire (Semi-FFQ) scored by frequency of consumption, the PSS-10 (scored 0–40), the MPQ (7-point ordinal scale over 28 days), and the 48-item GNKQ across four domains. Nutrient composition was analysed using the Indian Food Composition Table 2017. Statistical analysis was performed using SPSS version 21, employing descriptive statistics and inferential tests including chi-square, ANOVA, and t-tests to examine associations between variables.

Results:
The mean age of participants was 25.72 ± 4.60 years. The majority of riders experienced moderate perceived stress (52.0%), with a mean PSS score of 20.69 ± 10.02. Significant associations were observed between PSS category and age, family medical history, current medication use, dietary preference, and socioeconomic status. Anthropometric analysis revealed a statistically significant inverse relationship between perceived stress and BMI ($r = -0.257$, $p = 0.002$), with the High Stress group recording the lowest mean BMI (19.98 ± 2.39 kg/m²) and the highest prevalence of underweight (23.5%), while overweight and obesity were entirely absent in this category. Dietary assessment revealed a paradoxical nutritional profile characterised by excessive fat intake (316.1% of RDA) alongside suboptimal energy (88.7% RDA), carbohydrate (83.7% RDA), iron (73.6% RDA), and calcium (60.9% RDA) intake across all stress groups. Food frequency analysis indicated near-universal daily fried food consumption and markedly inadequate fruit intake. Meal pattern irregularity showed a directional increase with rising stress levels, though this did not reach statistical significance ($p = 0.069$). Nutrition knowledge scores were significantly higher in the High Stress group ($p = 0.005$), yet demonstrated no significant correlation with any dietary intake variable, confirming a nutrition knowledge–behaviour gap in this population.

Conclusion:
The study highlights that perceived occupational stress is inversely associated with BMI and nutritional status among food delivery riders, with highly stressed riders exhibiting greater underweight prevalence. Dietary patterns were characterised by excessive fat intake alongside deficiencies in energy, iron, and calcium. A nutrition knowledge–behaviour gap was evident, wherein higher stress correlated with greater nutrition knowledge but no meaningful dietary improvement. These findings underscore the need for multi-level interventions addressing food environment, stress management, and targeted nutrition support tailored to the occupational demands of the urban gig-economy workforce.

CHAPTER I
INTRODUCTION

In recent years, the food delivery industry has witnessed substantial expansion, driven by evolving consumer preferences, rapid technological advancements, and the proliferation of third-party delivery platforms. The global online food delivery market has shown remarkable growth, increasing from $115.07 billion in 2020 and projected to reach approximately $223.77 billion by 2025. Earlier estimates also indicate a rise from $107.44 billion in 2019 to $154.34 billion in 2023, reflecting the accelerating demand for app-based food services worldwide.(Samal et al, 2025)

The expansion of this sector has significantly contributed to the growth of the gig economy, creating new employment opportunities, particularly for delivery riders. According to the International Labor Organization Report (2021), the rise of platform-based work has enabled individuals to engage in flexible, short-term employment. However, unlike traditional employment models, food delivery companies often categorize riders as independent contractors or “gig workers,” thereby excluding them from formal employment benefits and protections.(Samal et al, 2025)

In the Indian context, delivery riders reportedly earn between Rs. 15,000 and Rs. 20,000 per month (Janata Daily), typically working six days a week for more than ten hours per day to achieve higher earnings. Although such work arrangements offer flexibility and income opportunities, they also impose considerable physical and psychological strain. Technological advancements, particularly the widespread use of smartphones and internet-based applications, have further transformed business practices and daily lifestyles. As noted by Ghajargar et al. [4], the increasing reliance on online platforms has expanded service coverage and enhanced convenience for consumers, thereby intensifying demand for delivery services.(Samal et al, 2025)

Despite these advantages, gig work is associated with several structural challenges, including low wages, lack of job security, and absence of social protection (Syazwan SYAH Zulkifly et al., 2023). These conditions place delivery riders in a precarious occupational environment, raising concerns regarding their overall well-being.

Food delivery riders are exposed to a wide range of occupational hazards due to the nature of their work. Research findings indicate that these risks can be broadly categorized into ergonomic, environmental, psychological, and health-related hazards (Syazwan SYAH Zulkifly et al., 2023). Ergonomic risks arise primarily from prolonged sitting and repetitive movements associated with riding motorcycles or bicycles, which may lead to musculoskeletal disorders. Additionally, the likelihood of road traffic accidents further increases physical vulnerability. Environmental exposure is another major concern, as riders frequently work under extreme weather conditions and are subjected to high levels of air pollution.

Psychological stress is a significant component of their occupational burden, often resulting from strict delivery deadlines, traffic congestion, and limited social interaction. From a health perspective, prolonged exposure to pollutants increases the risk of respiratory illnesses, while sedentary work patterns contribute to cardiovascular diseases such as heart disease and stroke.

The existing occupational health and safety frameworks are largely designed for traditional employer–employee relationships, making it difficult to incorporate gig workers into formal health protection systems. Furthermore, the absence of social insurance exacerbates the impact of health-related issues among these workers. In pursuit of cost efficiency, platform companies often overlook essential safety training and fail to implement adequate management systems, thereby exposing riders to high-risk work environments (Ai-Lin Mao et al., 2025).

Survey-based evidence suggests that gastrointestinal disorders are among the most commonly reported health problems among delivery riders, primarily due to irregular eating patterns and disrupted meal timings. COVID-19 and other respiratory illnesses also show high prevalence, particularly due to constant exposure to external environments and human interaction. These findings are consistent with studies conducted in other regions, including Ecuador (Mao et al., 2025).

Moreover, workload has been identified as a key determinant of health outcomes. Increased delivery demands and extended working hours are significantly associated with higher incidence of illness. Studies conducted in Vietnam and China further highlight that job burnout, time pressure, and workload intensity contribute to risky behaviors, increased stress levels, and compromised safety among riders (Mao et al., 2025).

Emerging literature highlights the growing prevalence of mental health issues among food delivery workers globally. Elevated levels of stress, anxiety, burnout, and depressive symptoms have been reported across various populations. In countries such as China, many delivery riders are internal migrants who live away from their families, leading to social isolation and increased psychological burden (Haiyi Long et al., 2025).

However, the relationship between gig work and mental health remains complex and, at times, contradictory. Some studies suggest that gig workers experience higher levels of loneliness and psychological distress compared to traditional workers (Glavin, Bierman, & Schieman, 2019). In contrast, other research indicates that transitioning to gig-based driving jobs may initially improve mental health outcomes, although anxiety levels may increase over time (Apouey & Stabile, 2020).

Food delivery riders exhibit unique occupational characteristics compared to conventional workers. While they may benefit from greater autonomy, flexibility, and decision-making capacity, which can enhance self-confidence and reduce psychological strain (Benedicte Apouey et al., 2020), other studies report poorer overall mental health and lower job satisfaction among gig workers (Hunefeld L et al., 2020).

Additional factors such as irregular work schedules, inadequate sleep, lack of career progression, and financial instability further contribute to mental health challenges. Jin et al. (2020) and Dutsch (2011) observed that the temporary nature of gig work limits long-term career prospects, thereby increasing stress and anxiety. Environmental factors, including exposure to weather conditions and pressure to meet strict delivery timelines, further intensify these issues (Yuxun Peng et al., 2022).

Sleep quality has also been identified as a critical determinant of mental health. Poor sleep is strongly associated with increased levels of anxiety and depression. Studies have shown that overwork and insufficient rest contribute significantly to burnout among delivery workers, emphasizing the need for regulation of working hours (Yuxun Peng et al., 2022). Additionally, physically demanding tasks and lower income levels are linked to higher psychological distress, whereas longer work experience and higher earnings may serve as protective factors against anxiety and depression.

Dietary intake and eating patterns have gained increasing attention in relation to occupational health, particularly among populations with irregular work schedules such as delivery riders. Meal timing, frequency, and composition play a crucial role in determining overall health outcomes.

Evidence suggests that irregular eating habits, including skipping meals and consuming food at unconventional times, are associated with increased risk of cardiometabolic disorders. Studies indicate that delayed meal timing and extended eating durations can disrupt metabolic processes and contribute to conditions such as obesity, insulin resistance, and cardiovascular diseases (Buthaina Alkhatib et al., 2024).

Skipping breakfast, in particular, has been linked to adverse lipid metabolism due to disruptions in circadian rhythms and hepatic gene expression. Similarly, irregular meal consumption affects hormonal regulation, including alterations in leptin, ghrelin, and cortisol levels, which play a critical role in appetite control and stress response (Peters et al., 2024; Schrader et al., 2024). These metabolic disturbances have broader implications for mental health, as they can influence brain function through mechanisms such as increased inflammation, dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, and poor sleep quality (Sălcudean et al., 2025; Kim et al., 2025).

Furthermore, dietary quality and eating behaviors have been closely linked to psychological well-being. Research indicates that poor dietary patterns and irregular meal consumption may contribute to the development and progression of depressive symptoms (Quirk et al., 2013). Regularity in meal consumption has emerged as a modifiable behavioral factor that can potentially improve both physical and mental health outcomes (Lee and Kim, 2021).

1.1 Rationale for the study

The food delivery industry in India has witnessed unprecedented growth, with millions of gig-based workers now forming an essential yet largely invisible component of the urban workforce. In Mumbai, a metropolitan city characterised by intense traffic, extreme weather conditions, and round-the-clock delivery demands, food delivery riders operate under particularly challenging occupational circumstances. Despite working more than ten hours a day with limited rest, irregular eating schedules, and minimal access to structured workplace health support, this workforce remains significantly understudied from a nutritional and public health perspective.

Food delivery riders face a unique convergence of stressors — strict delivery deadlines, job insecurity, income unpredictability, and physical demands — that collectively disrupt fundamental health behaviours, most notably dietary intake and meal regularity. These disruptions are not trivial; irregular meal timing and poor dietary quality have been closely linked to hormonal dysregulation, metabolic disturbances, and deteriorating mental health, all of which can compound over time into chronic disease risk. Yet, unlike shift workers in formal employment settings, gig workers fall outside conventional occupational health frameworks, leaving them without access to the nutrition interventions and health assessments that have proven effective in other working populations.

Although the occupational hazards faced by delivery riders — road accidents, burnout, anxiety, and depression — have received growing research attention, the nutritional dimensions of their work-life remain largely unexplored. Critical factors such as meal frequency, eating patterns, perceived stress, and nutrition knowledge, and how these interrelate to shape their overall nutritional status, have not been systematically investigated, particularly in the Indian urban context. This gap is significant, because without understanding the baseline dietary and stress profile of this population, targeted and meaningful interventions cannot be designed.

This study therefore aims to bridge this gap by comprehensively examining dietary intake, perceived stress levels, meal patterns, nutrition awareness, and nutritional status among food delivery riders in Mumbai. Understanding these associations can inform the development of practical, context-sensitive nutrition interventions and workplace health policies that address the unique challenges faced by this rapidly expanding yet underserved workforce.

1.2 Aim of the study

To study the dietary intake, perceived stress levels, and nutritional status, and their interrelationship among food delivery riders aged 18-35 in Mumbai, Maharashtra.

1.3 Objectives of the study

1. To assess anthropometric measurements using weight, height and BMI.
2. To evaluate the dietary intake of macronutrients and micronutrients using a 24-hour dietary recall.
3. To assess the perceived stress levels among food delivery riders using the Perceived Stress Scale (PSS).
4. To examine the meal timing, meal frequency, and eating behaviours using the Meal Pattern Questionnaire(MPQ).
5. To assess general nutrition knowledge among food delivery riders using the General Nutrition Knowledge Questionnaire (GNKQ).
6. To correlate the dietary intake, stress levels, nutrition knowledge in food delivery riders.

1.4 Research Hypothesis

There is an association between dietary intake, perceived stress levels, meal timing, meal frequency, and nutrition awareness with the nutritional status of food delivery riders in Mumbai. Specifically, higher levels of perceived stress are expected to correlate with poorer dietary intake and irregular meal patterns, while lower nutrition awareness is expected to be associated with inadequate nutrient consumption and compromised nutritional status among food delivery riders.

CHAPTER II
REVIEW OF LITERATURE

The food delivery industry has witnessed rapid global expansion, with India emerging as a major hub of gig-based employment (NITI Aayog, 2022). Despite the sector's growth, food delivery riders remain economically vulnerable, working long hours for low and unstable wages, without formal employment contracts, health coverage, or occupational welfare provisions. Their socioeconomic disadvantage is compounded by limited formal education, which restricts access to health and nutrition information. Studies consistently document low nutritional knowledge, inappropriate dietary behaviours, habitual meal skipping, and high prevalence of tobacco and alcohol use within this population (Bunjong et al., 2024).

Occupational stress is highly prevalent, with burnout, anxiety, and depression reported across multiple study populations, driven by algorithmic management, income insecurity, and adverse working conditions (Sathiyarajeswaran et al., 2025). Chronic stress further deteriorates dietary quality through neuroendocrine pathways, increasing preference for energy-dense, nutrient-poor foods (Cortes et al., 2021).

Irregular meal timing and meal skipping are independently associated with cardiometabolic risk (Akbar et al., 2024), while available data from Indian delivery riders indicate high rates of overweight and obesity coexisting with micronutrient deficiencies (Li et al., n.d.) (ICMR-INDIAB, 2025).

Evidence from workplace nutrition intervention research supports the efficacy of multi-component programmes in improving dietary quality and anthropometric outcomes, underscoring the need for targeted, context-sensitive nutritional strategies for this occupationally distinct and nutritionally vulnerable workforce (Rachmah et al., 2021).

2.1 Food delivery riders

The food delivery sector has experienced rapid growth in recent years, driven by shifting consumer expectations, technological advancements, and the expansion of third-party delivery platforms (Meena et al., 2022). The global online food delivery market is projected to reach $223.77 billion by 2025, rising significantly from $115.07 billion in 2020 (Statista, 2022). This expansion has also contributed to the growth of gig-based employment, offering increased livelihood opportunities for delivery riders, as highlighted by the International Labour Organization (ILO, 2021).

2.2 Gig Economy

The gig economy has become a transformative component of the global labour market, significantly altering traditional employment structures and influencing broader economic trajectories (Wood et al., 2021). It is characterised by flexible, short-term, and freelance work arrangements, primarily facilitated through digital platforms that connect independent workers with consumers and organisations (Koutsimpogiorgos et al., 2020).

2.2.1 Growth of Gig Economy

Over the past decade, the gig economy has witnessed substantial growth, with an increasing number of individuals opting for flexible forms of employment (Tan et al., 2021; Malik et al., 2021). Globally, this sector is expanding at a rapid pace and is projected to reach a market value of $1.847 trillion by 2032 (Charlton, 2024). This growth is largely driven by rising digitalisation, advancements in communication technologies, and the proliferation of online platforms that connect freelancers with clients.

The gig economy spans multiple sectors, including e-commerce, transportation, and delivery services, and is anticipated to generate nearly 90 million jobs while contributing approximately 1.25% to India's GDP by 2030. Market estimates further indicate that the gig economy, valued at USD 556.7 billion in 2024, is expected to grow to USD 646.77 billion in 2025 and reach USD 2146.87 billion by 2033, registering a CAGR of 16.18% during the period 2025–2033 (Business Research Insights, 2025).

In the Indian context, similar trends are evident, with the gig economy projected to expand at a compounded annual growth rate (CAGR) of 17% (Business Standard, 2024). This rapid expansion is expected to significantly increase the number of gig workers and enhance the sector's contribution to the national economy. Supporting this, estimates from NITI Aayog suggest that the gig workforce in India will grow to 23.5 million by 2029–30, compared to 7.7 million at present (NITI Aayog, 2022).

2.3 Scenario of Food Delivery Riders Globally and in India

The proliferation of digital platform-based economies over the past decade has fundamentally altered the nature of urban employment, with the on-demand food delivery sector emerging as one of its most visible manifestations. Driven by rapid smartphone penetration, expanding urban agglomerations, and evolving consumer lifestyles, the online food delivery market witnessed unprecedented growth particularly in the aftermath of the COVID-19 pandemic. According to market analyses, the global online food delivery services market was valued at approximately USD 128.32 billion in 2022 and expanded to USD 143.05 billion in 2023, reflecting a year-on-year growth rate of 11.5% (Teo et al., 2024). In the food delivery industry, the global market was valued at approximately USD 1,100 billion in 2022 and is projected to reach USD 1,510 billion by 2027, underscoring the sheer magnitude and momentum of this sector (Dong et al., 2025).

Underlying this market expansion is a rapidly swelling workforce of delivery riders who constitute the operational backbone of platform-based food delivery systems. In China alone, over 13 million riders are registered on food delivery platforms, serving 545 million users as of 2024 (Dong et al., 2025). In the United States, Uber's active earners — comprising both ride-sharing drivers and food delivery workers — reached a record 5.4 million in the fourth quarter of 2022, while DoorDash reported over 2 million monthly active delivery personnel during the same period (WTTW News, 2023). In Brazil, iFood estimated approximately 360,000 active drivers per month, of whom more than 70% were male with a mean age of 33 years (Prosus Report, 2025). Comparable trends have been observed across South and Southeast Asia, with platforms such as GrabFood, Foodpanda, and Gojek operating large delivery fleets across Malaysia, Indonesia, Thailand, and Vietnam.

India occupies a particularly significant position in the global gig economy landscape. According to the NITI Aayog, India's total gig workforce currently stands at approximately 12.7 million, with projections indicating a rise to 23.5 million by 2029-30 and potentially 61.6 million by 2047 (Outlook Business, 2026). India alone accounts for roughly 20% of the world's platform workforce, positioning it as the single largest supplier of gig labour globally (CIIE.CO, 2022, as cited in Outlook Business, 2026). The online food delivery sector, dominated by Zomato and Swiggy, has been a central driver of this labour market transformation. In the September quarter of a recent year, Zomato's parent entity reported nearly 8.94 lakh monthly active delivery partners across food delivery and quick commerce, while Swiggy disclosed approximately 6.91 lakh average monthly transacting partners, together engaging over 15 lakh delivery workers each month (Nifty Trader, 2026).

2.4 Impact of Socioeconomic Status on Food Delivery Riders

The food delivery sector has emerged as one of the fastest-growing segments of the gig economy, particularly in low- and middle-income countries. According to the NITI Aayog (2022), India's gig and platform workforce engaged approximately 7.7 million workers in 2020–21, a figure projected to escalate to nearly 23.5 million by 2029–30, representing close to 6.7% of the country's non-agricultural labour force. The economic contribution of gig workers, particularly in delivery services, is disproportionate to the financial security they enjoy. Pankaj and Jha (2024), as cited in the International Journal of Research and Innovation in Applied Science, noted that notable inequalities persist within the Indian gig economy, where workers frequently encounter long working hours, low wages, and job insecurity, conditions that are further exacerbated for individuals from marginalized socioeconomic backgrounds.

Despite the sector's rapid expansion, the income trajectory of food delivery riders remains precarious. A 2024 survey by the People's Association in Grassroots Action and Movements and the Indian Federation of App-based Transport Workers reported that over 43% of delivery riders earn less than ₹500 per day after operational expenses, roughly translating to ₹15,000 per month. Furthermore, a study by the National Council of Applied Economic Research (NCAER) found that the real wages of gig workers declined by approximately 11% between 2019 and 2022, falling to an average of ₹11,963 per month. These earnings are often insufficient to cover basic household expenditures, with over 70% of gig workers reporting financial difficulty in managing daily expenses due to irregular income flows (Fairwork India, 2023).

The socioeconomic profile of food delivery riders in India is further characterized by limited formal education. Data from a survey of over 4,000 gig workers indicates that nearly 29% have not progressed beyond middle school education, making this the single largest educational subgroup within the gig workforce (Outlook Business, 2026). Such educational constraints limit workers' access to health information, formal employment benefits, and upward occupational mobility. A 2024 NITI Aayog report additionally highlighted that approximately 90% of gig workers lack personal savings and remain highly vulnerable to financial emergencies, with health expenditures representing a particularly acute burden in the absence of employer-provided insurance coverage.

From a regulatory standpoint, the Code on Social Security (2020) formally recognised gig and platform workers as a category eligible for social security provisions; however, enforceable national standards on minimum wages, working hours, and occupational health protections have remained largely unimplemented. State-level initiatives such as the Rajasthan Platform-Based Gig Workers (Registration and Welfare) Act, 2023, which established a Gig Workers' Welfare Board funded through a cess on platform transactions, represent early legislative steps in addressing these deficits. Despite such efforts, the majority of food delivery riders across India continue to operate without formal employment contracts, employer-sponsored health coverage, or structured occupational health programmes, placing them in a uniquely vulnerable socioeconomic position with significant downstream consequences for their nutritional and physical well-being.

2.5 Job Insecurity, Irregular Schedules and Working Conditions of Delivery Riders

In India, NITI Aayog has pointed out the challenges in estimating the number of platform workers due to limited data, which complicates policy formulation for this workforce. Issues related to wages, job security, employment classification, and access to social protection for gig workers have been widely discussed in both academic and public discourse (Tiwari et al., 2019). Furthermore, within the framework of the sharing economy, food delivery companies typically classify riders as independent contractors rather than full-time employees, reflecting a broader shift in employment structures (Sundararajan, 2017). Consequently, riders often lack formal employment benefits and job stability. Evidence suggests that delivery riders earn approximately ₹15,000 to ₹20,000 per month, often working more than ten hours a day for six days a week to achieve these earnings (Aggarwal, 2022). Such demanding working conditions are associated with increased physical strain and mental health challenges among riders, underscoring the need for greater attention to their overall well-being.

