ASSESSMENT OF NUTRITIONAL STATUS AND ASSOCIATED FACTORS AMONG FACTORY WORKERS AGED 19 TO 59 YEARS IN KHANAR AREA, SUNSARI

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Assessment of Nutritional Status and Associated Factors among Factory Workers Aged 19 to 59 years in khanar Area, Sunsari

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Approval Letter

This ***dissertation*** entitled ***Assessment of Nutritional Status and Associated factors among Factory workers aged 19 to 59 years in khanar Area, Sunsari*** presented by **Simran Chaudhary** has been accepted as the partial fulfillment of the requirement for the **B.Sc. degree in Nutrition and Dietetics.**

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Abstract

This community-based cross-sectional study aimed to assess the nutritional status and its associated dietary, sociodemographic, and lifestyle factors among factory workers aged 19–59 years in Khanar Area, Sunsari. Anthropometric measurements, including Body Mass Index, Waist Circumference, and Waist-to-Hip Ratio, were recorded. Dietary intake was assessed using a 24-hour dietary recall and Food Frequency Questionnaire. Sociodemographic and behavioral data were collected through semi-structured interviews. Data analysis was performed using SPSS version 20, employing descriptive statistics and chi-square tests to determine significant associations.

The mean BMI was 25.86 ± 4.71 kg/m²; WC, 86.66 ± 9.84 cm; and WHR, 0.92 ± 0.07. Based on BMI, 31.5% of participants had a normal weight, 38.0% were overweight, 22.2% obese, and 8.3% exhibited thinness. Abdominal obesity was observed in 47.2% of participants based on WC and 69.9% based on WHR, with a higher prevalence among females. The average daily intake was 2307.10 ± 434.41 kcal of energy, 383.03 ± 90.64 g of carbohydrates, 54.82 ± 12.97 g of protein, and 53.83 ± 16.16 g of fat. Micronutrient intakes were notably low, particularly for calcium (600.82 ± 237.37 mg), iron (19.80 ± 5.10 mg), thiamine (1.60 ± 0.29 mg), riboflavin (2.32 ± 0.42 mg), and niacin (14.80 ± 4.60 mg). Dietary patterns indicated frequent intake of carbohydrate-rich staples but limited consumption of fruits, animal-source foods, and nuts. Significant associations were found between BMI and WC with gender, age, marital status, education, income, calorie intake, and flesh food consumption. WHR was significantly associated with family size, working hours, alcohol use, and macronutrient intake. The findings underscore the coexistence of overnutrition and thinness alongside widespread micronutrient deficiencies, reflecting a double burden of malnutrition. Tailored nutrition interventions focusing on dietary quality, micronutrient adequacy, and lifestyle modification particularly for female workers are essential to improve nutritional health outcomes.

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List of Abbreviations

Abbreviations	Full Form
AND	Academy of Nutrition and Dietetics
ASPEN	American Society for Parenteral and Enteral Nutrition
BAPEN	British Association for Parenteral And Enteral Nutrition
BMI	Body Mass Index
CBS	Central Bureau of Statistics
CDC	Centers for Disease Control and Prevention
DBM	Double Burden of Malnutrition
FAO	Food and Agriculture Organization
FCT	Food Composition Table
FFQ	Food Frequency Questionnaire
GLVs	Green Leafy Vegetables
GNI	Gross National Income
HDI	Human Development Index
ICMR	Indian Council of Medical Research
IPAQ	International Physical Activity Questionnaire
KOC	Kuwait Oil Company
MET	Metabolic Equivalent of Task
MNDs	Micronutrient Deficiencies
NDHS	Nepal Demographic and Health Survey
NSO	National Statistics Office
OSIR	Outbreak, Surveillance, Investigation & Response
PA	Physical Activity
RDA	Recommended Dietary Allowance
SPSS	Statistical Package for the Social Sciences
UNDP	United Nations Development Program
UNICEF	United Nations International for Children's Emergency Fund
WASH	Water Sanitation And Hygiene
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist Hip Ratio

PART I

INTRODUCTION

1.1 General Introduction

Nepal has 56,611 industries in the manufacturing sector, comprising 5,017 large-scale and 51,594 small-scale industries. The industrial sector employs approximately 500,000 Nepali citizens, including business owners, partners, and workers. Bagmati Province has the highest industrial workforce, engaging 159,746 individuals. Other provinces have the following employment figures: Koshi (95,964), Lumbini (87,067), Madhesh (80,773), Gandaki (40,632), Sudurpaschim (20,049), and Karnali (6,996). Furthermore, about 400,000 individuals have secured regular employment, with 381,681 workers receiving salaries and wages. Among them, 346,143 are engaged in the manufacturing sector. The total annual output of Nepal's industrial sector is valued at approximately NPR 1.2 trillion, with production costs estimated at NPR 846 billion. The contribution of industries to the national economy amounts to roughly NPR 354 billion in value addition (Dhungana, 2023).

From an economic perspective, Bloom and Canning (2004) emphasized that the overall national production or economic output of a country depends on several essential inputs, including physical capital, the available labor force, and the level of human capital. Human capital, in their view, is a broad concept that includes factors such as education, work experience, and most importantly, the health status of the population. Health is not only a fundamental aspect of human capital but also a critical element that directly contributes to improving economic performance and productivity. Their production function model highlights that better health conditions among individuals enhance the efficiency, capability, and effectiveness of both labor and other productive resources, ultimately leading to higher total productivity and sustained economic growth.

Similarly, Bloom *et al.* (2001) presented both theoretical frameworks and empirical evidence demonstrating that improved population health makes a substantial contribution to long-term economic growth and overall national development. Their work highlights that a healthy population forms the foundation of a productive labor force, capable of sustaining higher levels of efficiency and innovation over time. These findings therefore emphasize the critical importance of regularly assessing the nutritional and health status of individuals working in labor-intensive sectors, such as factory workers, whose physical

well-being and productivity are directly tied to the nation's economic performance. Work productivity is the main problem often faced by the factory workers. One factor that affects factory workers work productivity is dietary patterns. Dietary habits influence nutritional status and play a crucial role in the productivity of factory workers.

A well-balanced diet directly affects the type, frequency, and quantity of food and beverages consumed, ultimately shaping nutritional status. Adequate nutrition, determined by the selection of food ingredients and consumption patterns, helps maintain a proper nutrient balance in the body. The equilibrium between the quality and quantity of food and drink intake significantly impacts overall nutritional well-be _ Work productivity is directly affected by the nutritional status of workers. Research conducted showed a relationship between nutritional status, dietary patterns, and physical activity on work productivity (Meilinda *et al.*, 2024).

The nutritional status of factory workers in Nepal reflects a concerning trend of rising overweight and obesity, conditions that are no longer confined to urban or affluent populations but are increasingly observed among industrial laborers. Studies among iron and steel industry workers in Bara district reported that more than one-fourth of workers were either overweight or obese, with 22.1% overweight and 5.2% obese. Such findings highlight the dual burden of malnutrition in Nepal, where undernutrition persists while overnutrition and its associated health risks are emerging. This pattern indicates a shift in dietary and lifestyle behaviors among factory workers, making them vulnerable to nutrition-related noncommunicable diseases. Addressing these issues through workplace-centered nutrition education, dietary counseling, and health promotion initiatives is essential to safeguard the health and productivity of Nepal's industrial workforce (Sangroula *et al.*, 2020).

1.2 Statement of the problem

Factory workers constitute a vital part of the industrial sector and require focused attention, particularly as living standards continue to decline. Malnutrition is not limited to preschool-aged children, it also affects entire households, especially those headed by individuals in nutritionally disadvantaged occupations such as factory work. These workers frequently encounter significant dietary challenges that negatively influence the health and well-being of their families. Better health can make workers more productive, either through fewer days off or through increased output while working (Varma and Singh, 2015). Understanding the characteristics and needs of this workforce is crucial for developing policies that not only encourage economic growth but

also protect workers rights. Many factory workers have restricted access to healthcare due to strenuous job conditions, extended work hours, low wages, and limited resources. In research conducted in 2010, 85% of female garment factory workers were found to experience malnutrition, reproductive health issues, and community-acquired diseases in Bangladesh (Solinapa *et al.*, 2019).