2.6 Magnitude of Occupational Stress and Burnout in Delivery Riders

Occupational stress is defined as the psychological and physiological strain experienced by individuals when job demands persistently exceed their capacity or available resources to cope (Ganster & Rosen, 2013). For food delivery riders, the constellation of job demands is particularly multifaceted and chronic: tight delivery deadlines, algorithmic performance monitoring, income insecurity, customer incivility, adverse traffic conditions, and near-total absence of organizational support collectively constitute a high-demand, low-control work environment — a configuration consistently associated with elevated stress, burnout, and mental health deterioration across occupational health literature (Karasek, 1979; Bakker & Demerouti, 2007).

Empirical evidence on the prevalence of occupational stress and burnout among delivery workers, though still accumulating, paints a concerning picture. A systematic review by Xiong et al. (2022), following PRISMA guidelines and encompassing 15 studies published prior to February 2022 — predominantly involving Chinese couriers along with samples from France, Israel, and Malaysia — estimated the prevalence of burnout (or a burnout dimension) among couriers to range from 20% to 73%, with a median of 33%. The prevalence of occupational stress (or a stress dimension) ranged even more broadly, from 7% to 90%, with a median of 40% (Xiong et al., 2022). These wide ranges reflect methodological heterogeneity in measurement tools, population characteristics, and cut-off definitions rather than genuine uncertainty about the directionality of the problem.

More specific estimates from Chinese food delivery contexts are particularly stark. Lin and Li (2021, as cited in Cheung & Li, 2022) found that over 95% of food delivery drivers reported experiencing occupational stress, with three-quarters demonstrating stress levels indicative of high health risk. A study using data from 240 food and package delivery drivers in Beijing established that job demands — including workload volume, time pressure, and emotional labour demands — were significant predictors of burnout, with mindfulness emerging as a meaningful moderating factor (Cheung & Li, 2022). More recently, Dong et al. (2025) examined burnout under algorithmic management among Chinese food delivery riders and found that burnout was prevalent and influenced by a constellation of factors including the ranking and punishment systems embedded in platform algorithms, customer feedback mechanisms, and restaurant preparation time — highlighting the role of platform architecture in generating psychological harm.

2.6.1 Determinants, Correlates, and Consequences of Stress among Delivery Riders

The study demonstrated that among food delivery riders, specific behavioral patterns—including meal skipping, increased temptation to consume food during deliveries, dehydration, and substance use—were significantly associated with anxiety. Supporting evidence from research conducted among older adults in the United States indicated that individuals who skipped meals exhibited a higher prevalence of anxiety, depression, and insomnia symptoms compared to those who maintained regular eating patterns. After controlling for demographic variables such as age, gender, race, educational attainment, and comorbid conditions, meal skipping remained significantly associated with both anxiety ($OR = 2.84$, $P < .01$) and depression ($OR = 2.71$, $P < .05$) (Anderson et al., 2020).

Furthermore, dehydration, workplace conditions, burnout, and severe anxiety were identified as significant correlates of depression among food delivery riders. Notably, the interrelationship between burnout, anxiety, and depression appeared to be bidirectional. Evidence from a systematic review and meta-analysis indicated significant positive correlations between burnout and anxiety ($r = 0.460$, $SE = 0.014$, 95% CI = 0.421–0.497) as well as between burnout and depression (r = 0.520, SE = 0.012, 95% CI = 0.492–0.547), suggesting a closely interconnected relationship among these psychological constructs (Koutsimani et al., 2019).

Monthly income emerged as a significant predictor of anxiety and burnout; however, it did not show a statistically significant association with depression in the present study. In contrast, findings from a study conducted among Afghan healthcare workers reported a significant association between monthly income and depressive symptoms (AOR = 0.746, P = 0.0088) (Mohammadi et al., 2023). Similarly, research involving anesthesiology residents indicated that higher monthly income contributed to improved quality of life and a reduction in both burnout and anxiety levels (Yakar et al., 2024).

A growing body of literature has highlighted multiple mental health concerns among food delivery workers. For instance, a study conducted in the Helsinki region of Finland reported that platform-based delivery workers operated within precarious employment conditions, which adversely affected their occupational mental health (Mbare et al., 2023). Additional studies conducted across diverse geographical settings have consistently documented various psychological challenges faced by delivery riders (Gregory, 2021; Ma et al., 2023), while several investigations also examined the impact of the COVID-19 pandemic on their work-life balance and mental well-being (Pyo et al., 2023; Sarwar et al., 2021).

Qualitative research from Finland on platform couriers employed by Foodora found that algorithmic ranking systems created an 'unhealthy invisible competition' among riders, generating psychological pressure and competitive stress that manifested as mental exhaustion, insomnia, irritability, and burnout (Kituyi & Stam, 2023). Job insecurity — a structural feature of gig employment — emerged as a particularly potent stressor, with riders reporting persistent financial anxiety stemming from the absence of guaranteed minimum earnings (Kituyi & Stam, 2023).

The rapid proliferation of platforms such as Zomato, Swiggy, and Uber Eats has created employment opportunities while simultaneously institutionalizing working conditions that are conducive to chronic stress. The absence of welfare provisions, exposure to road hazards in India's chaotic urban traffic, and the physical demands of motorcycle-based delivery in a tropical climate are stressors whose cumulative health impacts remain incompletely characterized in existing literature.

It is worth noting that chronic occupational stress, when unmitigated, extends beyond psychological sequelae to produce measurable physiological effects. Sustained activation of the hypothalamic-pituitary-adrenal (HPA) axis and sympatho-adrenal medullary system under chronic stress is associated with hypertension, impaired immune function, dysregulated glucose metabolism, elevated inflammatory markers, and disrupted sleep architecture (Ganster & Rosen, 2013; Schaufeli, 2017). Such downstream effects are of direct relevance to nutritional status, given that chronic stress modulates appetite regulation, dietary choices, and gastrointestinal absorption — pathways that may exacerbate pre-existing nutritional deficiencies in an already nutritionally vulnerable workforce.

2.7 Occupational Hazards and Physical Health Consequences

The lifestyle of food delivery riders is characterised by prolonged working hours, irregular meal timing, limited structured physical activity, and exposure to a range of occupational hazards, collectively contributing to a health risk profile that is distinct from both sedentary office workers and conventional shift-based employees. In the Indian context, food delivery riders work an average of more than ten hours per day, approximately six days per week, in pursuit of adequate earnings (NITI Aayog, 2022). This demanding work schedule fundamentally disrupts conventional daily routines, including regular mealtimes, adequate sleep duration, and participation in health-promoting activities.

A cross-sectional study of 709 motorcycle food delivery riders in Chiang Mai, Thailand (Kwangsukstith et al., 2025) documented widespread exposure to occupational hazards including extreme temperatures, dust, smoke, and unpredictable weather, along with musculoskeletal complaints consistent with sustained postural and ergonomic strain. Complementary ergonomic assessment data (Daud et al., 2025) among food delivery riders in Eastern Peninsular Malaysia, using the Rapid Entire Body Assessment (REBA) method, identified a medium risk of work-related musculoskeletal disorders across the cohort, with riders using heavier motorcycles demonstrating significantly greater postural risk scores. These findings collectively indicate that the physical demands of food delivery work, though distinct from sedentary occupations, carry their own burden of musculoskeletal morbidity that warrants systematic occupational health surveillance.

2.8 Impact of Dietary Pattern on Nutritional Status of Delivery Riders

Delivery riders, by the nature of their occupation, are subject to a constellation of dietary risk factors that predispose them to both undernutrition and the early stages of overnutrition. The irregular working hours, absence of designated meal breaks, prolonged time on the road, economic constraints, and limited access to nutritious food options during work shifts collectively undermine dietary quality and regularity. While food delivery riders have received comparatively less targeted nutritional research than other mobile workers such as long-haul truck drivers, available evidence from comparable occupational groups and from urban gig workers in general provides a substantive basis for concern.

Research on long-haul truck drivers — an occupational group sharing many structural characteristics with food delivery riders including mobile work patterns, irregular meal timing, dependence on roadside food, and high occupational stress — consistently documents poor dietary quality and elevated rates of overweight and obesity. A cross-sectional study of 404 truck drivers of 24 nationalities conducted at truck stops in Germany found that only 24% were of normal weight, with 46% classified as overweight and 30% as obese (Bschaden et al., 2019). Dietary assessment revealed a shift toward energy-dense, nutrient-poor foods during working hours, including greater consumption of sausages, energy drinks, soft drinks, and canned foods compared to dietary patterns at home (Bschaden et al., 2019). Qualitative research among UK truck drivers identified time constraints, limited healthy food availability at service stations, insufficient nutritional knowledge, and the impracticality of food preparation during shifts as central barriers to healthy eating (Greenhalgh et al., 2025).

The nutritional status of urban low-income workers in India reflects the broader epidemiological reality of the country's dual burden of malnutrition — the coexistence of undernutrition and overnutrition within the same population and, frequently, within the same household. The ICMR-INDIAB survey, a nationally representative cross-sectional study, found that Indian diets are characterized by high intakes of low-quality carbohydrates — refined cereals and added sugars — associated with a 14-30% higher cardiometabolic risk (Nature Medicine, 2025). Urban participants in this survey exhibited a higher median BMI (23.5 kg/m²) compared to rural counterparts (21.6 kg/m²), along with greater prevalence of overweight (56% vs. 37%), generalized obesity (37% vs. 22%), abdominal obesity (48% vs. 31%), and hypertension (29% vs. 27%), despite also demonstrating the persistence of micronutrient deficiencies (Nature Medicine, 2025).

For delivery riders specifically, the physical demands of motorcycle-based delivery work — particularly in a megacity such as Mumbai with its heat, humidity, traffic congestion, and long working hours — generate elevated energy expenditure. However, their food environments typically offer limited access to nutritionally adequate meals during working hours. Riders are largely dependent on roadside food stalls, small eateries, and packaged foods that are calorically dense but micronutrient-poor, high in refined carbohydrates, saturated fats, and sodium, while being deficient in dietary fibre, protein of high biological value, vitamins, and minerals. This dietary profile, combined with irregular meal timing, meal skipping, and the physiological effects of chronic stress on appetite regulation, creates conditions highly conducive to both acute nutritional inadequacy and the progressive development of nutrition-related non-communicable diseases (NCDs).

2.8.1 Micronutrient Deficiencies in Delivery Riders

Micronutrients were defined by the World Health Organization as essential dietary components required in quantities of less than 100 mg per day, encompassing both vitamins and minerals (WHO, 2021a; WHO, 2021b). These nutrients played a critical role in physiological processes, including the synthesis of hormones, enzymes, and other bioactive compounds necessary for growth and development (WHO, 2021a; WHO, 2021b). Deficiencies of key micronutrients—particularly iron, iodine, and vitamin A—were recognised as major public health concerns, contributing to conditions such as anaemia, iodine deficiency disorders (including goitre and hypothyroidism), and vitamin A deficiency-related visual impairment and blindness (WHO, 2024; WHO, 2024).

India had been undergoing a significant nutrition transition characterised by the coexistence of undernutrition and overnutrition. Despite this dual burden, micronutrient deficiencies remained highly prevalent, with dietary patterns—particularly the predominance of cereal-based diets—identified as a contributing factor (Green et al., 2016; Law et al., 2020; Misra et al., 2011). Nutritional deficiencies were estimated to have contributed to approximately 0.5% (95% CI: 0.4%, 0.6%) of total deaths in India in 2016 (India State-Level Disease Burden Initiative Collaborators, 2017). Data from the National Family Health Survey-4 further indicated that India bore one of the highest burdens of anaemia globally (IIPS & MoHFW, 2017).

In response to the widespread prevalence of micronutrient deficiencies, the Government of India had implemented multiple interventions, including food fortification, dietary diversification, nutrition education, micronutrient supplementation, and improvements in environmental sanitation and hygiene. National initiatives such as those led by the Food Safety and Standards Authority of India and programmes like Poshan Abhiyaan were also introduced to address this issue (FSSAI, 2021; NITI Aayog, 2021). However, despite these concerted efforts, the outcomes had remained suboptimal, and national nutrition programmes had not fully achieved their intended targets (Bharadva et al., 2019).

Overall, micronutrient malnutrition persisted as a significant public health challenge in India. Existing strategies, including supplementation and fortification, had demonstrated only partial effectiveness, indicating the need for more comprehensive and context-specific approaches to address the underlying determinants of micronutrient deficiencies.

2.8.2 Prevalence of Micronutrient Deficiencies

Iron deficiency had been recognised as a major global health concern, affecting over 2 billion individuals worldwide. The prevalence was estimated to be approximately 40% in developing countries, compared to around 10% in developed regions. The underlying causes of chronic iron deficiency were multifactorial and varied across demographic factors such as age, gender, geographical location, and dietary practices. In addition to these common determinants, less frequent etiologies included chronic blood loss, gastrointestinal malabsorption, and certain inherited disorders (Jogu et al., 2026).

Iron deficiency anaemia remains among the most prevalent micronutrient disorders in India, disproportionately affecting men engaged in physically demanding occupations where dietary iron intake is insufficient relative to physiological demand.

Vitamin D deficiency is increasingly recognized as a major public health concern, paradoxically even in a sun-abundant country such as India; a comprehensive review of nutritional trends over five decades documented a progressive decline in dietary calcium intake and widespread vitamin D insufficiency across urban populations, driven by reduced consumption of cereals and dairy, urbanization, and lifestyle modifications (Harinarayan & Joshi, 2019). Vitamin B12 deficiency, particularly prevalent among vegetarian populations — which constitute a substantial proportion of India's urban poor — is associated with neurological dysfunction, megaloblastic anaemia, and cognitive impairment (Pant et al., 2024; Frontiers in Nutrition, 2025).

The inadequate absorbable zinc intake in India has risen from 17.1% of the population in 1983 to 24.6% in 2011-12, adding approximately 82 million more individuals to the zinc-deficient population, with projections indicating further deterioration with population aging and climate change (Frontiers in Nutrition, 2025). A survey by the IMRB indicated that 73% of urban Indians are protein-deficient, while 93% are unaware of their daily protein requirements — a knowledge gap with profound implications for dietary choices and nutritional adequacy, particularly among low-literacy populations (Workforce Health Index, 2025).

Dietary calcium deficiency had been identified as a widespread global concern, with estimates suggesting that nearly half of the world’s population had inadequate calcium intake. While calcium was primarily recognised for its fundamental role in maintaining bone health, insufficient intake had also been associated with a range of adverse health outcomes, including certain cancers and cardiovascular diseases. The risk of inadequate calcium consumption was particularly pronounced in low- and middle-income countries (LMICs), although a considerable proportion of individuals in high-income countries (HICs) also failed to meet recommended intake levels.

Calcium functioned as an essential mineral with critical roles across multiple physiological systems, including the skeletal, cardiovascular, endocrine, and nervous systems. Approximately 99% of total body calcium was stored in the bones, where it contributed to structural integrity and served as a reservoir for maintaining calcium homeostasis. The remaining fraction participated in various metabolic and regulatory processes, such as vascular and muscular contraction, neural transmission, transmembrane transport, enzymatic activity, and hormonal regulation (Shlisky et al., 2022).

2.8.3 Determinants and Implications of Micronutrient Deficiencies in Vulnerable Populations

The finding that educational and socioeconomic advantage does not adequately protect against micronutrient inadequacy in urban India has sobering implications for food delivery riders, who occupy a considerably lower socioeconomic stratum.

For food delivery riders, the risk of micronutrient deficiency is further compounded by the physiological consequences of chronic occupational stress. Cortisol elevation associated with chronic stress is known to promote catabolism, impair gastrointestinal absorption of certain micronutrients, increase urinary excretion of magnesium and zinc, and suppress immune function in ways that increase micronutrient utilization. This creates a bidirectional relationship wherein nutritional deficiency exacerbates stress vulnerability, while chronic stress worsens nutritional status — a vicious cycle that has yet to be systematically examined in the food delivery rider population in India.

2.9 Dietary Interventions in Delivery Riders

The role of structured dietary interventions in improving nutritional outcomes among working populations has been substantiated across multiple study designs. The workplace is increasingly recognised as a strategically important setting for health promotion, given that a significant proportion of dietary consumption occurs during work hours and that structured access to employees allows for targeted programme delivery. A systematic review was conducted on the effectiveness of nutrition and health interventions in workplace settings and concluded that multi-component programmes incorporating both nutritional education and environmental modification consistently yield improvements in dietary quality, anthropometric parameters, and metabolic indicators (Rachmah et al., 2021).

Workforce nutrition programmes, in a comprehensive review published in the International Journal of Environmental Research and Public Health, encompass three broad intervention areas: improving access to nutritious foods through canteen modifications and subsidised healthy options; nutrition education initiatives aimed at improving health literacy and behaviour change; and nutritional health assessments combined with individualised counselling (Nyhus Dhillon and Ortenzi et al., 2023).

From a clinical perspective, worksite dietary interventions have demonstrated measurable reductions in weight and body mass index (BMI). A meta-analysis published in the journal Nutrients reported a weighted mean decrease in BMI of 1.26 kg/m^2 and a corresponding reduction in body weight of 4.37 kg in participants receiving dietary interventions, with effect sizes being most pronounced in programmes of shorter duration, typically below six months (Rachmah et al., 2021). These findings carry implications for food delivery riders, who represent an occupationally distinct subgroup characterised by erratic meal patterns, high physical exertion, and limited access to formal nutritional support. The evidence thus makes a compelling case for the development and evaluation of targeted dietary intervention frameworks specifically designed for the logistical and temporal constraints inherent to gig-based food delivery work.

2.10 Lack of Awareness of Health and Nutrition in Delivery Riders

Health and nutrition literacy among food delivery riders is an area that has received limited systematic investigation, despite its significance for this occupational group. Available evidence points towards a widespread deficit in nutrition knowledge and health awareness, which directly influences the dietary choices and health behaviours of this workforce. A cross-sectional study conducted among 264 food delivery workers in Chiang Mai Province, Thailand, reported that 67.4% of participants demonstrated low levels of nutritional knowledge, 44.3% held poor food consumption attitudes, and 83.0% engaged in inappropriate food consumption behaviours (Bunjong et al., 2024). Despite a majority maintaining normal nutritional status at the time of assessment, the authors cautioned that persistently inadequate knowledge, attitudes, and behaviours may eventually predispose workers to overnutrition and associated non-communicable diseases if corrective educational measures are not implemented.

Similar patterns have been observed in the Indian context. A study examining health status and dietary habits of food aggregator app delivery partners in Mumbai found that 76.7% of participants did not consider breakfast an important meal, and approximately 42% reported habitually skipping meals (Li et al., 2024). These findings suggest that even in the absence of overt nutritional deficiency, the dietary behaviours adopted by delivery riders reflect a limited understanding of meal importance, nutrient adequacy, and the consequences of irregular eating on metabolic health.

The qualitative evidence corroborates these quantitative observations (Kim et al., 2026), in a qualitative interview study conducted among motorcycle-based food delivery workers in South Korea, found that challenging working conditions generated both physical and emotional stressors, which in turn precipitated negligent driving and unhealthy lifestyle habits. Importantly, while participants recognised traffic accidents as the primary occupational risk, health maintenance and dietary quality received considerably less attention, reflecting a passive orientation toward preventive health management.

2.11 Behavioural Risk Factors and Health-Compromising Habits

A study conducted (Li et al., 2024) on food aggregator delivery partners in Mumbai reported that the mean duration of employment was 28.4 months, with an average daily working time of 10.4 hours. Within this cohort, 33.3% consumed alcohol, 48.3% reported smoking, and 46.7% engaged in tobacco use, while 77.3% had no health policy coverage. These behavioural risk factors, compounded by prolonged occupational exposure to traffic pollution, heat, and physical strain, substantially elevate the likelihood of developing non-communicable diseases over time.

The high prevalence of tobacco use among delivery riders has been corroborated in a large-scale cross-sectional study (Li et al., 2024) conducted among 1,879 food delivery riders in Guangzhou and Shenzhen, China, which found that 65.5% of participants were current smokers. Logistic regression analyses demonstrated that job-related uncertainty, stress, and emotional exhaustion were independently and significantly associated with smoking behaviour, underscoring the interplay between occupational pressures and health-risk lifestyle choices in this population. These findings highlight that unhealthy lifestyle behaviours among delivery riders are not merely a reflection of individual choices but are deeply embedded within the structural and psychosocial conditions of gig-based employment.

2.12 Health Management Attitudes and Institutional Gaps

From a broader occupational health perspective, the qualitative evidence reinforces these quantitative observations (Kim et al., 2026), in a thematic analysis conducted among motorcycle-based food delivery workers in South Korea, found that challenging working conditions generated compounding physical and emotional stressors that precipitated negligent driving behaviours and a progressive deterioration in health-related habits. Notably, a majority of participants demonstrated a passive attitude toward health management, with proactive health-seeking behaviour confined to a minority who adopted individual coping strategies in the absence of institutional support.

This passive orientation toward lifestyle management, observed across multiple international study settings, reflects the structural inadequacy of occupational health provisions for gig-based delivery workers. Unlike formally employed shift workers who may benefit from employer-mandated health screenings, occupational health nurses, and workplace wellness programmes, food delivery riders operate largely outside such institutional frameworks. This highlights the urgent need for context-specific lifestyle health promotion frameworks tailored to the unique occupational realities of this group, including flexible scheduling of health assessments, mobile health outreach initiatives, and platform-integrated wellness communications.

2.13 Stress Management in Food Delivery Riders

2.13.1 Prevalence and Sources of Occupational Stress

Occupational stress represents one of the most pervasive and consequential health concerns among food delivery riders. The inherently precarious nature of gig-based employment, characterised by income instability, absence of job security, algorithmic performance monitoring, and continuous exposure to traffic-related hazards, generates a multifactorial stress burden that differs qualitatively from stress experienced within conventional employment settings. In a cross-sectional study among 425 male app-based food delivery riders in Tamil Nadu, documented a high prevalence of anxiety, depression, and burnout. Moderate and moderate-to-severe anxiety was identified in 23.7% and 12.5% of participants respectively, while moderate and moderate-to-severe depression was present in 26.8% and 16.2%. Low to medium burnout was observed in 89.2% of the cohort. Multivariate logistic regression analyses revealed that monthly income, severe depression, and dehydration were independently and significantly associated with burnout and anxiety, highlighting the complex interplay between economic vulnerability and psychological distress in this occupational group (Sathiyarajeswaran et al., 2025).

The role of algorithmic management as a distinct and emerging stressor in food delivery has been examined (Dong et al., 2025), identified that factors including punishment systems, work monitoring mechanisms, ranking systems, customer feedback, and restaurant preparation time were significantly associated with rider burnout. The authors concluded that individualised support, humane organisational design, and a supportive social environment could collectively attenuate the negative mental health consequences of algorithmic oversight, recommending these as priority targets for occupational health policy in the gig economy.

2.13.2 Stress and Its Physical Safety Consequences

Beyond psychological morbidity, occupational stress in food delivery riders manifests in direct and measurable physical harm. In a cross-sectional study of 248 food delivery riders employing structural equation modelling, they demonstrated that stress-related psychosocial factors at work were independently associated with occupational traffic crashes, with fatigue acting as a significant mediating variable. These findings emphasise that stress in delivery riders does not merely impair psychological wellbeing but translates into unsafe road behaviour and an elevated risk of accident-related injury, reinforcing the urgency of stress surveillance and targeted management programmes within this population (Useche et al., 2024).

This relationship between occupational stressors and physical safety outcomes is further supported by evidence indicating that delivery riders experiencing high levels of emotional exhaustion are significantly more likely to engage in risky driving behaviours, including speeding and distracted riding, as a consequence of diminished cognitive control and attentional capacity under chronic stress load (Kim et al., 2026). The compounding effect of stress-induced fatigue, inadequate sleep, and poor nutritional status on rider alertness and road safety represents a critical but underexplored dimension of occupational health in the food delivery sector.

2.13.3 Physiological Mechanisms Linking Stress to Dietary Behaviour

The physiological consequences of sustained psychological stress on dietary intake have been characterised through well-established neuroendocrine pathways. Chronic stress activates the hypothalamic-pituitary-adrenal (HPA) axis, elevating cortisol secretion, which in turn stimulates appetite and increases preference for energy-dense, high-sugar, and high-fat foods, while simultaneously impairing the capacity for controlled and mindful eating (Cortes et al., 2021).

Among industrial and retail workers assessed using the Perceived Stress Scale (PSS-10), higher stress scores were independently associated with a significantly greater likelihood of consuming ultra-processed food categories, including sugary drinks, fast foods, and processed meats (Cortes et al., 2021).

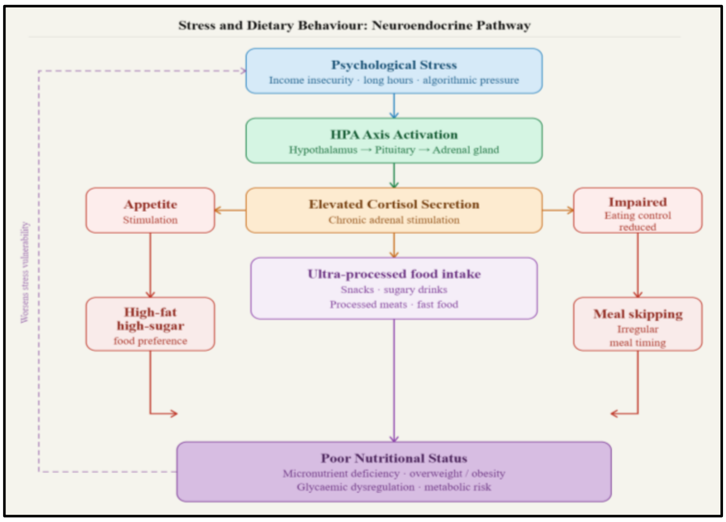

Figure 2.1 physiological pathway linking psychological stress to dietary behaviour via HPA axis activation

In a study specifically among shift workers, (Canuto et al., 2021) found that higher PSS-10 scores were associated with a 28% greater probability of consuming a dietary pattern dominated by snacks and fast foods, even after adjustment for demographic and occupational confounders. These neurobiological and behavioural links between perceived stress and poor dietary quality have direct implications for food delivery riders, who face both elevated stress exposure and severely constrained access to nutritious food options during their working hours.

2.14 Dietary Management in Food Delivery Riders

2.14.1 Meal Timing, Meal Skipping, and Circadian Disruption

Dietary management in food delivery riders encompasses both the spontaneous dietary behaviours adopted by riders in response to their occupational constraints and the broader strategies that may be implemented to optimise their nutritional status. Due to the absence of formalised occupational nutrition programmes for gig workers, most existing evidence on dietary management in this population has been drawn from observational data on dietary patterns, meal timing, food choice behaviour, and nutrient intake adequacy.

Irregular meal timing and meal skipping are among the most consistently reported dietary management challenges in this group.

A study (Akbar et al., 2024), published in Nutrients and using data from 10,486 participants in the National Health and Nutrition Examination Survey (NHANES 2005–2016), found that unfavourable meal timing, meal skipping, and shift work were each independently associated with a significantly higher likelihood of Circadian Syndrome, a condition encompassing metabolic syndrome components alongside short sleep and depressive symptoms. The odds ratios for unfavourable mealtime, meal skipping, and shift work were 1.24, 1.39, and 1.37, respectively, underscoring the cardiometabolic consequences of disrupted eating patterns.

For food delivery riders, whose working conditions closely parallel those of shift workers in terms of unpredictable schedules and prolonged working periods, these findings are particularly salient. A study among Japanese workers published in Nutrients further demonstrated that irregular meal timing was significantly associated with higher neuroticism, increased snacking frequency, and a greater incidence of sleep disturbances and poor subjective health, with mental health emerging as the outcome most strongly correlated with meal timing irregularity (Nakajima et al., 2021). This bidirectional relationship between meal patterns and mental health is especially pertinent for delivery riders, where occupational stressors and dietary irregularity may mutually reinforce one another.

2.14.2 Nutritional Status and Dietary Intake Patterns

Macronutrient and micronutrient intake patterns among delivery riders have been examined in limited but informative studies. Among 60 food aggregator delivery partners in Mumbai, 25 participants (41.7%) presented with a normal BMI, 13 (21.7%) were overweight, and 20 (33.3%) were classified as obese, reflecting the coexistence of nutritional excess and dietary inadequacy that characterises many physically active, nutritionally unmonitored populations (Li et al., n.d.). High rates of meal skipping, inadequate breakfast consumption, and reliance on convenience foods have been identified as the dominant dietary patterns in this group, collectively increasing vulnerability to micronutrient deficiencies, glycaemic dysregulation, and weight-related comorbidities.

A study among food delivery workers in Chiang Mai Province, Thailand, further revealed that 83.0% of participants exhibited inappropriate food consumption behaviours, while 67.4% demonstrated low levels of nutritional knowledge (Bunjong et al., 2024). Despite a majority maintaining normal nutritional status at the time of assessment, the authors cautioned that persistently inadequate dietary practices, if left unaddressed, may gradually predispose this population to overnutrition and diet-related chronic disease. These findings collectively underscore the need for systematic dietary assessment tools such as the 24-hour dietary recall, food frequency questionnaires, and meal pattern questionnaires to accurately capture the nutritional vulnerabilities of food delivery riders in the Indian urban context.

2.14.3 Evidence-Based Dietary Interventions and Future Directions

From the broader occupational nutrition literature, the evidence indicates that effective dietary management in working populations requires an integration of individualised counselling, structured environmental food access, and nutritional education tailored to the specific constraints of the occupational group (Nyhus Dhillon et al., 2023; Panchbhaya et al., 2021). The study further emphasised that comprehensive workforce nutrition programmes targeting high-risk worker categories demonstrated the most consistent improvements across nutritional, anthropometric, and metabolic outcomes, with individualised counselling and worksite environmental modifications identified as the most effective components.

For food delivery riders, whose mobility, time constraints, and economic limitations impose unique barriers to conventional dietary management strategies, the development of feasible, context-sensitive dietary guidance, potentially delivered through digital platforms or rider aggregator applications, represents a promising and as yet underexplored avenue for improving nutritional outcomes in this rapidly growing workforce.

CHAPTER III
METHODOLOGY

The rapid expansion of the food delivery sector has led to the emergence of a large gig-based workforce exposed to irregular work schedules, prolonged working hours, and limited access to nutritious meals, thereby increasing their vulnerability to poor dietary intake, elevated stress levels, and adverse nutritional outcomes. In occupational health research, the workplace is recognized as a critical determinant of health behaviors, with evidence suggesting that unhealthy dietary patterns and occupational stress contribute significantly to the rising burden of non-communicable diseases among working populations (Rachmah et al., 2021). Food delivery riders, in particular, experience unique occupational challenges such as time pressure, job insecurity, and inconsistent income, which have been associated with increased levels of anxiety, burnout, and compromised well-being (Samal et al., 2025). Furthermore, the lack of structured workplace nutrition environments limits their access to balanced meals, reinforcing dependence on convenient, energy-dense foods. Workforce nutrition interventions—including improved access to healthy foods, nutrition education, and regular health assessments—have been shown to positively influence dietary behaviors, enhance productivity, and reduce health risks (Dhillion-Ortenzi et al., 2023). The study aims to assess the dietary intake, stress scores, and nutritional status among food delivery riders and to understand the interplay between occupational stressors and health outcomes, and to inform targeted interventions aimed at improving their overall well-being.

3.1 Study Design
The study was a cross-sectional observational study.

3.1.1 Study Sample
The study included male food delivery riders aged 18–35 years working in Mumbai, Maharashtra.

3.1.2 Study Site
Mumbai, Maharashtra

3.1.3 Sample Size
The total sample size (N) was 150 food delivery riders residing and working in Mumbai.

3.1.4 Method of Sample Selection
The samples were recruited using a purposive sampling method. Participants were selected from various locations across Mumbai, including delivery hotspots and food outlet clusters. The purpose of the study was clearly explained to all participants. Written informed consent was obtained prior to participation.

3.1.5 Inclusion Criteria
Subjects were recruited based on the following inclusion criteria:

- Men aged 18–35 years old at the time of enrollment
- Currently employed as a food-delivery rider and actively delivering for ≥3 months
- Able to comprehend and respond to the study questionnaire in the study language(s) (e.g., English, Hindi, local language) and able to give informed consent

3.1.6 Exclusion Criteria

Subjects were eliminated based on the following exclusion criteria:

- Any known chronic illness

3.1.7 Study Duration

The study was conducted for four months.

3.2 Ethical Approval

The ethics approval was obtained from the Inter System Biomedical Ethics Committee (ISBEC) before the start of the study (Appendix A).

3.3 Informed Consent

Participants were provided with a Participant Information Sheet and Consent Form detailing the purpose, procedures, and confidentiality aspects of the study. Written informed consent was obtained from all participants before data collection.

3.4 Recruitment Process of Samples

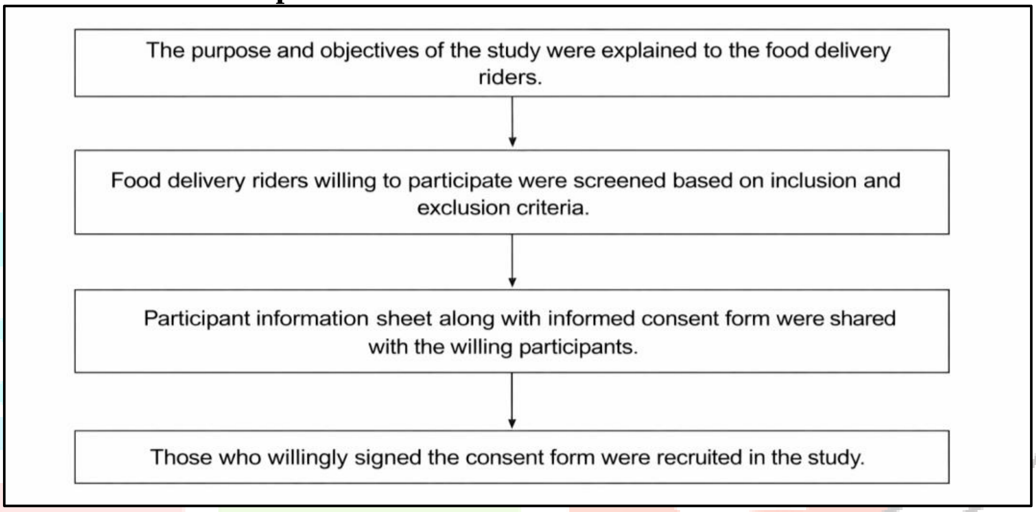

Figure 3.4.1 - recruitment process of samples

Figure 3.4.1 depicts the flow of recruitment of participants in the study. The purpose and objectives of the study were first explained to the participants. Willing participants were screened based on predefined inclusion and exclusion criteria. Participant information sheets along with informed consent forms were provided and explained. Only those who provided consent were recruited into the study.

3.5 Flowchart of Methodology

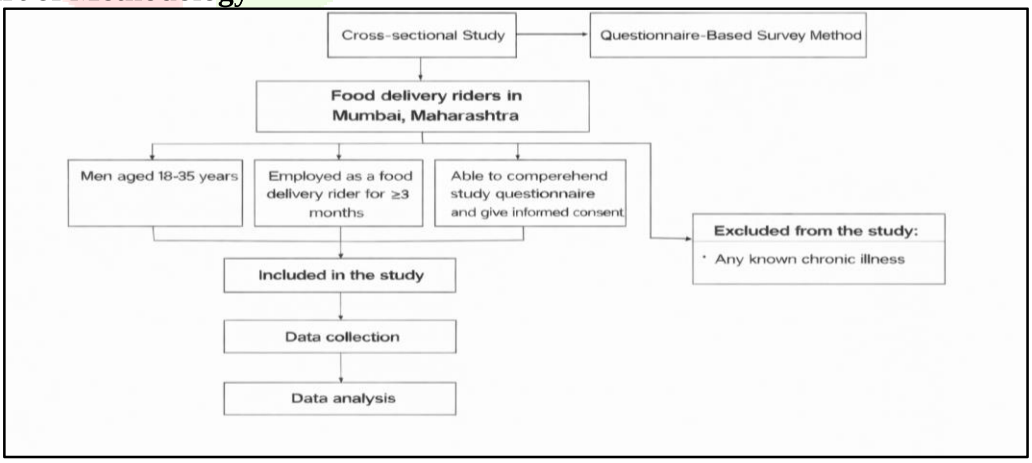

Figure 3.5.1 - flowchart summary of study methodology

Figure 3.5.1 depicts the methodological flow of the study on dietary intake, stress score, and nutritional status among food delivery riders in Mumbai, Maharashtra.

It was a cross-sectional observational study conducted among eligible food delivery riders. Participants meeting inclusion criteria were recruited, while those with any known chronic illness were excluded. The collected data was systematically analyzed to derive results and draw conclusions.

3.6 Research Tools for Data Collection

A case record form was administered for data collection using the interview technique. The following sections were included in the case record form:

3.6.1 Demographic characteristics
3.6.2 Anthropometric measurements - Height, weight, and BMI
3.6.3 Dietary Intake - 24 hour dietary recall and semi quantitative Food Frequency Questionnaire (Semi-FFQ)
3.6.4 Stress Score - Perceived Stress Score (PSS)
3.6.5 Meal Timing and Frequency - Meal Pattern Questionnaire (MPQ)
3.6.6 Nutrition Awareness - General Nutrition Knowledge Questionnaire (GNKQ)

3.6.1 Demographic characteristics

Information on age, past medical history, past medical history in the family, current medication intake, dietary preferences(vegetarian, non vegetarian or ovo vegetarian) and socioeconomic status was collected through structured interviews and review of medical records.

3.6.2 Anthropometric Data

Anthropometric measurements are non-invasive, quantitative techniques used to assess the physical dimensions and composition of the human body. According to the Centers for Disease Control and Prevention (CDC), anthropometry serves as a reliable indicator for evaluating nutritional status across different population groups. In adult populations, these measurements are essential for identifying undernutrition, overweight, obesity, and associated health risks. The core anthropometric parameters include height, weight, and body mass index (BMI), which provide a standardized approach to assess body composition (Casadei & Kiel, 2022).

For the present study involving food delivery riders, height and weight were measured using standard procedures, and BMI was calculated using the formula weight (kg)/height (m^2). The classification of nutritional status was carried out based on the World Health Organization (WHO) BMI classification for adults, which categorizes individuals into underweight, normal weight, overweight, and obese based on established cut-off values. BMI is widely used in epidemiological studies due to its simplicity, cost-effectiveness, and strong association with health outcomes, including non-communicable diseases. These anthropometric indicators provide valuable insights into the nutritional status of food delivery riders and help in understanding the relationship between occupational factors, dietary intake, and overall health.

3.6.3 Dietary Assessment:

3.6.3.1 24-hour Diet Recall

A 24-hour dietary recall is a valid method used to assess an individual's food and beverage intake by having them recount everything they consumed in the past 24 hours. This approach offers detailed, quantitative insights into recent dietary habits and is valued for its simplicity and efficiency. The process typically involves a trained interviewer guiding the participant through their day, prompting for details about portion sizes, preparation methods, and any forgotten items, often using a structured, multi-pass approach to improve accuracy (Rahman et al., 2025;Chowdhury et al., 2020)

3.6.3.2 A Semi-Quantitative Food Frequency Questionnaire (semi-FFQ)

Semi-FFQ is a dietary assessment tool designed to estimate an individual’s usual intake of foods and nutrients over a specific period, typically the past month or year.The semi-FFQ also asks about typical portion sizes, allowing for a more accurate estimation of nutrient and energy intake (Qin et al., 2023).

In the dietary assessment process of the study, a qualified dietitian instructed the participants' parents to estimate the quantity of food their child consumed at each meal using standardized household measures, such as cups and spoons. These estimates of cooked food portions were then utilized to back-calculate the amount of raw ingredients consumed in the entire meal. The raw ingredients were quantified in grams or millilitres, depending on the nature of the food item. This approach allowed for a more accurate estimation of the child's actual dietary intake based on standardized measurements.The nutrient composition of all meals consumed was calculated. The macronutrients like energy, protein, carbohydrates, fats, and micronutrients like selenium,zinc and vitamin C were calculated. Nutrient intakes were analyzed using standard food composition table (Indian Food Composition Table 2017). In the dietary assessment process, a qualified dietitian instructed the participants' parents to estimate the quantity of food their child consumed at each meal using standardized household measures, such as cups and spoons. These estimates of cooked food portions were then utilized to back-calculate the amount of raw ingredients consumed in the entire meal. The raw ingredients were quantified in grams or millilitres, depending on the nature of the food item. In addition to the 24-hour dietary recall, a semi-quantitative Food Frequency Questionnaire (FFQ) was also administered to gather information on the frequency and approximate quantity of commonly consumed foods over a period of month.

Scoring of FFQ

The daily intake of each food item (g/d) and beverage (ml/d) is calculated using the frequency of consumption. The following values for reported frequencies are used to determine the daily intake by multiplying the stated portion unit by the frequency of ingestion: more than three times per day = 10, twice daily = 9, once daily = 8, 5-6 times per week = 7, 2-4 times per week =6, once per week =5, 2-3 times per month = 4, monthly = 3, less than once per month = 2, and never eaten or don't know the food = 1.

3.6.4 Stress Score - Perceived Stress Score (PSS)

Widely used psychological instrument developed by Cohen, Kamarck, and Mermelstein in 1983. The PSS was designed to measure the degree to which individuals perceive situations in their lives as stressful, unpredictable, uncontrollable, and overwhelming, focusing on subjective stress appraisal rather than objective stressors (Cohen et al., 1983). It assesses perceived stress over the preceding one month, making it suitable for cross-sectional studies examining associations between stress, lifestyle factors, and health outcomes.