One in three people globally suffer from at least one form of malnutrition, leading to poor health outcomes and low productivity in the workplace. Consequently, malnutrition of all forms also brings significant losses in productivity and work potential, posing challenges to employers in high-, low- and middle-income countries. Given that about 60% of the global population will spend one-third of their time at work during their adult life and employers have an incentive to maximize performance, the workplace offers an important, relatively unexploited opportunity to address malnutrition in all its forms (Dhilon Nyhus and Ortenzi, 2023).

It is assumed that employees spend a significant portion of their lives at work, and the pressure of work may affect their eating behavior and lifestyle at work, which may lead to overweight and obesity. In turn, overweight/obesity may affect their performance at work and may increase the risk of different chronic diseases (Yamada *et al.*, 2001). Moreover, various risk factors contribute to overweight and obesity. Recent data indicates that overweight and obesity now affect over 30% of industrial workers in similar low- and middle-income countries (Ranawat and Mogra, 2016).

Factory workers play a vital yet often overlooked role in our society, working tirelessly behind the scenes to produce the goods we rely on every day. Despite their immense contribution to the nation's economy, their own health and nutritional needs are frequently neglected. Many of these individuals endure long hours, irregular eating patterns, limited food choices, and minimal access to health education. As a result, they are at risk of both undernutrition and overnutrition, facing health challenges that not only reduce their productivity but quietly diminish their well-being and quality of life.

While there is extensive global research on nutritional health of industrial workers, there is a significant lack of research focused on the nutritional status of factory workers in Nepal. With only a few studies, such as one in Bara District (Sangroula *et al.*, 2020) that looked solely at male industrial workers, the evidence base remains thin and incomplete.

There is virtually no inclusive research in Nepal that considers both male and female workers or investigates multiple associated risk factors such as diet, lifestyle, and nutritional status. This research seeks to fill that void by exploring the distinct challenges faced by workers in Nepal's manufacturing sector, particularly the impact of diet, working conditions, and socioeconomic status on their overall well-being. By understanding these elements, it will be possible to develop health interventions and policies that are more suited to the needs of Nepal’s industrial workforces. ..

1.3 Conceptual Framework

This conceptual framework illustrates the relationship between the dependent and independent variables in the study. The nutritional status of factory workers is the dependent variable, which is influenced by various independent variables such as sociodemographic characteristics (e.g., age, Gender, education), behavioral factors (e.g., smoking, alcohol consumption), dietary practices (e.g., calorie intake, food frequency), and physical activity levels as shown in fig1.1 .