PSS-10, consists of 10 items, each rated on a 5-point Likert scale ranging from 0 (never) to 4 (very often). Of the 10 items, four items are positively stated and require reverse scoring. The total PSS score is obtained by summing the responses to all items after reverse scoring the positively worded questions. Total scores range from 0 to 40, with higher scores indicating greater perceived stress. Stress levels are generally interpreted as: **Low stress: 0–13, Moderate stress: 14–26, High perceived stress: 27–40**

Table 3.1 - PSS scoring

SCORE	INTERPRETATION
0–13	Low stress
14-26	Moderate stress
27-40	High perceived stress

3.6.5 Meal Timing and Frequency - Meal Pattern Questionnaire (MPQ)

The instrument captures the frequency of consumption of main meals and snacks over the preceding 28 days, thereby providing an estimate of habitual eating behavior. Participants were asked to report how often they consumed specific eating occasions, including breakfast, mid-morning snack, lunch, mid-afternoon snack, evening meal, evening snack, and nocturnal eating. To improve accuracy, respondents were instructed to consider both weekdays and weekends while answering. (Holmback et al., 2010).

The questionnaire clearly distinguishes between meals/snacks and non-qualifying items. Regular foods such as cooked meals, sandwiches, fruits, and dairy-based items were considered valid eating occasions, whereas sugar-dense foods (e.g., confectionery, chips) and beverages (e.g., tea, coffee, soft drinks) were excluded. Special instructions were provided for ambiguous cases (e.g., brunch categorized as lunch), ensuring consistency in responses. Such structured classification improves the reliability of self-reported dietary data and minimizes misclassification bias in meal pattern research (Leech et al., 2015).

Table 3.2 - MPQ scoring

SCORE	DAYS
0	No days
1	1-5
2	6-12
3	13-15
4	16-22
5	23-27
6	Every day

Each item in the MPQ was scored on a 7-point ordinal scale based on the number of days the eating occasion occurred in the past 28 days: 0 = no days, 1 = 1–5 days, 2 = 6–12 days, 3 = 13–15 days, 4 = 16–22 days, 5 = 23–27 days, and 6 = every day.

3.6.6 Nutrition Awareness - General Nutrition Knowledge Questionnaire (GNKQ)

The instrument comprises multiple sections that evaluate awareness of expert dietary advice, identification of nutrient composition of foods, and the ability to make healthier dietary choices in practical situations. Participants were instructed to complete the questionnaire independently and select "not sure" where applicable to reduce the likelihood of guessing and improve the accuracy of responses (Parmenter et al., 1999).

The questionnaire includes a mix of multiple-choice, true/false, and classification-based items (e.g., identifying foods high or low in specific nutrients, recognizing balanced meal options, and interpreting food labels), ensuring a comprehensive assessment of both theoretical and applied nutrition knowledge. (Kliemann et al., 2016).

TheGNKQ comprises 48 items across 4 core dimensions:

1. **Dietary Recommendations (Section 1: 9 items)** – Assesses awareness of expert guidelines related to intake of various foods, fats, and dietary practices.
2. **Food Groups and Nutrients (Section 2: 10 items)** – Evaluates knowledge of nutrient composition, including sugar, salt, fibre, protein, and types of fats in foods.
3. **Food Choices (Section 3: 13 items)** – Measures the ability to make healthier food selections in practical situations, including meal choices and interpretation of food labels.
4. **Diet–Disease Relationships and Weight Management (Section 4: 16 items)** – Assesses understanding of the link between diet and health conditions such as obesity, cardiovascular diseases, and diabetes, along with weight management concepts.

Scoring System:

Each item is scored as:

0 = Incorrect / Not sure

1 = Correct

All responses are summed to obtain a total nutrition knowledge score, with higher scores indicating better knowledge. Section-wise scores are also calculated to evaluate domain-specific knowledge. (Parmenter et al., 1999; Kliemann et al., 2016).

3.7 Data Analysis

Data analysis was performed using SPSS (Statistical Package for Social Sciences) software (version 21). Data were generated in the form of tables and figures. Descriptive statistics such as mean, frequency, and standard deviation were used to analyse variables. Inferential statistics such as the chi-square test, ANOVA and T- test were performed to determine the association between variable

CHAPTER IV
RESULTS AND DISCUSSION

This cross-sectional study entitled, "Study on Dietary Intakes, Stress Score and Nutritional Status in Food Delivery Riders in Mumbai, Maharashtra" evaluated the dietary practices, perceived stress levels, and nutritional status among food delivery riders aged 18–35 years. The study further examined the interrelationship between meal timing, meal frequency, nutrition awareness, dietary intake, and overall nutritional status. Perceived stress was assessed using the Perceived Stress Scale (PSS). Dietary intake was evaluated using a 24-hour dietary recall method along with a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate habitual nutrient intake. Meal timing, meal frequency, and eating behaviours were assessed using the Meal Pattern Questionnaire (MPQ). Nutrition awareness was evaluated using the General Nutrition Knowledge Questionnaire (GNKQ). Anthropometric measurements including height, weight, and Body Mass Index (BMI) were recorded to determine the nutritional status of the participants. Additionally, demographic characteristics and general health-related information of the participants were collected to provide contextual understanding of the study population.

This chapter accomplished the objectives of the study by analysing the data obtained through appropriate statistical methods.

The components of the results of the study are as follows:

1. Baseline Demographic Characteristics of the Study Participants
2. Anthropometric Measurements and Nutritional Status of the Study Participants
3. Dietary Intake Patterns of the Study Participants (24-hour Recall and FFQ Analysis)
4. Meal Timing, Meal Frequency and Eating Behaviour Patterns of the Study Participants
5. Perceived Stress Scores of the Study Participants
6. Nutrition Knowledge Scores of the Study Participants
7. Association between Dietary Intake, Meal Patterns, Stress Levels and Nutritional Status of the Study Participants
8. Correlation between Nutrition Knowledge, Eating Behaviour and Nutritional Status of the Study Participants

4.1 Baseline Demographic Characteristics of the Food Delivery Riders

The study sample consisted of 150 male food delivery riders recruited from Mumbai, Maharashtra. The minimum age of the participants was 18 years and the maximum age was 35 years, with a mean age of 25.72 ± 4.60 years. With respect to perceived stress, 38 participants (25.3%) were categorised under Low Stress (PSS score 0–13), 78 participants (52.0%) under Moderate Stress (PSS score 14–26), and 34 participants (22.7%) under High Stress (PSS score 27–40), based on the Perceived Stress Scale (PSS-10) scoring criteria.

Table 4.1.1 demographic characteristics of the study sample between PSS categories

Demographic Characteristics	Total (N=150) (N, %)	PSS Category			Chi-Square test value	p-value
		Low Stress (n=38)	Moderate Stress (n=78)	High Stress (n=34)		
Age (in years)						
18–35 years	150 (100.0)	38 (100.0)	78 (100.0)	34 (100.0)	27.604	0.000*
Medical History						
Yes	14 (9.3)	4 (10.5)	6 (7.7)	4 (11.8)	0.550	0.760

No	136 (90.7)	34 (89.5)	72 (92.3)	30 (88.2)		
Family Medical History						
Yes	4 (2.7)	0 (0.0)	0 (0.0)	4 (11.8)	14.021	0.001*
No	146 (97.3)	38 (100.0)	78 (100.0)	30 (88.2)		
Current Medication Consumption						
Yes	11 (7.3)	7 (18.4)	4 (5.1)	0 (0.0)	10.123	0.006*
No	139 (92.7)	31 (81.6)	74 (94.9)	34 (100.0)		
Socioeconomic Class (Kuppuswamy Scale)						
Upper Middle (II)	27 (18.0)	8 (21.1)	12 (15.4)	7 (20.6)	15.896	0.003*
Lower Middle (III)	11 (7.3)	7 (18.4)	0 (0.0)	4 (11.8)		
Upper Lower (IV)	112 (74.7)	23 (60.5)	66 (84.6)	23 (67.6)		

*Frequency Percentage (N, %); *p < 0.05 (Statistically Significant)*
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.1.1 presents a comprehensive analysis of the demographic characteristics of the participants across the three Perceived Stress Scale (PSS) categories — Low Stress (n = 38; 25.3%), Moderate Stress (n = 78; 52.0%), and High Stress (n = 34; 22.7%). The mean PSS score of the total sample was 20.69 ± 10.02, indicating that the majority of riders experienced moderate perceived stress. Chi-square analyses revealed statistically significant associations between PSS category and age group ($\chi^2 = 27.604$, $p < 0.001$), family medical history ($\chi^2 = 14.021$, $p = 0.001$), current medication use ($\chi^2 = 10.123$, $p = 0.006$), dietary preference ($\chi^2 = 10.382$, $p = 0.034$), and socioeconomic status ($\chi^2 = 15.896$, $p = 0.003$). Medical history alone did not demonstrate a statistically significant association with PSS category ($\chi^2 = 0.550$, $p = 0.760$).

The age distribution of the sample revealed that 62 (41.3%) riders were aged 18–24 years, 64 (42.7%) were aged 25–30 years, and 24 (16.0%) were aged 31–35 years. A statistically significant association was observed between age group and PSS category ($\chi^2 = 27.604$, $p < 0.001$). Riders in the 25–30 year age group constituted the majority of those in the Low Stress category (73.7%), whereas the 18–24 year age group was most heavily represented in the Moderate Stress category (56.4%). In the High Stress category, riders aged 18–24 years (41.2%) and 25–30 years (47.1%) were comparably represented. This pattern is consistent with evidence indicating that younger workers in the gig economy experience heightened psychological vulnerability owing to financial precarity, job insecurity, and inadequate social protection (Samal et al., 2025). The concentration of moderate-to-high stress among the youngest age cohort (18–24 years) may reflect compounding psychosocial pressures including entry-level earnings, absence of occupational benefits, and exposure to road-related hazards — stressors documented to amplify perceived stress in delivery-based occupations (Useche et al., 2024).

The vast majority of participants (90.7%; n = 136) reported no personal medical history, with no significant difference across PSS categories ($\chi^2 = 0.550$, $p = 0.760$). This finding may reflect recruitment bias, as the study excluded participants with known chronic illness per the eligibility criteria, thereby limiting variability on this variable.

In contrast, family medical history demonstrated a highly significant association with PSS category ($\chi^2 = 14.021$, $p = 0.001$). All four participants reporting a positive family medical history (2.7%) were exclusively concentrated in the High Stress group (11.8%), with no representation in the Low or Moderate Stress categories. This finding aligns with the broader understanding that awareness of familial disease burden functions as a chronic psychological stressor, increasing vigilance and worry related to personal health outcomes. Evidence from occupational health literature suggests that workers who perceive themselves as genetically predisposed to illness demonstrate heightened stress reactivity and greater health anxiety (Shrivastava et al., 2024).

Current medication use was reported by 11 (7.3%) participants and showed a statistically significant inverse association with PSS category ($\chi^2 = 10.123$, $p = 0.006$). Notably, medication use was highest in the Low Stress group (18.4%), intermediate in the Moderate Stress group (5.1%), and entirely absent in the High Stress group (0.0%). This counter-intuitive gradient may reflect a form of therapeutic buffering, wherein pharmacological management of underlying subclinical conditions mitigates perceived stress in riders who would otherwise experience higher psychological burden. Alternatively, the pattern may suggest that highly stressed riders are less likely to seek or adhere to medical care — a pattern documented in gig-economy workers characterised by limited access to employer-sponsored healthcare and reluctance to take time off for medical consultations (Samal et al., 2025).

Dietary preference was significantly associated with PSS category ($\chi^2 = 10.382$, $p = 0.034$). Non-vegetarianism was the predominant dietary pattern across all stress groups, but its prevalence was markedly higher in the Moderate Stress group (82.1%) relative to the Low (55.3%) and High Stress (64.7%) groups. Vegetarianism was most prevalent among riders in the Low Stress category (34.2%). Ovo-vegetarianism was uniformly distributed across all three categories (Low: 10.5%; Moderate: 5.1%; High: 11.8%).

The higher proportion of vegetarians in the Low Stress category is consistent with evidence linking plant-based dietary patterns to lower perceived stress and improved psychological well-being. Diets rich in fruits, vegetables, and whole grains are associated with reduced inflammatory markers and more favourable neuroendocrine stress responses, mediated in part through the gut-brain axis (Bunjong et al., 2024). Conversely, the predominance of non-vegetarianism in the Moderate Stress group may reflect the broader eating behaviours of urban male gig-workers who rely heavily on roadside and convenience-based non-vegetarian food options due to time constraints and occupational demands (Li et al., n.d.).

Socioeconomic classification using the Kuppuswamy Scale revealed a predominantly Lower Middle class (Class III; Upper Lower in original scale notation) sample (n = 112; 74.7%), with smaller proportions in the Upper Middle class (n = 27; 18.0%) and Upper Lower class (n = 11; 7.3%). A statistically significant association was found between SES and PSS category ($\chi^2 = 15.896$, $p = 0.003$). Upper Middle class participants were concentrated in the Low Stress (18.4%) and High Stress (11.8%) groups but were entirely absent from the Moderate Stress group. Lower Middle class riders constituted the majority across all PSS categories, while Upper Lower class riders were proportionally represented in the Low (21.1%), High (20.6%), and Moderate (15.4%) Stress groups.

The significant SES–stress association supports the well-established socioeconomic gradient in psychological health, wherein lower socioeconomic position confers greater exposure to financial stressors, housing instability, and resource scarcity — all established determinants of perceived stress (Rachmah et al., 2021). Specifically, within the food delivery workforce, riders in the upper-lower socioeconomic stratum are likely to depend on delivery income as their primary livelihood, amplifying the psychological burden associated with performance-based earnings, physical hazards, and income volatility. This is corroborated by national estimates that food delivery riders in India earn between ₹15,000 and ₹20,000 per month, working upwards of ten hours daily across six days per week (Samal et al., 2025), conditions conducive to sustained economic and psychological stress.

Age Distribution of Food Delivery Riders

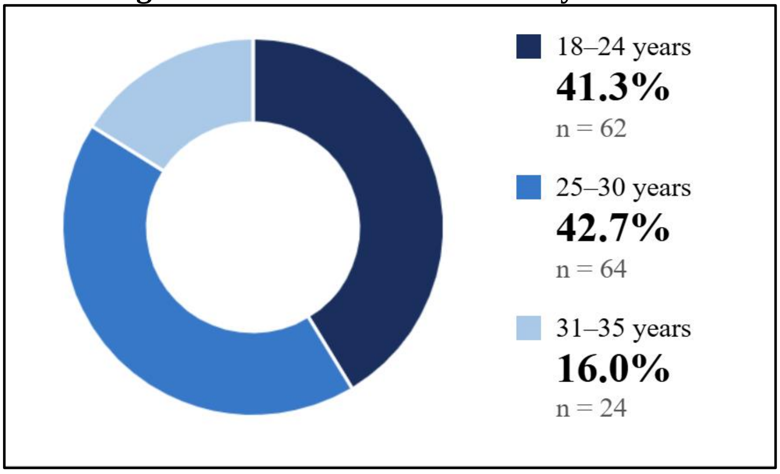

Figure 4.1.1 age distribution (in years) of the study participants (N = 150)

The age of the study participants ranged from 18 to 35 years. The most commonly represented age group was 25–30 years (n = 64, 42.7%), followed closely by the 18–24 years group (n = 62, 41.3%). A comparatively smaller proportion of participants fell within the 31–35 years age group (n = 24, 16.0%). Overall, the majority of participants (84.0%) were below 30 years of age, reflecting the predominantly young adult demographic characteristic of the food delivery workforce.

This age distribution is consistent with the occupational profile of gig-economy delivery workers, wherein younger males are disproportionately represented due to the physically demanding and schedule-intensive nature of the role. Evidence from a cross-sectional study conducted among app-based food delivery riders in Tamil Nadu reported a comparable young adult demographic, with riders predominantly in the 20–30 year age range, working extended hours under performance-based earning structures (Samal et al., 2025). The predominance of younger riders in the 18–30 year bracket in the present study may reflect the relatively lower entry barriers associated with delivery-based gig employment — requiring no formal educational qualifications — making it an accessible livelihood option for young men in urban settings, many of whom may be first-generation migrants or individuals supplementing household income.

From a nutritional and occupational health standpoint, the young adult age range carries particular significance. Young workers in physically demanding occupations are at heightened risk of inadequate dietary intake relative to their elevated energy expenditure, irregular meal patterns, and limited nutrition awareness — all of which may compound over time to adversely affect metabolic and cardiovascular health outcomes (Bunjong et al., 2024). Furthermore, the concentration of participants in the economically productive 18–30 year age window underscores the public health relevance of this cohort; dietary and stress-related health risks established during this period are likely to have long-term implications for chronic disease burden, particularly given the documented associations between occupational stress, poor dietary quality, and non-communicable disease risk in shift-based and gig-economy workers (Rachmah et al., 2021; Useche et al., 2024).

Dietary Preference Distribution Among Study Participants

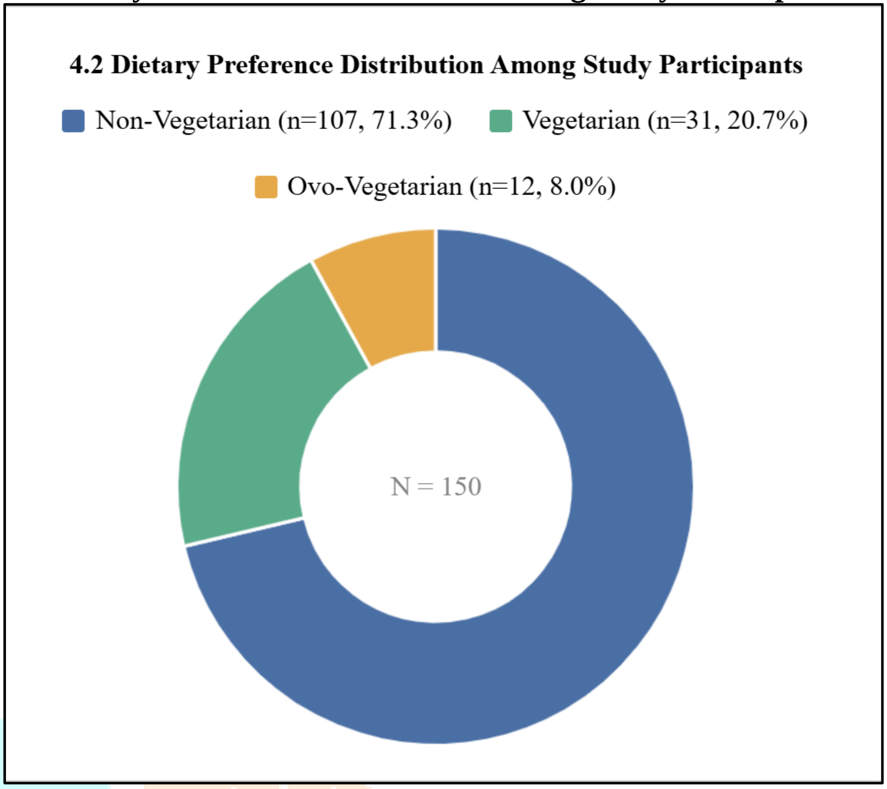

Figure 4.1.2 dietary preference distribution among the study participants (N = 150)

The dietary preferences of the study participants revealed a predominant non-vegetarian pattern across the sample. The majority of riders reported a non-vegetarian dietary preference (n = 107, 71.3%), followed by vegetarian (n = 31, 20.7%) and ovo-vegetarian (n = 12, 8.0%). Collectively, participants consuming animal-derived products in some form — whether meat-inclusive or egg-inclusive — constituted 79.3% of the total sample, indicating that plant-exclusive dietary patterns were comparatively uncommon in this cohort.

This distribution is consistent with the broader dietary landscape of urban male workers in Maharashtra, where non-vegetarian food consumption is prevalent and is frequently driven by affordability, palatability, and ease of access at roadside food outlets — all of which are particularly relevant to the occupational context of food delivery riders (Li et al., n.d.). The heavy reliance on non-vegetarian and convenience-based food options among this workforce is further compounded by irregular working hours, which restrict opportunities for home-cooked meal consumption and increase dependence on ready-to-eat street food, the majority of which tends to be non-vegetarian and energy-dense (Bunjong et al., 2024).

From a nutritional standpoint, the predominance of non-vegetarianism in this sample warrants attention in the context of dietary quality assessment. While non-vegetarian diets are not inherently nutritionally inferior, specific dietary patterns within this category — characterised by high consumption of fried preparations, processed meat products, and low intake of fruits, vegetables, and whole grains — are associated with elevated saturated fat intake, poor micronutrient diversity, and increased cardiometabolic risk (Hemiö et al., 2015; O'Brien et al., 2020). Given the physically demanding and stress-laden nature of food delivery work, the nutritional adequacy of dietary patterns in this population requires careful examination, particularly with respect to energy balance, protein quality, and micronutrient sufficiency.

Socioeconomic class distribution among the study participants

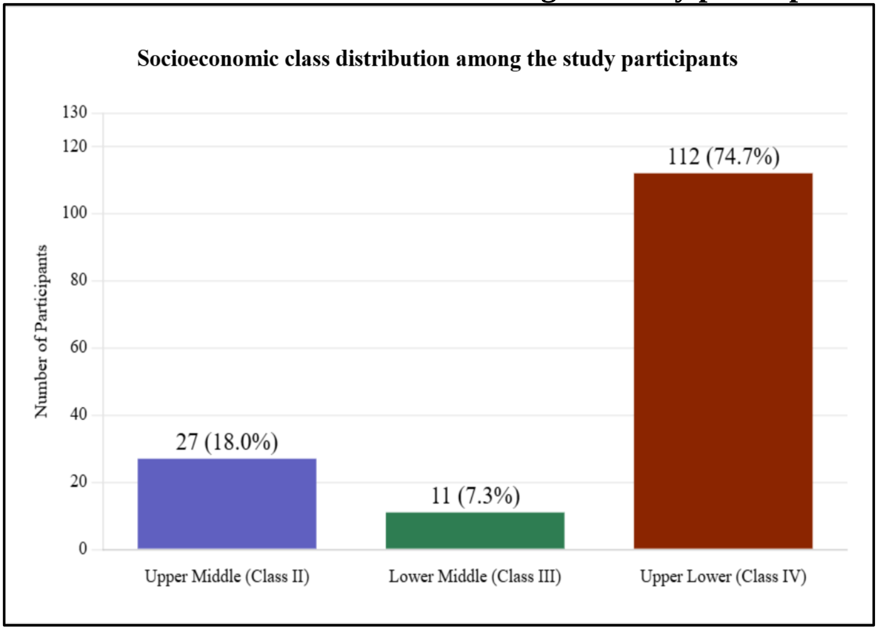

Figure 4.1.3 socioeconomic class distribution among the study participants (N = 150) based on the Kuppuswamy scale

The socioeconomic classification of participants, assessed using the Kuppuswamy Scale, revealed that the overwhelming majority of the study sample belonged to the Upper Lower class (Class IV; n = 112, 74.7%), followed by the Upper Middle class (Class II; n = 27, 18.0%), with the smallest proportion classified under the Lower Middle class (Class III; n = 11, 7.3%). No participants fell within the Upper (Class I) or Lower (Class V) socioeconomic categories. The strong concentration of participants in the Upper Lower socioeconomic stratum reflects the broader socioeconomic profile of the food delivery gig workforce in urban India.

This finding is consistent with national evidence indicating that food delivery riders in India predominantly belong to economically marginalised segments of the urban workforce, many of whom engage in delivery-based gig employment as their primary or sole source of income (Samal et al., 2025). The Upper Lower classification on the Kuppuswamy Scale is typically characterised by low monthly household income, limited educational attainment of the family head, and elementary or semi-skilled occupational categories — a profile that closely mirrors the economic realities of gig-based delivery workers who often lack formal employment contracts, social security benefits, employer-sponsored health insurance, or paid leave entitlements.

From a nutritional and public health perspective, lower socioeconomic status is a well-established determinant of dietary quality, with individuals in lower income brackets demonstrating reduced consumption of nutrient-dense food groups — including fruits, vegetables, dairy, and lean protein sources — and greater reliance on energy-dense, micronutrient-poor convenience foods (Rachmah et al., 2021). For food delivery riders operating within constrained economic circumstances, the intersection of financial stress, long working hours, and limited access to balanced meals creates a compounding nutritional vulnerability. This is further corroborated by evidence from workforce nutrition literature, which identifies lower socioeconomic position as independently associated with poorer dietary diversity, higher rates of meal skipping, and reduced nutrition knowledge — all of which are directly relevant to the variables under investigation in the present study (Dhillion-Ortenzi et al., 2023; Rachmah et al., 2021).

4.2 Anthropometric Measurements of the Study Sample

Table 4.2.1 comparison of anthropometric measurements between PSS categories

Variable	Low Stress (n=38)	Moderate Stress (n=78)	High Stress (n=34)	Total (N=150)	F-value	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
Anthropometric Measurements						
Weight (kg)	69.24 ± 14.86	63.73 ± 13.10	54.82 ± 6.36	63.11 ± 13.34	12.265	0.000*
Height (cm)	170.84 ± 5.11	168.38 ± 7.70	165.82 ± 6.44	168.43 ± 7.02	4.818	0.009*
BMI (kg/m²)	23.64 ± 4.44	22.46 ± 4.00	19.98 ± 2.39	22.20 ± 4.02	8.615	0.000*

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); One-Way ANOVA*
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.2.1 illustrates the comparison of anthropometric parameters among food delivery riders classified into three PSS categories — Low Stress (n = 38), Moderate Stress (n = 78), and High Stress (n = 34). One-way ANOVA revealed statistically significant differences across all anthropometric variables examined ($p < 0.05$), suggesting a meaningful relationship between perceived stress levels and the physical characteristics of the study participants.

Weight (kg) demonstrated a highly significant difference across PSS categories ($F = 12.265$, $p < 0.001$). A clear inverse trend was observed, with mean weight progressively declining from 69.24 ± 14.86 kg in the Low Stress group to 63.73 ± 13.10 kg in the Moderate Stress group and 54.82 ± 6.36 kg in the High Stress group. This gradient indicates that riders with higher perceived stress were, on average, notably lighter than their lower-stress counterparts — a finding that warrants careful interpretation in the context of occupational nutrition and stress physiology.

Height (cm) also demonstrated a statistically significant difference across PSS categories ($F = 4.818$, $p = 0.009$), with mean height declining from 170.84 ± 5.11 cm in the Low Stress group to 168.38 ± 7.70 cm in the Moderate Stress group and 165.82 ± 6.44 cm in the High Stress group. While height is a largely fixed anthropometric parameter in adults and is not expected to be directly influenced by perceived stress, this finding may reflect underlying socioeconomic and nutritional differences between the stress groups, given that adult stature is strongly shaped by early-life nutritional adequacy and socioeconomic conditions (Rachmah et al., 2021).

BMI (kg/m^2) similarly exhibited a highly significant inverse association with PSS category ($F = 8.615$, $p < 0.001$). Mean BMI declined progressively from 23.64 ± 4.44 kg/m^2 in the Low Stress group to 22.46 ± 4.00 kg/m^2 in the Moderate Stress group and 19.98 ± 2.39 kg/m^2 in the High Stress group. Notably, the mean BMI of the High Stress group (19.98 kg/m^2) approaches the lower boundary of the normal BMI range as per Asian cut-offs (18.5–22.9 kg/m^2), suggesting that riders experiencing the highest psychological burden may also be at nutritional risk from the undernutrition end of the spectrum.

Overall, the findings consistently indicate that as the PSS category increased from low to high stress, participants exhibited significantly lower mean values for weight, BMI, and height, alongside a younger age profile. The inverse relationship between perceived stress and BMI is of particular clinical and public health significance. Chronic psychological stress is known to dysregulate appetite-regulating hormones — including cortisol, leptin, and ghrelin — and may precipitate both under-eating and disordered meal patterns

(Tomiyama, 2018). In the context of food delivery riders, who are exposed to sustained occupational stressors including time pressure, physical exertion, traffic hazards, and income insecurity, elevated stress may suppress appetite, reduce meal frequency, and promote energy deficit — collectively contributing to lower body weight and BMI in the High Stress group. This is corroborated by evidence from Demirci and Kaptanoğlu (2022), who reported that shift workers experiencing greater occupational stress demonstrated lower meal frequency and poorer dietary regularity, factors directly linked to reduced energy intake and lower body weight. Furthermore, the narrow standard deviation of BMI in the High Stress group (±2.39 kg/m²) relative to the Low Stress group (±4.44 kg/m²) suggests greater homogeneity in nutritional status among highly stressed riders, possibly reflecting a convergence toward lower weight driven by shared patterns of meal skipping, irregular eating, and limited access to adequate nutrition during extended working hours (Hemiö et al., 2015; Bunjong et al., 2024).

Table 4.2.2 classification of study participants based BMI classification according to WHO across PSS categories

WHO BMI Classification	BMI Range (kg/m²)	Low Stress (n=38)		Moderate Stress (n=78)		High Stress (n=34)	
		n	%	n	%	n	%
WHO BMI Classification (World Health Organization, 2000)							
Underweight	< 18.5	4	10.5	11	14.1	8	23.5
Normal	18.5 – 24.9	17	44.7	49	62.8	26	76.5
Overweight	25.0 – 29.9	13	34.2	15	19.2	0	0.0
Obese (Class I & above)	≥ 30.0	4	10.5	3	3.8	0	0.0
Total	—	38	100.0	78	100.0	34	100.0
Chi-Square test value		$\chi^2 = 20.918$				p = 0.002*	

*Frequency Percentage (%); *p < 0.05 (Statistically Significant); Chi-Square Test*

WHO BMI Classification: Underweight <18.5 kg/m²; Normal 18.5–24.9 kg/m²; Overweight 25.0–29.9 kg/m²; Obese Class I 30.0–34.9 kg/m²

PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Note: No participants were classified under Obese Class II (BMI 35.0–39.9) or Obese Class III (BMI ≥ 40.0)

Table 4.2.2 presents the classification of food delivery riders according to the World Health Organization (WHO) BMI categories — Underweight (< 18.5 kg/m²), Normal (18.5–24.9 kg/m²), Overweight (25.0–29.9 kg/m²), and Obese (≥ 30.0 kg/m²) — across the three PSS categories. Chi-square analysis revealed a statistically significant association between BMI classification and PSS category ($\chi^2 = 20.918$, $p = 0.002$), indicating that the distribution of weight status differed meaningfully across perceived stress levels. No participants were classified under Obese Class II (BMI 35.0–39.9 kg/m²) or Obese Class III (BMI ≥ 40.0 kg/m²).

The majority of participants across all three PSS categories were classified within the Normal BMI range (18.5–24.9 kg/m²), with 17 (44.7%) in the Low Stress group, 49 (62.8%) in the Moderate Stress group, and 26 (76.5%) in the High Stress group. The progressive increase in the proportion of Normal BMI participants from the Low to the High Stress category is noteworthy and reflects the inverse relationship between perceived stress and BMI observed in the anthropometric analysis (Table 4.2.1).

Underweight status (BMI < 18.5 kg/m²) was observed in 4 participants (10.5%) in the Low Stress group, 11 (14.1%) in the Moderate Stress group, and 8 (23.5%) in the High Stress group. The markedly higher prevalence of underweight riders in the High Stress category — nearly one in four participants — is a clinically significant finding that reinforces the association between elevated perceived stress and lower body weight in this cohort. Chronic psychological stress is known to suppress appetite through neuroendocrine mechanisms involving elevated cortisol, reduced ghrelin sensitivity, and dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, collectively contributing to reduced energy intake and progressive weight loss in susceptible individuals (Tomiyama, 2018). In the occupational context of food delivery work, wherein riders are simultaneously exposed to time pressure, physical exertion, income insecurity, and traffic-related hazards, sustained stress may compound appetite suppression and meal skipping — behaviours directly associated with underweight status in physically demanding gig-economy workers (Samal et al., 2025; Useche et al., 2024).

Overweight status (BMI 25.0–29.9 kg/m²) was present in 13 participants (34.2%) in the Low Stress group and 15 (19.2%) in the Moderate Stress group, with a striking absence of any overweight participants in the High Stress group (0.0%). Similarly, obesity (Class I; BMI ≥ 30.0 kg/m²) was observed exclusively in the Low Stress (n = 4, 10.5%) and Moderate Stress (n = 3, 3.8%) groups, with no obese participants identified in the High Stress category. The complete absence of overweight and obese riders in the High Stress group is one of the most compelling findings of the present study and provides strong directional evidence for an inverse relationship between perceived stress and BMI classification in this cohort. This pattern diverges from the more commonly reported positive association between stress and obesity in sedentary or office-based occupational populations, wherein stress-induced hyperphagia — driven by increased preference for energy-dense, palatable foods — is the predominant behavioural response (Tomiyama, 2018). In contrast, among food delivery riders — who engage in sustained physical activity throughout their working hours — the predominant stress-related dietary behaviour may be appetite suppression and meal irregularity rather than overeating, ultimately manifesting as lower body weight and BMI in the most highly stressed individuals.

This finding is further contextualised by the socioeconomic profile of the High Stress group, wherein a larger proportion of riders belonged to the Upper Lower socioeconomic class — a stratum characterised by lower household income and potentially more limited access to adequate dietary quantity and variety. The convergence of high psychological stress, lower socioeconomic status, meal irregularity, and energy deficit in the High Stress group collectively creates a nutritional environment conducive to underweight and normal-weight status rather than overweight or obesity (Rachmah et al., 2021; Demirci & Kaptanoğlu, 2022). These findings are consistent with evidence from comparable urban Indian working-class populations, wherein physically demanding occupational roles combined with economic constraints and high stress burden were associated with lower BMI and increased prevalence of underweight, particularly among younger male workers (Bunjong et al., 2024; Li et al., 2024).

Overall, the WHO BMI classification analysis reveals that while the majority of food delivery riders in all stress categories maintained a normal weight status, the High Stress group demonstrated a disproportionately higher prevalence of underweight and a complete absence of overweight and obesity. The statistically significant association between BMI classification and PSS category ($p = 0.002$) underscores the importance of addressing perceived stress as a determinant of nutritional status in this population — not only in the context of overweight and metabolic risk, but critically also in the context of undernutrition and its associated implications for physical work capacity, immune function, and long-term health outcomes (Shrivastava et al., 2024; Rachmah et al., 2021).

4.3 Association between PSS and Nutrient Intake of the Study Participants

Table 4.3a mean macronutrient intake based on PSS categories of the study population

Variable	Low Stress (n=38)		Moderate Stress (n=78)		High Stress (n=34)		Total (N=150)		F value	p value
	Mean ± SD	% RDA	Mean ± SD	% RDA	Mean ± SD	% RDA	Mean ± SD	% RDA		
	Macronutrients									
Energy (kcal)	2413.34 ± 356.34	88.4	2415.59 ± 508.93	88.5	2449.76 ± 465.57	89.7	2422.77 ± 462.17	88.7	0.074	0.928
Protein (g)	65.19 ± 11.28	120.7	67.31 ± 16.28	124.6	65.37 ± 15.15	121.1	66.33 ± 14.85	122.8	0.348	0.707
Carbohydrates (g)	325.97 ± 45.84	83.6	324.17 ± 70.53	83.1	332.71 ± 73.39	85.3	326.56 ± 65.55	83.7	0.201	0.818
Fats (g)	93.54 ± 20.27	311.8	94.88 ± 23.43	316.3	96.11 ± 17.54	320.4	94.82 ± 21.32	316.1	0.130	0.878

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); One-Way ANOVA*

RDA based on ICMR (2020) for adult Indian males with moderate physical activity: Energy = 2730 kcal; Protein = 54 g; Carbohydrates = 390 g; Fats = 30 g

PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.3a presents the comparison of mean nutrient intake among food delivery riders categorised by PSS category — Low Stress (n = 38), Moderate Stress (n = 78), and High Stress (n = 34). The parameters analysed include energy, protein, carbohydrates, and fats as macronutrients, along with their respective percentages of the Recommended Dietary Allowance (RDA) as per the Indian Council of Medical Research (ICMR, 2020) guidelines for adult Indian males with moderate physical activity. One-way ANOVA was applied to assess statistically significant differences across the three PSS categories.

The mean energy intake was comparable across all three PSS categories, with 2413.34 ± 356.34 kcal in the Low Stress group (88.4% RDA), 2415.59 ± 508.93 kcal in the Moderate Stress group (88.5% RDA), and 2449.76 ± 465.57 kcal in the High Stress group (89.7% RDA). Although the High Stress group demonstrated marginally higher energy intake, the differences across groups were not statistically significant (F = 0.074, p = 0.928). Notably, none of the three groups met 100% of the energy RDA, with the overall sample achieving only 88.7% of the recommended energy intake. This consistent energy deficit across all stress categories is of considerable concern, particularly given the high physical demands of food delivery work, which involves prolonged cycling or motorbike riding, manual handling, and extended working hours often exceeding ten hours daily (Samal et al., 2025). Suboptimal energy intake in physically demanding occupational cohorts has been documented in prior workforce nutrition studies and is associated with reduced work capacity, fatigue, and impaired cognitive performance — outcomes that carry direct occupational safety implications for delivery riders (Rachmah et al., 2021).

Mean protein intake was adequate relative to the ICMR RDA across all PSS categories, with the Low Stress group reporting 65.19 ± 11.28 g (120.7% RDA), the Moderate Stress group 67.31 ± 16.28 g (124.6%

RDA), and the High Stress group 65.37 ± 15.15 g (121.1% RDA). The overall mean protein intake of 66.33 ± 14.85 g represented 122.8% of the RDA. Despite a marginal upward trend in protein intake in the Moderate Stress group, no statistically significant difference was observed across PSS categories (F = 0.348, p = 0.707). The adequate protein intake across all groups likely reflects the high non-vegetarian dietary pattern documented in this cohort (71.3%), wherein regular consumption of chicken, fish, and eggs contributes substantially to dietary protein adequacy. This finding is consistent with evidence demonstrating that non-vegetarian dietary patterns are associated with higher protein intake in Indian urban working populations (Hemiö et al., 2015). While protein intake exceeded the RDA across all groups, the quality and bioavailability of dietary protein — influenced by cooking method and food source — may vary considerably within this population and warrants further investigation.

Carbohydrate intake was below the ICMR RDA across all PSS categories, with the Low Stress group reporting 325.97 ± 45.84 g (83.6% RDA), the Moderate Stress group 324.17 ± 70.53 g (83.1% RDA), and the High Stress group 332.71 ± 73.39 g (85.3% RDA). The overall carbohydrate intake of 326.56 ± 65.55 g corresponded to 83.7% of the recommended intake. No statistically significant differences were observed across PSS categories (F = 0.201, p = 0.818), suggesting that perceived stress level does not meaningfully influence carbohydrate consumption patterns in this cohort. Despite falling below the RDA, carbohydrate intake was the closest to recommended levels among all macronutrients assessed, consistent with the high cereal and pulse consumption documented in the FFQ findings of the present study, wherein all 150 participants reported daily cereal intake. The moderate shortfall in carbohydrate intake relative to RDA may reflect overall energy insufficiency rather than selective avoidance of carbohydrate-rich foods (Bunjong et al., 2024).

Fat intake demonstrated the most striking deviation from RDA across all nutrient parameters assessed. The Low Stress group reported 93.54 ± 20.27 g (311.8% RDA), the Moderate Stress group 94.88 ± 23.43 g (316.3% RDA), and the High Stress group 96.11 ± 17.54 g (320.4% RDA), with an overall mean of 94.82 ± 21.32 g representing 316.1% of the ICMR recommended fat intake. Despite the markedly elevated fat intake across all groups, no statistically significant difference was found between PSS categories (F = 0.130, p = 0.878). The consistently excessive fat intake — exceeding three times the RDA across all stress groups — is a major nutritional concern in this cohort and directly aligns with the FFQ finding of near-universal daily fried food consumption (46.0% once daily) and high bakery product intake. This pattern of extreme fat overconsumption is well-documented in gig-economy and shift-based worker populations, wherein structural constraints including time pressure, limited access to home-cooked meals, and proximity to fried street food vendors collectively drive high-fat dietary patterns (O'Brien et al., 2020; Hemiö et al., 2015). Sustained excess fat intake of this magnitude is independently associated with elevated cardiometabolic risk, dyslipidaemia, and increased risk of non-communicable diseases — outcomes of particular concern in a young adult male workforce (Useche et al., 2024).

Table 4.3b mean micronutrient intake based on PSS categories of the study population

Variable	Low Stress (n=38)		Moderate Stress (n=78)		High Stress (n=34)		Total (N=150)		F value	p value
	Mean ± SD	% RDA	Mean ± SD	% RDA	Mean ± SD	% RDA	Mean ± SD	% RDA		
	Micronutrients									
Iron (mg)	12.12 ± 1.12	71.3	12.55 ± 2.08	73.8	12.88 ± 2.47	75.7	12.52 ± 1.99	73.6	1.333	0.267
Calcium (mg)	370.01 ± 49.67	61.7	345.83 ± 79.74	57.6	404.66 ± 75.87	67.4	365.29 ± 75.70	60.9	7.920	0.001

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); One-Way ANOVA*
RDA based on ICMR (2020) for adult Indian males with moderate physical activity: Iron = 17 mg; Calcium = 600 mg
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.3b presents the comparison of mean micronutrient intake among food delivery riders categorised by PSS category — Low Stress (n = 38), Moderate Stress (n = 78), and High Stress (n = 34). The parameters analysed include iron and calcium as key micronutrients, along with their respective percentages of the Recommended Dietary Allowance (RDA) as per the Indian Council of Medical Research (ICMR, 2020) guidelines for adult Indian males with moderate physical activity. One-way ANOVA was applied to assess statistically significant differences across the three PSS categories.

Mean iron intake was below the ICMR RDA across all PSS categories, with the Low Stress group reporting 12.12 ± 1.12 mg (71.3% RDA), the Moderate Stress group 12.55 ± 2.08 mg (73.8% RDA), and the High Stress group 12.88 ± 2.47 mg (75.7% RDA). The overall iron intake of 12.52 ± 1.99 mg corresponded to 73.6% of the recommended intake. No statistically significant differences were observed across PSS categories ($F = 1.333$, $p = 0.267$). The consistent iron deficit across all stress groups is nutritionally significant in the context of physical activity demands, as iron is critical for haemoglobin synthesis, oxygen transport, and aerobic work capacity — all of which are directly relevant to the physical performance requirements of food delivery work. Suboptimal iron intake in physically demanding occupational cohorts has been associated with reduced muscular endurance, increased susceptibility to fatigue, and impaired occupational performance (Rachmah et al., 2021). The pattern of iron inadequacy observed in the present study is consistent with findings from comparable urban Indian working-class populations, wherein low dietary diversity and limited consumption of iron-rich foods such as green leafy vegetables, organ meats, and fortified cereals contribute to persistent micronutrient gaps.

Calcium was the only nutrient demonstrating a statistically significant difference across PSS categories ($F = 7.920$, $p = 0.001$). Mean calcium intake was 370.01 ± 49.67 mg in the Low Stress group (61.7% RDA), 345.83 ± 79.74 mg in the Moderate Stress group (57.6% RDA), and 404.66 ± 75.87 mg in the High Stress group (67.4% RDA). Despite this statistically significant variation, all three groups fell substantially below the ICMR recommended intake of 600 mg per day, with the overall mean calcium intake of 365.29 ± 75.70 mg representing only 60.9% of the RDA. The significantly higher calcium intake observed in the High Stress group relative to the Moderate Stress group is an unanticipated finding that warrants careful interpretation. One plausible explanation is that highly stressed riders may consume greater quantities of milk-based beverages — including tea and flavoured milk — as a coping or comfort behaviour, thereby inadvertently increasing their calcium intake. This is consistent with evidence suggesting that stress-induced changes in dietary behaviour can manifest as increased consumption of specific food categories, including dairy-based beverages, among certain occupational subgroups (Demirci & Kaptanoğlu, 2022). Irrespective of the between-group variation, the universal calcium insufficiency across all PSS categories is of significant public health concern, particularly given the weight-bearing physical demands of food delivery work and the association between chronic calcium deficiency and long-term musculoskeletal morbidity (Shrivastava et al., 2024).

Overall, the nutrient intake findings reveal a paradoxical pattern characterised by simultaneous macronutrient excess and micronutrient deficiency — excessive fat intake coexisting with inadequate energy, carbohydrate, iron, and calcium intake relative to ICMR recommendations. This nutritional profile, wherein dietary fat drastically exceeds recommended levels while overall energy and micronutrient adequacy remain suboptimal, reflects the dietary consequences of a convenience-food-dominated eating pattern driven by occupational constraints, limited food environment diversity, and low nutrition awareness — all of which are highly relevant determinants of dietary quality in gig-economy workers (Bunjong et al., 2024; Rachmah et al., 2021; Samal et al., 2025). The absence of statistically significant differences in most nutrient parameters across PSS categories further suggests that dietary intake patterns in this cohort are primarily shaped by occupational and environmental determinants rather than psychological stress per se, underscoring the need for structural food environment interventions alongside individual-level nutrition education strategies.

4.4 Food Frequency of the Study Participants.

Frequency of Cereal, Pulses & Legumes, Vegetable and Fruit Consumption

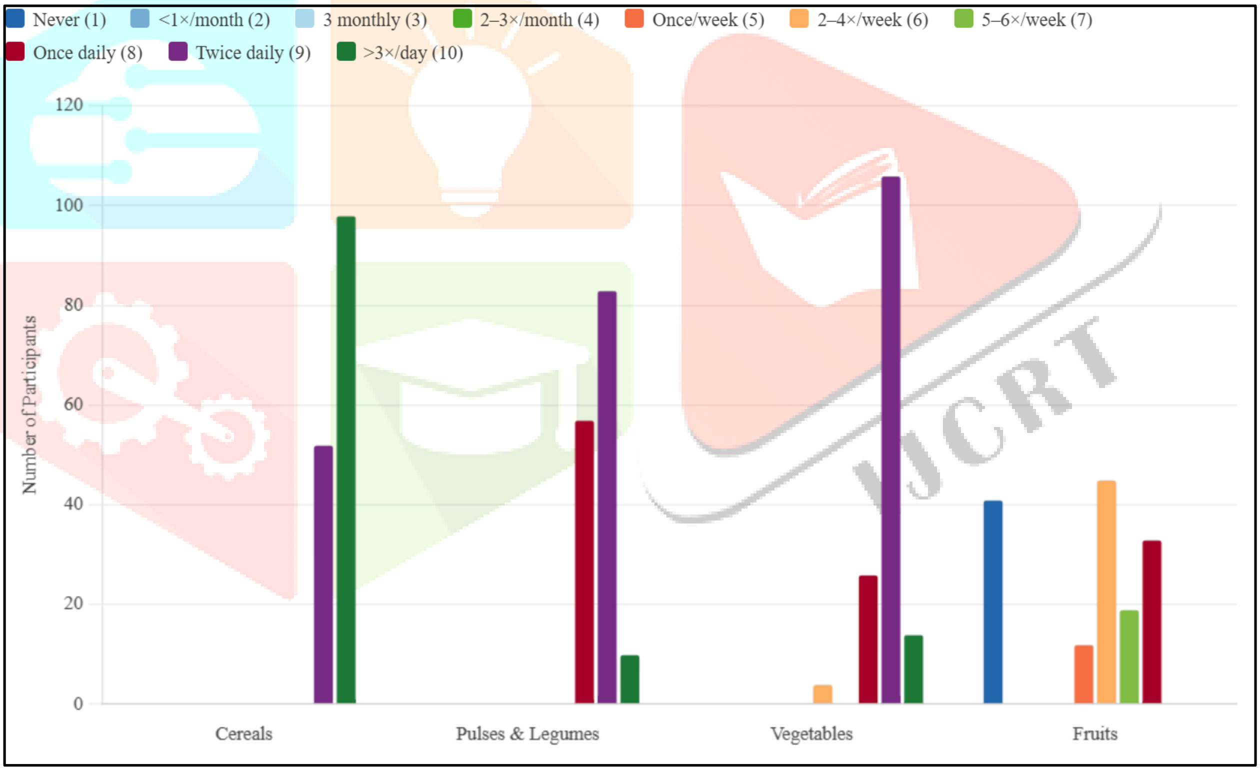

Figure 4.4.1 frequency of cereals, pulses & legumes, vegetables, fruits consumption among the study participants (N = 150)

Cereals emerged as the most consistently and frequently consumed food group across the entire sample. All 150 participants reported high-frequency cereal consumption, with 98 (65.3%) consuming cereals once daily and 52 (34.7%) consuming them twice daily. The absence of any participant reporting infrequent or zero cereal consumption underscores the foundational role of cereals — predominantly rice and wheat-based preparations such as roti, rice, and bread — in the daily dietary pattern of urban male food delivery workers. This near-universal reliance on cereals as the primary dietary staple is consistent with the nutritional epidemiology of the urban Indian working-class population, wherein cereal-based foods serve as the predominant source of energy, contributing substantially to total daily carbohydrate intake (Hemiö et al., 2015).

Pulses and legumes were similarly consumed at high frequency, with the majority of participants reporting twice daily (n = 83, 55.3%) or once daily (n = 57, 38.0%) intake, and only 10 participants (6.7%) consuming them more than thrice daily. The high regularity of pulse consumption reflects the cultural centrality of dal-based preparations in the Indian dietary pattern, wherein pulses serve as an accessible and affordable protein source across socioeconomic strata. Given that a substantial proportion of the sample reported vegetarian or ovo-vegetarian dietary preferences (28.7% combined), pulses likely function as the primary dietary protein vehicle for a significant subset of participants (Rachmah et al., 2021).

Vegetables were consumed with high regularity across the sample. The predominant consumption frequency was twice daily (n = 106, 70.7%), followed by once daily (n = 26, 17.3%) and more than thrice daily (n = 14, 9.3%). Only 4 participants (2.7%) reported consuming vegetables merely 2–4 times per week, indicating that vegetable intake is well-integrated into the daily dietary routine of the majority of riders. This high vegetable consumption frequency is a nutritionally encouraging finding, as adequate vegetable intake is associated with improved micronutrient status, dietary fibre adequacy, and reduced cardiometabolic risk — protective factors of particular relevance in a high-stress occupational group (Bunjong et al., 2024).

Fruits, in contrast, demonstrated a markedly lower and more variable consumption pattern. Over one-quarter of participants (n = 41, 27.3%) reported never consuming fruits, while the most common frequency among consumers was 2–4 times per week (n = 45, 30.0%), followed by once daily (n = 33, 22.0%) and 5–6 times per week (n = 19, 12.7%). Only 12 participants (8.0%) reported once-weekly consumption. This low fruit consumption is of considerable nutritional concern, as inadequate fruit intake is associated with reduced antioxidant, vitamin C, and dietary fibre intake, and is a recognised modifiable risk factor for non-communicable disease development (O'Brien et al., 2020). The low fruit consumption likely reflects both economic constraints and the limited availability of affordable, fresh fruit options in the occupational food environment of food delivery riders, who primarily rely on roadside and street food vendors during their working hours (Li et al., 2024).

Frequency of Milk and Milk Product, Eggs and Poultry Consumption

Figure 4.4.2 frequency of milk & milk products, eggs, non-vegetarian foods consumption among the study participants (N = 150)

Milk and milk products were consumed daily by the large majority of participants, with once daily intake reported by 109 participants (72.7%). However, considerable heterogeneity was observed at lower frequency categories — 20 participants (13.3%) consumed milk products 2–4 times per week, 7 (4.7%) consumed them 5–6 times per week, and 7 (4.7%) reported never consuming milk or milk products. Only 3 participants (2.0%) reported less than once monthly consumption, and 4 (2.7%) consumed them more than thrice daily. The subset reporting absent or very infrequent milk consumption raises potential concerns regarding dietary calcium adequacy, given that milk and milk products are the principal dietary source of bioavailable calcium. In a physically active male population performing sustained weight-bearing occupational activity, adequate calcium intake is critical for musculoskeletal health and injury prevention (Rachmah et al., 2021).

Eggs demonstrated a bimodal consumption pattern reflective of the dietary diversity within the sample. The most common frequencies were 5–6 times per week (n = 48, 32.0%) and 2–4 times per week (n = 46, 30.7%), indicating that the majority of egg consumers incorporated eggs as a near-daily dietary component. Once daily consumption was reported by 14 participants (9.3%), and once weekly by 7 (4.7%). However, 32 participants (21.3%) reported never consuming eggs — consistent with the vegetarian proportion of the sample — and 3 (2.0%) reported less than once monthly consumption. For non-vegetarian and ovo-vegetarian participants, eggs represent a nutritionally dense, affordable, and readily accessible protein source well-suited to the time-constrained dietary patterns of food delivery workers (Bunjong et al., 2024).

Non-vegetarian foods (chicken/fish) were consumed predominantly 2–4 times per week (n = 87, 58.0%), making this the most common consumption pattern among non-vegetarian participants. An additional 12 participants (8.0%) consumed non-vegetarian foods 5–6 times per week, and 11 (7.3%) reported once weekly intake. A notable proportion of 40 participants (26.7%) reported never consuming non-vegetarian foods, directly corresponding to the vegetarian and ovo-vegetarian dietary preferences within the sample. The high frequency of non-vegetarian consumption among the majority of participants reflects the broader dietary landscape of urban male gig-economy workers in Mumbai, where non-vegetarian street food options are widely accessible, affordable, and energy-dense (Li et al., n.d.; Samal et al., 2025). However, the nutritional quality of non-vegetarian intake within this cohort is likely influenced by cooking method — predominantly fried or heavily spiced preparations consumed at roadside stalls — which may reduce the net protein quality and increase the saturated fat content of these meals (Hemiö et al., 2015).

Frequency of Discretionary Food and Beverage Consumption

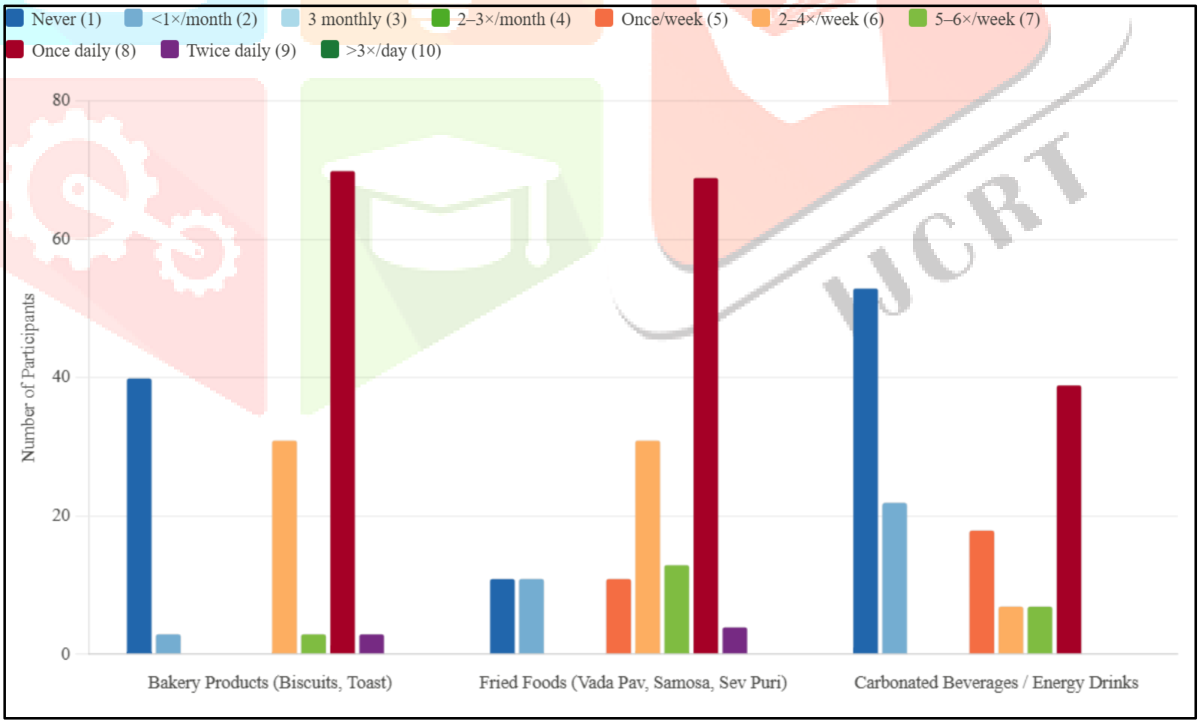

Figure 4.4.3 frequency of discretionary food and beverage consumption among the study participants (N = 150)

Bakery products like biscuits, toast were consumed with strikingly high frequency, with once daily intake reported by the largest proportion of participants (n = 70, 46.7%), followed by 2–4 times per week (n = 31, 20.7%) and never (n = 40, 26.7%). A small subset reported twice daily (n = 3, 2.0%) and 5–6 times per week (n = 3, 2.0%) consumption. The high daily prevalence of bakery product consumption is largely attributable to the portability, affordability, and low preparation time of biscuits and toast — characteristics that render them particularly appealing to time-constrained workers operating across extended shifts. However, regular consumption of commercially produced bakery items is associated with high refined carbohydrate, sodium, and trans-fat content, contributing to poor dietary quality and elevated cardiometabolic risk (O'Brien et al., 2020).

Fried foods (vada pav, samosa pav, chinese preparations, sev puri) exhibited the most nutritionally concerning consumption pattern across all food groups assessed. Once daily intake was reported by the largest proportion of participants (n = 69, 46.0%), followed by 2–4 times per week (n = 31, 20.7%), 5–6 times per week (n = 13, 8.7%), twice daily (n = 4, 2.7%), and once weekly (n = 11, 7.3%). Less than once monthly consumption was reported by 11 participants (7.3%), and only 11 (7.3%) reported never consuming fried foods. Collectively, over 85% of participants consumed fried street foods at least once weekly, with nearly half doing so on a daily basis. This near-ubiquitous reliance on fried street food is a defining feature of the food delivery rider dietary pattern, reflecting the structural food environment constraints of gig-economy employment — including limited break durations, proximity to fried food stalls along delivery routes, and the high energy density and palatability of these options relative to their cost (Useche et al., 2024; Samal et al., 2025). The sustained high saturated and trans-fat load associated with daily fried food consumption poses a significant long-term cardiometabolic risk in this population, particularly in the context of co-existing elevated perceived stress levels.

Carbonated beverages and energy drinks were consumed regularly by a substantial subset of participants. Once daily intake was reported by 39 participants (26.0%), once weekly by 18 (12.0%), 2–4 times per week by 7 (4.7%), and 5–6 times per week by an additional 7 (4.7%). In contrast, 53 participants (35.3%) reported never consuming carbonated beverages, and 22 (14.7%) consumed them less than once monthly. The regular consumption of carbonated and energy drinks among approximately half the sample is of nutritional and physiological concern. Energy drinks in particular contain high concentrations of caffeine, added sugars, and stimulant compounds, which — when consumed regularly under conditions of occupational stress and sleep disruption — may further dysregulate cortisol secretion, appetite regulation, and sleep quality (Demirci & Kaptanoğlu, 2022). Furthermore, the high sugar content of regular carbonated beverages contributes to excess energy intake and is independently associated with increased cardiometabolic risk, dental erosion, and insulin resistance in physically active working populations (O'Brien et al., 2020).

Overall, the FFQ findings reveal a dietary pattern characterised by high cereal, pulse, and vegetable consumption alongside strikingly high fried food and bakery product intake, moderate animal protein consumption, markedly inadequate fruit intake, and regular consumption of discretionary beverages. This pattern — energy-dense, micronutrient-variable, and high in saturated and trans-fats — is consistent with dietary profiles documented in other physically demanding, time-constrained, and lower socioeconomic occupational cohorts in urban India and globally (Bunjong et al., 2024; Hemiö et al., 2015; O'Brien et al., 2020). These findings collectively underscore the urgent need for targeted nutritional interventions addressing food environment, dietary awareness, and meal planning support within the food delivery workforce.

4.5 Association between PSS and MPQ of the Study Participants

Table 4.5.1 association between PSS categories and MPQ scores in the study population

Variable	Low Stress (n = 38)	Moderate Stress (n = 78)	High Stress (n = 34)	F value	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
MPQ Score	21.61 ± 2.51	20.77 ± 4.04	22.47 ± 3.68	2.716	0.069

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); One-Way ANOVA*
MPQ = Meal Pattern Questionnaire; PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40
MPQ Score Range: 0–42; Higher scores indicate greater meal irregularity

Table 4.5.1 presents the comparison of Meal Pattern Questionnaire (MPQ) scores among food delivery riders categorised by their Perceived Stress Scale (PSS) category — Low Stress (n = 38), Moderate Stress (n = 78), and High Stress (n = 34). The mean MPQ score was 21.61 ± 2.51 in the Low Stress group, 20.77 ± 4.04 in the Moderate Stress group, and 22.47 ± 3.68 in the High Stress group. Although the High Stress group demonstrated the highest MPQ score — indicating the most irregular meal patterns — and the Moderate Stress group the lowest, the differences across PSS categories did not reach statistical significance ($F = 2.716$, $p = 0.069$).Despite the absence of statistical significance, the directional trend observed in this study is noteworthy and warrants careful interpretation. Riders experiencing the highest levels of perceived stress reported the most irregular meal patterns, while those in the Moderate Stress category demonstrated comparatively more regular eating behaviours. This pattern is consistent with the well-established psychobiological relationship between psychological stress and eating behaviour dysregulation. Chronic stress activates the hypothalamic–pituitary–adrenal (HPA) axis, resulting in elevated cortisol secretion, which is known to alter appetite-regulating hormones — including leptin, ghrelin, and neuropeptide Y — thereby disrupting the regularity, timing, and frequency of meal consumption (Tomiyama, 2018). In the context of food delivery riders, who are simultaneously exposed to time pressure, traffic-related stress, performance-based income insecurity, and extended working hours, the physiological stress response may compound pre-existing tendencies toward meal skipping, irregular eating times, and reduced meal frequency — all of which are captured by higher MPQ scores.

The borderline p-value of 0.069 — marginally above the conventional threshold of 0.05 — suggests a trend that may achieve statistical significance in a larger sample. The relatively modest sample size of the High Stress group (n = 34) and the wide standard deviation observed across MPQ categories likely contributed to the absence of statistical significance, reflecting inter-individual variability in stress-related eating behaviours. Similar findings have been reported in occupational stress literature, wherein physically demanding and psychologically burdensome work environments were associated with disrupted meal patterns, increased meal skipping, and irregular eating timing — though not always achieving statistical significance due to sample heterogeneity (Shrivastava et al., 2024; Demirci & Kaptanoğlu, 2022). Useche et al. (2024) similarly documented that stress-related psychosocial factors among food delivery riders were associated with adverse health behaviours, including disrupted daily routines and reduced self-care — patterns that are plausibly reflected in the meal irregularity trend observed in the present study.

Thus, while statistical significance was not achieved, the directional trend supports the hypothesis that higher perceived stress is associated with greater meal pattern irregularity in this occupational cohort. These findings underscore the importance of addressing psychological stress as a determinant of dietary behaviour in food delivery workers, and suggest that stress management interventions may serve a dual role — improving both psychological wellbeing and meal pattern regularity — within this population (Samal et al., 2025; Rachmah et al., 2021).

4.6 Association between PSS and GNKQ of the Study Participants

Table 4.6.1 association between PSS categories and GNKQ scores in the study population

Variable	Low Stress (n = 38)	Moderate Stress (n = 78)	High Stress (n = 34)	F value	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
GNKQ Score	23.87 ± 7.21	24.53 ± 6.38	28.97 ± 9.31	5.404	0.005*

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); One-Way ANOVA*
GNKQ = General Nutrition Knowledge Questionnaire; PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40
GNKQ Score Range: 0–100; Higher scores indicate greater nutrition knowledge

Table 4.6.1 presents the comparison of General Nutrition Knowledge Questionnaire (GNKQ) scores among food delivery riders categorised by PSS category — Low Stress (n = 38), Moderate Stress (n = 78), and High Stress (n = 34). One-way ANOVA revealed a statistically significant difference in GNKQ scores across PSS categories ($F = 5.404$, $p = 0.005$), indicating that perceived stress level was meaningfully associated with nutrition knowledge scores in this cohort.

The mean GNKQ score demonstrated a progressive and statistically significant increase across PSS categories, with the Low Stress group reporting the lowest nutrition knowledge score (23.87 ± 7.21), followed by the Moderate Stress group (24.53 ± 6.38), and the High Stress group recording the highest mean GNKQ score (28.97 ± 9.31). The overall mean GNKQ score for the total sample was 25.37 ± 7.55, with scores ranging from 14 to 43 across all participants. The markedly higher nutrition knowledge observed in the High Stress group — approximately 5 points above the Low Stress group — is an unanticipated and particularly noteworthy finding that warrants detailed interpretation in the context of the broader results of the present study.

4.7 Association between Anthropometric and Dietary Intakes in the Study Population

Table 4.7a Pearson correlation between anthropometric parameters and macronutrient intake among the study participants (N = 150)

Anthropometric Variable	Total (N=150) Mean ± SD	Energy (kcal)		Protein (g)		Carbohydrates (g)		Fats (g)	
		2422.77 ± 462.17		66.33 ± 14.85		326.56 ± 65.55		94.82 ± 21.32	
		r	p	r	p	r	p	r	p
Macronutrients									
Weight (kg)	63.11 ± 13.34	.236**	0.004	.186*	0.023	.213**	0.009	.234**	0.004
Height (cm)	168.43 ± 7.02	.164*	0.045	.219**	0.007	0.157	0.055	0.132	0.107
BMI (kg/m²)	22.20 ± 4.02	.202*	0.013	0.115	0.160	.181*	0.027	.212**	0.009

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)*
r = Pearson Correlation Coefficient; p = Significance value (2-tailed)
Overall mean ± SD of macronutrients shown in subheader row; BMI = Body Mass Index

Table 4.7b Pearson correlation between anthropometric parameters and micronutrient intake among the study participants (N = 150)

Anthropometric Variable	Total (N=150) Mean ± SD	Iron (mg)		Calcium (mg)	
		12.52 ± 1.99		365.29 ± 75.70	
		r	p	r	p
Micronutrients					
Weight (kg)	63.11 ± 13.34	0.017	0.839	0.112	0.172
Height (cm)	168.43 ± 7.02	0.023	0.776	.232**	0.004
BMI (kg/m²)	22.20 ± 4.02	0.002	0.983	0.014	0.870

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)*
r = Pearson Correlation Coefficient; p = Significance value (2-tailed)
Overall mean ± SD of micronutrients shown in subheader row; BMI = Body Mass Index

Tables 4.7a and 4.7b present the Pearson correlation between anthropometric parameters — weight, height, and BMI — and dietary intake variables comprising macronutrients (energy, protein, carbohydrates, and fats) and micronutrients (iron and calcium) respectively, for the total study sample (N = 150). The overall sample means were 63.11 ± 13.34 kg for weight, 168.43 ± 7.02 cm for height, and 22.20 ± 4.02 kg/m² for BMI. Pearson correlation analysis was conducted to assess the linear associations between body composition indices and habitual dietary intake patterns in this occupational cohort.

Anthropometric Parameters and Macronutrient Intake (Table 4.7a)

Weight demonstrated statistically significant positive correlations with all four macronutrients assessed — energy (r = 0.236, p = 0.004), protein (r = 0.186, p = 0.023), carbohydrates (r = 0.213, p = 0.009), and fats (r = 0.234, p = 0.004). The consistent and significant positive associations between body weight and all macronutrient intake variables indicate that heavier riders consumed greater quantities of energy, protein, carbohydrates, and dietary fat. This pattern is physiologically consistent with the greater absolute energy and macronutrient requirements associated with higher body mass, wherein larger body size is accompanied by elevated basal metabolic rate, greater lean mass, and correspondingly higher total dietary intake (Hemiö et al., 2015). The broadly comparable correlation coefficients observed across all four macronutrients — ranging from r = 0.186 for protein to r = 0.236 for energy — suggest that weight is associated with overall dietary quantity rather than the composition of the diet, reflecting a generalised pattern of higher total food intake among heavier riders rather than selective overconsumption of any specific macronutrient. This finding is consistent with evidence from comparable physically demanding occupational cohorts, wherein body weight was found to be a stronger predictor of total energy intake than individual macronutrient consumption (O'Brien et al., 2020; Rachmah et al., 2021).

Height demonstrated statistically significant positive correlations with energy (r = 0.164, p = 0.045) and protein (r = 0.219, p = 0.007), but not with carbohydrates (r = 0.157, p = 0.055) or fats (r = 0.132, p = 0.107). The significant positive association between height and protein intake is particularly noteworthy, as taller individuals typically possess greater skeletal muscle mass and lean body mass — both of which are associated with higher habitual protein requirements and consumption (Hemiö et al., 2015). The borderline non-significant association between height and carbohydrate intake (p = 0.055) suggests a directional trend that may achieve statistical significance in a larger sample. The absence of a significant height–fat correlation indicates that fat intake in this cohort is not associated with stature, and is instead driven by dietary pattern and food environment factors — specifically the near-universal daily fried food consumption documented in the FFQ findings — rather than body size-related requirements (Useche et al., 2024; Bunjong et al., 2024).

BMI demonstrated statistically significant positive correlations with energy (r = 0.202, p = 0.013), carbohydrates (r = 0.181, p = 0.027), and fats (r = 0.212, p = 0.009), but not with protein (r = 0.115, p = 0.160). The significant BMI–energy, BMI–carbohydrate, and BMI–fat associations collectively indicate that riders with higher BMI values consumed greater quantities of total energy, carbohydrates, and dietary fat. The absence of a significant BMI–protein correlation is consistent with the pattern observed for weight, wherein protein intake is more closely related to lean body mass and stature than to adiposity indices such as BMI. The significant BMI–fat correlation (r = 0.212, p = 0.009) is of particular nutritional and clinical relevance, as it provides direct evidence of a positive linear association between dietary fat intake and BMI in this cohort — a finding that is consistent with the broader literature on fat intake and adiposity (O'Brien et al., 2020; Tomiyama, 2018). Given that mean fat intake across the total sample exceeded 316% of the ICMR RDA, the positive BMI–fat association suggests that excess dietary fat is contributing meaningfully to higher BMI values among a subset of riders. The significant BMI–carbohydrate association (r = 0.181, p = 0.027) similarly reflects the contribution of total carbohydrate intake to energy balance and body composition, consistent with the high cereal and fried food consumption documented in the FFQ and 24-hour dietary recall findings (Bunjong et al., 2024).

Overall, the macronutrient correlation findings reveal that weight and BMI are the most nutritionally sensitive anthropometric parameters in this cohort, demonstrating significant associations with the majority of macronutrients assessed. Height, while significantly associated with energy and protein, shows a narrower range of significant dietary correlations — reflecting its role as an indicator of lean mass rather than adiposity. The consistent positive directionality of all significant correlations reinforces the interpretation that higher anthropometric values in this cohort are associated with greater overall dietary intake, with fat and energy intake emerging as the most consistently significant dietary predictors of both weight and BMI (Rachmah et al., 2021; O'Brien et al., 2020).

Anthropometric Parameters and Micronutrient Intake (Table 4.7b)

Weight demonstrated no statistically significant correlation with either iron (r = 0.017, p = 0.839) or calcium (r = 0.112, p = 0.172). The near-zero correlation coefficient for the weight–iron association (r = 0.017) indicates a complete absence of any linear relationship between body weight and iron intake in this cohort. Similarly, the non-significant weight–calcium correlation suggests that calcium consumption is not determined by body mass in this population. These findings indicate that micronutrient intake among food delivery riders is independent of body weight, and is instead governed by food preference, dietary pattern, and habitual consumption of specific food groups — particularly dairy products for calcium and green leafy vegetables and non-vegetarian foods for iron — rather than by body size-related requirements (Shrivastava et al., 2024; Rachmah et al., 2021).

Height demonstrated no significant correlation with iron intake (r = 0.023, p = 0.776). However, a statistically significant positive correlation was observed between height and calcium intake (r = 0.232, p = 0.004) — the only significant micronutrient–anthropometric association identified in the entire correlation analysis. The significant height–calcium correlation is biologically plausible and consistent with evidence that calcium intake during childhood and adolescence is a principal determinant of skeletal growth, bone mineral density, and ultimately attained adult stature (Shrivastava et al., 2024). Taller riders in the present study may represent individuals who consumed greater quantities of dairy products and calcium-rich foods during their developmental years — a dietary pattern that may have persisted into adulthood as a habitual behaviour, thereby maintaining higher calcium intake in taller individuals relative to their shorter counterparts. This interpretation is supported by the FFQ findings of the present study, wherein milk and milk products were consumed once daily by 72.7% of participants, with variation in dairy consumption frequency likely contributing to the observed height–calcium association. The significant positive direction of this correlation further reinforces the role of dietary calcium as a determinant of skeletal development in this population, even when assessed cross-sectionally in adulthood (Rachmah et al., 2021).

BMI demonstrated no statistically significant correlation with either iron (r = 0.002, p = 0.983) or calcium (r = 0.014, p = 0.870). The near-zero coefficients for both associations — particularly iron (r = 0.002) and calcium (r = 0.014) — indicate a complete absence of any linear relationship between BMI and micronutrient intake in this cohort. This finding is consistent with evidence demonstrating that micronutrient intake in physically active male populations is primarily determined by dietary diversity and food group consumption rather than by body composition indices such as BMI (Bunjong et al., 2024). The absence of a BMI–calcium correlation is particularly notable in the context of the study's earlier finding that High Stress riders — who had the lowest mean BMI (19.98 kg/m²) — also reported the highest mean calcium intake (404.66 mg/day). This apparent paradox suggests that the calcium–BMI relationship in this cohort is non-linear and confounded by stress-related dietary behaviours — including the potential stress-driven consumption of dairy-based beverages — which are not captured by simple bivariate Pearson correlation analysis (Demirci & Kaptanoğlu, 2022).

Overall, the micronutrient correlation findings reveal a strikingly different pattern from the macronutrient analysis — whereas macronutrient intake was broadly and significantly associated with anthropometric parameters, micronutrient intake demonstrated almost complete independence from body weight, height, and BMI. The sole significant finding — the height–calcium correlation ($r = 0.232$, $p = 0.004$) — highlights the unique role of calcium in skeletal development and its persistence as a dietary determinant of adult stature, while the universal absence of iron–anthropometric correlations underscores that iron intake in this population is driven by dietary pattern and food group diversity rather than body composition. These findings collectively reinforce the need for micronutrient-targeted dietary interventions that address food group diversity and dietary quality — rather than simply total food quantity — within the food delivery rider population, given that micronutrient adequacy operates through pathways entirely distinct from those governing macronutrient intake and body composition (Rachmah et al., 2021; Bunjong et al., 2024; Shrivastava et al., 2024).

4.8 Association between Anthropometric Parameters and PSS in the Study Population

Table 4.8.1 Pearson correlation between anthropometric parameters and PSS score among the study participants (N = 150)

Anthropometric Parameter	Low Stress (n = 38)	Moderate Stress (n = 78)	High Stress (n = 34)	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Anthropometric Measurements					
Weight (kg)	69.24 ± 14.86	63.73 ± 13.10	54.82 ± 6.36	−0.319	0.000*
Height (cm)	170.84 ± 5.11	168.38 ± 7.70	165.82 ± 6.44	−0.228	0.005*
BMI (kg/m²)	23.64 ± 4.44	22.46 ± 4.00	19.98 ± 2.39	−0.257	0.002*

*Mean ± Standard Deviation; *p < 0.05 (Statistically Significant); Pearson Correlation (2-tailed)*
Negative r values indicate an inverse relationship between the anthropometric parameter and PSS score
PSS = Perceived Stress Scale; BMI = Body Mass Index
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.8.1 presents the Pearson correlation between anthropometric parameters — weight, height, and BMI — and the Perceived Stress Scale (PSS) score across the three stress categories among food delivery riders (N = 150). The mean values of all three anthropometric parameters demonstrated a consistent and progressive decline from the Low Stress to the High Stress category, and Pearson correlation analysis confirmed statistically significant inverse relationships between PSS score and all three anthropometric variables.

Weight demonstrated the strongest inverse correlation with PSS score among all anthropometric parameters assessed ($r = -0.319$, $p < 0.001$). Mean weight declined progressively from 69.24 ± 14.86 kg in the Low Stress group to 63.73 ± 13.10 kg in the Moderate Stress group and 54.82 ± 6.36 kg in the High Stress group — a difference of approximately 14.4 kg between the lowest and highest stress categories. The significant negative correlation indicates that riders with higher perceived stress scores were systematically lighter than their lower-stress counterparts. This inverse weight–stress relationship in a physically active male cohort diverges from the commonly reported positive association between chronic stress and weight gain observed in sedentary populations, wherein stress-induced hyperphagia and cortisol-mediated fat deposition are the predominant pathophysiological mechanisms (Tomiyama, 2018). In contrast, among food delivery riders who engage in sustained physical exertion throughout their working hours, elevated stress appears to be associated with appetite suppression, increased meal skipping, and overall energy deficit — behavioural patterns that collectively contribute to lower body weight in the most highly stressed individuals. This interpretation is consistent with the FFQ and dietary recall findings of the present study, wherein no significant difference in macronutrient intake was observed across PSS categories, yet the High Stress group demonstrated the lowest mean BMI — suggesting that the stress–weight relationship in this cohort is mediated through behavioural and metabolic pathways beyond simple macronutrient intake (Demirci & Kaptanoğlu, 2022; Bunjong et al., 2024).

Height demonstrated a statistically significant inverse correlation with PSS score ($r = -0.228$, $p = 0.005$). Mean height declined from 170.84 ± 5.11 cm in the Low Stress group to 168.38 ± 7.70 cm in the Moderate Stress group and 165.82 ± 6.44 cm in the High Stress group. While adult height is a largely fixed biological parameter not directly modifiable by psychological stress, the significant inverse correlation observed in this study likely reflects underlying socioeconomic and nutritional differences between the stress groups. Adult stature is strongly determined by early-life nutritional adequacy, socioeconomic conditions, and healthcare access during childhood and adolescence — factors that are differentially distributed across socioeconomic strata (Rachmah et al., 2021). Given that the High Stress group in the present study was disproportionately concentrated in the Upper Lower socioeconomic class and younger age category, the lower mean height in this group may reflect historically poorer nutritional conditions during developmental years rather than a direct effect of current perceived stress. This finding underscores the importance of contextualising anthropometric data within the broader socioeconomic and lifecycle trajectory of this occupational cohort (Samal et al., 2025).

BMI demonstrated a statistically significant inverse correlation with PSS score ($r = -0.257$, $p = 0.002$). Mean BMI declined progressively from 23.64 ± 4.44 kg/m² in the Low Stress group to 22.46 ± 4.00 kg/m² in the Moderate Stress group and 19.98 ± 2.39 kg/m² in the High Stress group. The mean BMI of the High Stress group (19.98 kg/m²) approaches the lower boundary of the normal BMI range as per Asian cut-offs (18.5–22.9 kg/m²), and is accompanied by a markedly narrower standard deviation (±2.39) compared to the Low Stress group (±4.44), suggesting greater homogeneity in nutritional status — specifically a convergence toward lower BMI — among the most highly stressed riders. The significant inverse BMI–PSS correlation corroborates the WHO BMI classification findings (Table 4.2.2), wherein overweight and obese participants were entirely absent from the High Stress group, while the prevalence of underweight was highest in this category (23.5%). This pattern is consistent with evidence from comparable physically demanding occupational cohorts, wherein high occupational stress was associated with lower BMI through mechanisms involving chronic sympathetic nervous system activation, elevated resting energy expenditure, and stress-induced dysregulation of appetite-regulating hormones including ghrelin and leptin (Tomiyama, 2018; Useche et al., 2024). Furthermore, the narrow BMI distribution in the High Stress group suggests that the physiological and behavioural consequences of sustained high stress — including meal irregularity, appetite suppression, and energy deficit — exert a homogenising effect on body composition within this occupational subgroup, an observation that merits further investigation in longitudinal studies of food delivery worker health (Shrivastava et al., 2024).

Overall, the Pearson correlation analysis confirms a consistent, statistically significant, and clinically meaningful inverse relationship between perceived stress and all three anthropometric parameters — weight ($r = -0.319$), height ($r = -0.228$), and BMI ($r = -0.257$) — among food delivery riders. These findings collectively reinforce the hypothesis that higher occupational stress in this cohort is associated with lower body weight and BMI rather than weight excess, a pattern that diverges from stress–obesity associations reported in sedentary populations and highlights the unique nutritional vulnerabilities of physically demanding gig-economy workers. The inverse anthropometric–stress gradient observed across PSS categories provides compelling evidence for the need to address perceived stress as a determinant of both nutritional status and physical health outcomes in food delivery rider populations, with particular attention to the risk of undernutrition and its associated occupational and health consequences (Bunjong et al., 2024; Rachmah et al., 2021; Samal et al., 2025).

4.9 Association between GNKQ and PSS in the Study Population

Table 4.9.1 Pearson correlation between GNKQ score and PSS score among the study participants (N = 150)

Variable	Low Stress (n=38)	Moderate Stress (n=78)	High Stress (n=34)	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Nutrition Knowledge					
GNKQ Score	23.87 ± 7.21	24.53 ± 6.38	28.97 ± 9.31	0.143	0.082

Mean ± Standard Deviation; Pearson Correlation (2-tailed); p > 0.05 = Not Statistically Significant
GNKQ = General Nutrition Knowledge Questionnaire; PSS = Perceived Stress Scale
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.9.1 presents the Pearson correlation between the General Nutrition Knowledge Questionnaire (GNKQ) score and the Perceived Stress Scale (PSS) score across the three PSS categories among food delivery riders (N = 150). The mean GNKQ score demonstrated a progressive increase from the Low Stress group (23.87 ± 7.21) to the Moderate Stress group (24.53 ± 6.38) and the High Stress group (28.97 ± 9.31). Pearson correlation analysis revealed a weak positive association between GNKQ and PSS scores (r = 0.143, p = 0.082), which did not reach statistical significance at the conventional 0.05 threshold.

The borderline p-value of 0.082 — marginally above the significance threshold — suggests a directional trend wherein higher perceived stress is associated with greater nutrition knowledge scores, even in the absence of formal statistical significance. This pattern is consistent with the statistically significant ANOVA finding reported in Table 4.5.2 (F = 5.404, p = 0.005), wherein GNKQ scores differed significantly across PSS categories, and collectively reinforces the knowledge–behaviour gap as a central finding of this study. The positive directionality of the correlation — wherein riders with higher stress scores report higher nutrition knowledge — may reflect heightened health consciousness among stressed individuals who actively seek nutritional information as a cognitive coping response, or alternatively, greater exposure to digital media and health content among the predominantly younger High Stress cohort (Tomiyama, 2018; Bunjong et al., 2024). Critically, however, the absence of a statistically significant correlation between GNKQ and PSS at the bivariate level underscores that nutrition knowledge, while directionally associated with stress, is not a primary determinant of perceived stress in this population — and that the relationship between the two constructs is likely mediated by occupational, environmental, and socioeconomic factors (Rachmah et al., 2021).

4.10 Association between Nutrient Intake and PSS in the Study Population

Table 4.10a Pearson correlation between macronutrient intake and PSS score among the study participants (N = 150)

Macronutrient	Low Stress (n=38)	Moderate Stress (n=78)	High Stress (n=34)	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Macronutrients					
Energy (kcal)	2413.34 ± 356.34	2415.59 ± 508.93	2449.76 ± 465.57	0.041	0.620
Protein (g)	65.19 ± 11.28	67.31 ± 16.28	65.37 ± 15.15	−0.010	0.906
Carbohydrates (g)	325.97 ± 45.84	324.17 ± 70.53	332.71 ± 73.39	0.031	0.710
Fats (g)	93.54 ± 20.27	94.88 ± 23.43	96.11 ± 17.54	0.085	0.298

Mean ± Standard Deviation; Pearson Correlation (2-tailed); p > 0.05 = Not Statistically Significant
PSS = Perceived Stress Scale; PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.10a presents the Pearson correlation between macronutrient intake — energy, protein, carbohydrates, and fats — and PSS score across the three stress categories. None of the macronutrients demonstrated a statistically significant correlation with PSS score: energy (r = 0.041, p = 0.620), protein (r = −0.010, p = 0.906), carbohydrates (r = 0.031, p = 0.710), and fats (r = 0.085, p = 0.298). Mean values across all four macronutrients remained largely comparable across PSS categories, with only marginal and non-significant variations between groups.

The complete absence of statistically significant correlations between any macronutrient and PSS score is an important finding in itself. It indicates that perceived stress level does not independently predict macronutrient intake in this cohort, and that the dietary patterns of food delivery riders are primarily shaped by occupational, environmental, and economic determinants — including proximity to fried street food, affordability constraints, and limited break durations — rather than by psychological stress per se. This finding is consistent with evidence from shift-based and physically demanding occupational cohorts, wherein dietary behaviour was found to be more strongly influenced by the food environment and work schedule than by individual psychological state (Hemiö et al., 2015; O'Brien et al., 2020). The marginal positive trend observed for fat intake across stress categories (Low: 93.54 g; Moderate: 94.88 g; High: 96.11 g) — though not statistically significant — suggests a slight directional association between higher stress and greater fat consumption, consistent with stress-driven preference for energy-dense, palatable foods, which warrants investigation in larger longitudinal studies (Tomiyama, 2018; Demirci & Kaptanoğlu, 2022).

Table 4.10b Pearson correlation between micronutrient intake and PSS score among the study participants (N = 150)

Micronutrient	Low Stress (n=38)	Moderate Stress (n=78)	High Stress (n=34)	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Micronutrients					
Iron (mg)	12.12 ± 1.12	12.55 ± 2.08	12.88 ± 2.47	0.097	0.235
Calcium (mg)	370.01 ± 49.67	345.83 ± 79.74	404.66 ± 75.87	0.137	0.095

Mean ± Standard Deviation; Pearson Correlation (2-tailed); $p > 0.05$ = Not Statistically Significant
PSS = Perceived Stress Scale; PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.10b presents the Pearson correlation between micronutrient intake — iron and calcium — and PSS score. Iron intake demonstrated no statistically significant correlation with PSS score ($r = 0.097$, $p = 0.235$), with mean iron intake showing a marginal non-significant increase from the Low Stress (12.12 ± 1.12 mg) to the High Stress group (12.88 ± 2.47 mg). Calcium intake also did not demonstrate a statistically significant Pearson correlation with PSS score ($r = 0.137$, $p = 0.095$), despite the significant ANOVA finding reported in Table 4.3b ($F = 7.920$, $p = 0.001$). The discrepancy between the ANOVA and Pearson correlation findings for calcium reflects the non-linear, non-monotonic pattern of calcium intake across PSS categories — wherein the Moderate Stress group reported the lowest calcium intake (345.83 ± 79.74 mg), while the High Stress group reported the highest (404.66 ± 75.87 mg) — a pattern that ANOVA captures through group comparisons but Pearson correlation, which assumes a linear monotonic relationship, does not. The absence of statistically significant linear correlations for both micronutrients reinforces the broader conclusion that PSS score is not a linear predictor of dietary micronutrient intake in this cohort, and that the relationship between psychological stress and micronutrient consumption is complex, non-linear, and mediated by behavioural and contextual factors not fully captured by bivariate correlation analysis (Rachmah et al., 2021; Samal et al., 2025).

4.11 Association between GNKQ and Dietary Intake in the Study Population

Table 4.11a Pearson correlation between GNKQ score and macronutrient intake across PSS categories among the study participants (N = 150)

Dietary Intake Variable	Low Stress (n=38) GNKQ: 23.87 ± 7.21	Moderate Stress (n=78) GNKQ: 24.53 ± 6.38	High Stress (n=34) GNKQ: 28.97 ± 9.31	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Macronutrients					
Energy (kcal)	2413.34 ± 356.34	2415.59 ± 508.93	2449.76 ± 465.57	−0.034	0.683
Protein (g)	65.19 ± 11.28	67.31 ± 16.28	65.37 ± 15.15	0.078	0.340
Carbohydrates (g)	325.97 ± 45.84	324.17 ± 70.53	332.71 ± 73.39	0.006	0.943
Fats (g)	93.54 ± 20.27	94.88 ± 23.43	96.11 ± 17.54	−0.137	0.094

Mean ± Standard Deviation; Pearson Correlation (2-tailed); p > 0.05 = Not Statistically Significant
GNKQ = General Nutrition Knowledge Questionnaire; GNKQ score shown per PSS category in column headers
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Table 4.11b Pearson correlation between GNKQ score and micronutrient intake across PSS categories among the study participants (N = 150)

Dietary Intake Variable	Low Stress (n=38) GNKQ: 23.87 ± 7.21	Moderate Stress (n=78) GNKQ: 24.53 ± 6.38	High Stress (n=34) GNKQ: 28.97 ± 9.31	Pearson r	p value
	Mean ± SD	Mean ± SD	Mean ± SD		
Micronutrients					
Iron (mg)	12.12 ± 1.12	12.55 ± 2.08	12.88 ± 2.47	0.097	0.237
Calcium (mg)	370.01 ± 49.67	345.83 ± 79.74	404.66 ± 75.87	0.028	0.730

Mean ± Standard Deviation; Pearson Correlation (2-tailed); p > 0.05 = Not Statistically Significant
GNKQ = General Nutrition Knowledge Questionnaire; GNKQ score shown per PSS category in column headers
PSS Category: Low Stress = Score 0–13; Moderate Stress = Score 14–26; High Stress = Score 27–40

Tables 4.11a and 4.11b presents the Pearson correlation between GNKQ score and all dietary intake variables — macronutrients and micronutrients — across PSS categories. None of the dietary intake variables demonstrated a statistically significant correlation with GNKQ score: energy (r = −0.034, p = 0.683), protein (r = 0.078, p = 0.340), carbohydrates (r = 0.006, p = 0.943), fats (r = −0.137, p = 0.094), iron (r = 0.097, p = 0.237), and calcium (r = 0.028, p = 0.730).

The complete absence of statistically significant correlations between GNKQ score and any dietary intake variable — across both macronutrients and micronutrients — constitutes one of the most compelling and practically significant findings of the present study. It provides direct empirical evidence for the nutrition knowledge–behaviour gap in this population, confirming that greater theoretical knowledge of nutrition principles does not translate into meaningfully different patterns of energy, macronutrient, or micronutrient intake among food delivery riders. The near-zero correlation coefficients observed across all variables — particularly for carbohydrates ($r = 0.006$) and energy ($r = -0.034$) — indicate a complete absence of linear association between nutrition knowledge and dietary intake in this cohort. This finding is consistent with evidence from behavioural nutrition research demonstrating that nutrition knowledge is a necessary but insufficient condition for dietary behaviour change, particularly in populations where structural barriers — including food environment constraints, time pressure, economic limitations, and occupational stress — exert a dominant influence on food choices (Bunjong et al., 2024; Dhillion-Ortenzi et al., 2023). The marginal negative trend for fat intake ($r = -0.137$, $p = 0.094$) — approaching but not reaching significance — suggests that riders with higher nutrition knowledge may consume marginally less fat, a finding that warrants investigation in larger samples. Overall, these results reinforce the need for dietary interventions that go beyond education to address the structural and environmental determinants of food choice within the gig-economy workforce (Rachmah et al., 2021; O'Brien et al., 2020; Samal et al., 2025).

CHAPTER IV
SUMMARY AND CONCLUSION

5.1 Summary of the Study

This cross-sectional observational study, titled "Study on Dietary Intakes, Stress Score and Nutritional Status in Food Delivery Riders in Mumbai, Maharashtra," was conducted among 150 male food delivery riders aged 18–35 years, actively working across Mumbai. The primary aim was to comprehensively evaluate dietary intake, perceived stress levels, meal patterns, nutrition knowledge, and nutritional status in this rapidly growing yet nutritionally underserved occupational group. Data were collected using a structured case record form administered through personal interviews, encompassing a 24-hour dietary recall, a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), the Perceived Stress Scale (PSS-10), the Meal Pattern Questionnaire (MPQ), and the General Nutrition Knowledge Questionnaire (GNKQ). Anthropometric parameters — height, weight, and Body Mass Index (BMI) — were measured using standard procedures and classified according to World Health Organization (WHO) criteria. Sociodemographic and behavioural characteristics were also recorded to contextualise findings within the occupational realities of gig-based delivery work.

Food delivery riders in Mumbai operate under a unique convergence of occupational stressors — strict delivery deadlines, income insecurity, algorithmic monitoring, prolonged working hours exceeding ten hours daily, and continuous environmental exposure — all of which collectively undermine dietary regularity, nutritional adequacy, and psychological well-being. Despite forming an essential component of the urban gig economy and constituting one of the fastest-growing informal workforces in India, this occupational group has remained significantly underrepresented in nutritional and occupational health research. The present study sought to address this gap by simultaneously examining dietary intake, stress, meal patterns, and nutrition awareness among food delivery riders in a metropolitan context.

The findings of this study directly addressed all six stated objectives: assessing anthropometric measurements; evaluating macronutrient and micronutrient intake; measuring perceived stress levels; examining meal timing, frequency, and eating behaviour patterns; assessing general nutrition knowledge; and exploring correlations between dietary intake, stress, and nutrition knowledge with overall nutritional status.

5.2 Key Research Findings

Anthropometric Findings:

The mean age of participants was 25.72 ± 4.60 years, with the majority (84.0%) below 30 years of age, reflecting the young adult demographic characteristic of the food delivery workforce. The overall mean BMI was 22.20 ± 4.02 kg/m², falling within the normal range per WHO classification. However, a statistically significant inverse relationship was observed between perceived stress and all three anthropometric parameters — weight ($r = -0.319$, $p < 0.001$), height ($r = -0.228$, $p = 0.005$), and BMI ($r = -0.257$, $p = 0.002$) — indicating that riders with higher stress levels were systematically lighter and had lower BMI. Notably, the High Stress group demonstrated a 23.5% prevalence of underweight and a complete absence of overweight or obese participants, while overweight and obesity were concentrated exclusively in the Low and Moderate

Stress categories. This inverse pattern diverges from the commonly reported stress–obesity association in sedentary populations and suggests that in physically demanding gig-economy workers, elevated stress is more likely to manifest as appetite suppression, meal irregularity, and energy deficit rather than hyperphagia.

Nutrient Intake Patterns:

The 24-hour dietary recall revealed a paradoxical nutritional profile characterised by the simultaneous coexistence of macronutrient excess and micronutrient deficiency. Mean energy intake across the sample was 2422.77 ± 462.17 kcal, representing 88.7% of the ICMR-recommended dietary allowance (RDA) for adult Indian males with moderate physical activity — a shortfall of particular concern given the elevated energy demands of motorcycle-based delivery work. Protein intake was adequate at 66.33 ± 14.85 g (122.8% RDA), likely attributable to the high prevalence of non-vegetarian dietary preferences (71.3%) and regular pulse consumption. Carbohydrate intake (326.56 ± 65.55 g; 83.7% RDA) fell below recommendations, consistent with an overall energy deficit pattern. In stark contrast, dietary fat intake was strikingly excessive, averaging 94.82 ± 21.32 g — representing 316.1% of the ICMR RDA — directly attributable to the near-universal daily consumption of fried street foods documented in the FFQ findings.

Micronutrient intake was universally inadequate. Iron intake averaged 12.52 ± 1.99 mg (73.6% RDA), posing a risk of impaired haemoglobin synthesis and reduced aerobic work capacity. Calcium intake of 365.29 ± 75.70 mg represented only 60.9% of the RDA, constituting the most deficient micronutrient across all PSS categories. Importantly, no statistically significant differences in macronutrient or iron intake were observed across PSS categories, indicating that dietary patterns in this cohort are primarily determined by occupational and environmental factors — particularly the food environment encountered during working hours — rather than by psychological stress per se. Calcium intake alone showed a statistically significant between-group difference ($F = 7.920$, $p = 0.001$), with the High Stress group unexpectedly reporting the highest calcium consumption, possibly reflecting stress-driven dairy beverage consumption as a coping behaviour.

Dietary Pattern (Food Frequency Questionnaire):

The FFQ revealed a dietary pattern dominated by high-frequency cereal consumption — universally reported by all 150 participants — along with regular pulse and vegetable intake. However, this nutritionally adequate foundation was substantially undermined by near-ubiquitous daily fried food consumption, with 46.0% of participants consuming fried street foods such as vada pav, samosa, and chinese preparations at least once daily, and over 85% doing so at least once per week. Bakery product consumption was similarly prevalent, with 46.7% reporting once-daily intake. Fruit intake was critically low, with 27.3% of participants reporting never consuming fruits and the majority consuming them only 2–4 times per week. Regular consumption of carbonated beverages and energy drinks was documented in approximately half the sample, contributing to excess sugar and caffeine intake under conditions of chronic occupational stress. Milk and milk products were consumed once daily by 72.7% of participants, though a notable subset (4.7%) reported no dairy consumption, raising additional calcium adequacy concerns. These dietary patterns — energy-dense, saturated-fat-rich, and micronutrient-variable — collectively reflect the structural food environment constraints and economic limitations that govern dietary choice among urban gig-economy workers.

Perceived Stress Levels:

The mean PSS-10 score of the total sample was 20.69 ± 10.02, indicating a predominantly moderate stress profile. Distribution across PSS categories revealed that 25.3% (n = 38) of riders were classified under Low Stress, 52.0% (n = 78) under Moderate Stress, and 22.7% (n = 34) under High Stress. Statistically significant associations were observed between PSS category and several demographic variables, including age group ($\chi^2 = 27.604$, $p < 0.001$), family medical history ($\chi^2 = 14.021$, $p = 0.001$), current medication use ($\chi^2 = 10.123$, $p = 0.006$), dietary preference ($\chi^2 = 10.382$, $p = 0.034$), and socioeconomic status ($\chi^2 = 15.896$, $p = 0.003$). The youngest riders (18–24 years) were most heavily represented in the Moderate Stress category, consistent with heightened psychological vulnerability among entry-level gig workers exposed to financial precarity and occupational hazards. The predominance of vegetarian dietary preference in the Low Stress group is consistent with evidence linking plant-based dietary patterns to more favourable neuroendocrine stress responses.

Meal Pattern and Eating Behaviour:

Although the association between PSS category and MPQ score did not achieve statistical significance ($F = 2.716$, $p = 0.069$), a directional trend was observed wherein the High Stress group demonstrated the most irregular meal patterns (MPQ score: 22.47 ± 3.68) compared to the Moderate (20.77 ± 4.04) and Low (21.61 ± 2.51) Stress groups. The borderline p-value suggests that a larger sample may confirm this relationship.

This pattern is consistent with the established psychobiological link between chronic occupational stress and meal timing dysregulation, mediated through HPA axis activation and cortisol-driven alterations in appetite-regulating hormones. The occupational constraints of food delivery work — including the absence of designated meal breaks, time pressure, and extended shifts — independently contribute to irregular meal patterns, which in turn increase cardiometabolic risk.

Nutrition Knowledge and the Knowledge–Behaviour Gap:

A statistically significant difference in GNKQ scores was observed across PSS categories ($F = 5.404$, $p = 0.005$). Counter-intuitively, the High Stress group demonstrated the highest mean nutrition knowledge score (28.97 ± 9.31), compared to the Low Stress (23.87 ± 7.21) and Moderate Stress (24.53 ± 6.38) groups. Despite this, nutrition knowledge demonstrated a complete absence of statistically significant correlation with any macronutrient or micronutrient intake variable — confirming a classical manifestation of the nutrition knowledge–behaviour gap. The near-zero correlation coefficients between GNKQ score and all dietary intake variables (energy: $r = -0.034$; carbohydrates: $r = 0.006$; fats: $r = -0.137$) provide direct empirical evidence that theoretical nutrition awareness does not translate into improved dietary behaviour in this cohort. Structural barriers — including constrained food environments, time pressure, economic limitations, and occupational stress — exert a dominant influence over food choices, rendering individual knowledge an insufficient determinant of dietary quality.

Correlations Across Domains:

Pearson correlation analyses revealed that body weight was significantly positively correlated with all four macronutrients — energy ($r = 0.236$, $p = 0.004$), protein ($r = 0.186$, $p = 0.023$), carbohydrates ($r = 0.213$, $p = 0.009$), and fats ($r = 0.234$, $p = 0.004$) — reflecting the greater total dietary intake associated with larger body mass. BMI was significantly associated with energy, carbohydrates, and fat, but not protein, highlighting the role of excess fat and carbohydrate intake in body composition within this cohort. The sole significant micronutrient–anthropometric correlation was between height and calcium intake ($r = 0.232$, $p = 0.004$), consistent with the role of dietary calcium in skeletal development during childhood and adolescence. Micronutrient intake was otherwise entirely independent of body weight and BMI, underscoring that micronutrient adequacy in this population is governed by dietary diversity and food group composition rather than overall food quantity. The inverse anthropometric–PSS gradient across all three parameters confirms perceived stress as a determinant of nutritional status in food delivery riders, with implications extending beyond traditional stress–obesity frameworks.

5.3 Conclusion

The study highlights the interconnected role of anthropometric, dietary, psychological, and occupational factors in shaping the nutritional profile of food delivery riders. Participants with higher perceived stress demonstrated lower BMI, greater meal irregularity, and increased underweight prevalence. Nutrition knowledge correlated with stress levels yet failed to translate into improved dietary behaviour, confirming a knowledge–behaviour gap. Nutritional intake did not meet RDA levels, with near-universal consumption of energy-dense, micronutrient-poor fried foods alongside deficiencies in iron and calcium. These findings underscore the urgent need for multidisciplinary strategies integrating nutrition support, stress management, food environment improvements, and behavioural modification tailored to the gig-economy workforce.

5.4 Limitations of the Study

a. **Single-day dietary recall:** The use of a single 24-hour dietary recall, while supplemented by the SQ-FFQ, may not fully capture habitual dietary intake, seasonal variation, or day-to-day variability in food consumption among food delivery riders.

b. **Self-reported data:** Dietary recall, stress perception, and meal pattern data rely on self-report, introducing potential for recall bias, social desirability bias, and underreporting or overreporting of specific food items or eating behaviours.

c. **Purposive sampling:** Participants were recruited from delivery hotspots and food outlet clusters using purposive sampling, which may limit the generalisability of findings to all food delivery riders in Mumbai or across other Indian cities.

d. **Absence of biochemical markers:** The study relied exclusively on anthropometric and dietary assessments to evaluate nutritional status. The absence of biochemical investigations — including serum ferritin, haemoglobin, vitamin D, vitamin B12, and zinc levels — limits the ability to clinically confirm micronutrient deficiency states.

e. **Absence of gut and immune assessment:** Unlike some comparable occupational health studies, the present study did not evaluate gastrointestinal symptoms or immune status, which may represent additional health domains of concern in this population.

5.5 Recommendations for Future Research

a. **Conduct longitudinal studies:** Prospective cohort designs are needed to establish temporal and causal relationships between occupational stress, dietary intake, meal patterns, and nutritional status outcomes in food delivery riders over time.
b. **Integrate biochemical assessments:** Future research should incorporate serum markers of micronutrient status — including ferritin, haemoglobin, vitamin D, vitamin B12, and zinc — alongside gut microbiota profiling, to provide a comprehensive assessment of nutritional and physiological health in this population.
c. **Employ randomised and representative sampling:** Adoption of randomised sampling strategies across diverse localities and delivery platforms would enhance the representativeness and external validity of findings.
d. **Include larger and more diverse samples:** Future studies should extend to female delivery workers, riders across multiple Indian cities, and platform-stratified subgroups to improve generalisability of nutritional and stress-related findings.
e. **Design and evaluate targeted dietary interventions:** Evidence-based, multi-component dietary intervention programmes — combining food environment modification, nutrition education, and digital health support — should be developed and rigorously evaluated in food delivery rider populations, using platforms and applications accessible during working hours.
f. **Investigate stress management interventions:** Randomised controlled trials examining the impact of workplace stress management programmes — including mindfulness-based interventions, peer support initiatives, and platform-level policy reforms — on dietary behaviour, meal regularity, and nutritional status in delivery riders are warranted.
g. **Explore micronutrient interactions:** Specifically, the interrelationships between iron, calcium, vitamin B12, and vitamin D and their combined effects on physical work capacity, immune function, and mental health outcomes in gig-economy workers merit systematic investigation.
h. **Engage platform companies and policymakers:** Collaborative research with delivery platforms, municipal authorities, and regulatory bodies should be pursued to co-design and implement structured occupational health and nutrition welfare programmes, including mandated rest breaks, access to nutritious food options during working hours, and platform-integrated health literacy initiatives.
i. **Conduct qualitative research:** In-depth qualitative exploration of cultural norms, behavioural motivations, and psychosocial barriers to healthy eating and health-seeking behaviour among food delivery riders would complement quantitative findings and enhance the development of context-sensitive interventions

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