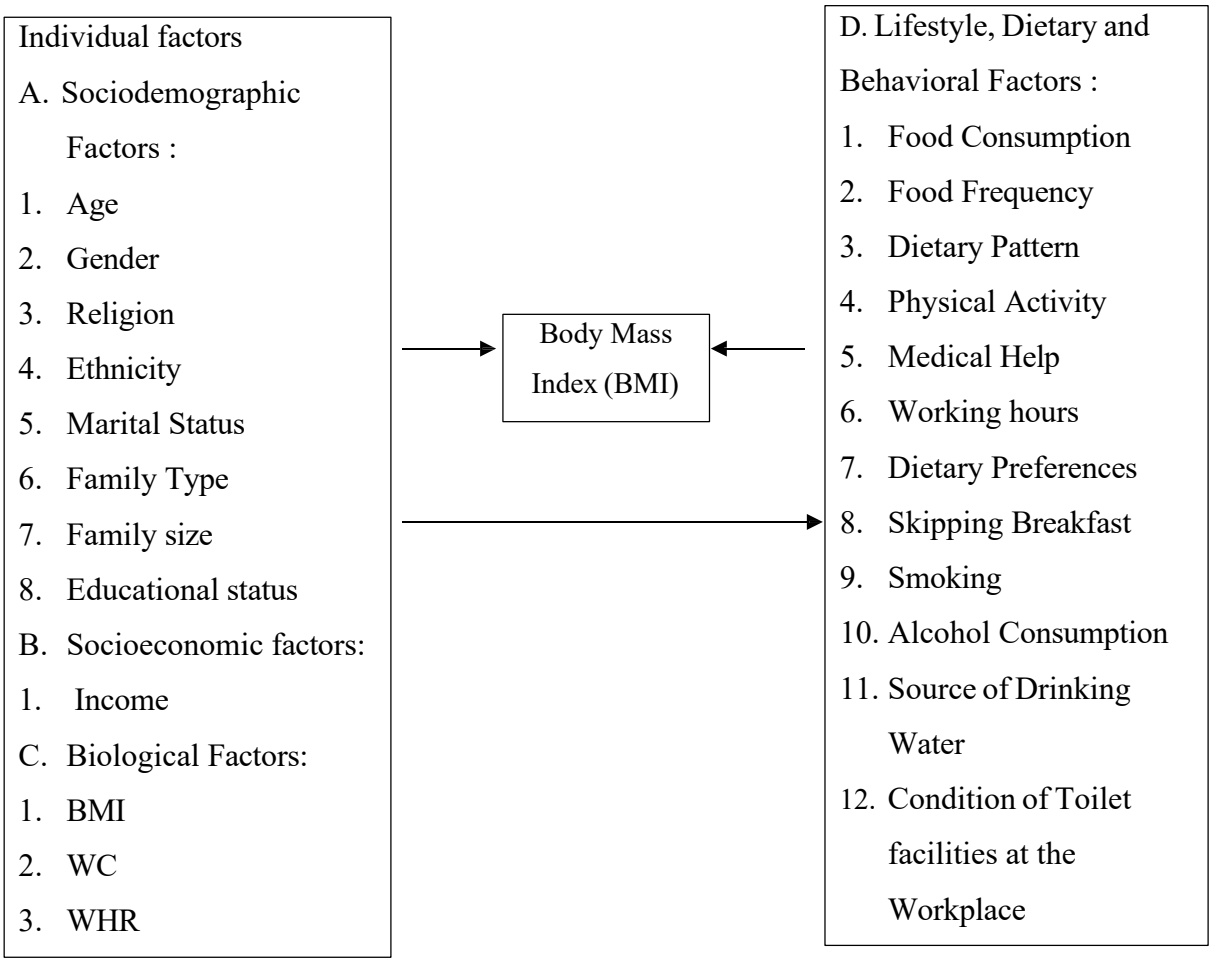

Fig 1.1 Conceptual Framework of the Study, Adapted and modified from conceptual framework of (Sangroula *et al.*, 2020)

1.4 Objectives of the Study

The objective of the research is divided into two parts:

1.4.1 General objectives

To study the nutritional status and associated factors among factory workers aged 19-59 years in Khanar Area, Sunsari.

1.4.2 Specific Objectives

- To determine the nutritional status of 19-59 years of factory workers in khanar Area, Sunsari.
- To evaluate dietary intake patterns and nutrient adequacy among factory workers.
- To compare the nutritional status of male and female factory workers in khanar area.
- To identify factors associated with nutritional status of factory workers of 19-59 years of age.

1.5 Research Questions

- What is the current nutritional status of 19-59 years of factory workers in khanar Area, Sunsari?
- What are the dietary intake patterns and nutrient adequacy levels among factory workers?
- What is the nutritional status of male and female factory workers in khanar area?
- What are the factors associated with nutritional status of factory workers ?

1.6 Significance of the study

- Provide information about the nutritional status of adult factory workers in khanar.
- Helps aware people about the current scenario of nutrition and health related problems among Factory workers in khanar.
- Help identify the risk groups and extent of nutritional risks for further intervention.
- Identify different anthropometric, socioeconomic, demographic factors that affect nutritional status of Factory workers directly or indirectly.

- Serve as helpful guide to make a program related to nutrition for this area.
- Serves as baseline data for other organizations and institutions.
- This study provides valuable data for governments, non-governmental organizations, and stakeholders to utilize in designing and implementing programs for factory workers.

1.7 Limitations of the study

- Seasonal variation may be there as this is cross-sectional study done for specific period.

PART II

Literature review

2.1 Nutrition

Nutrition refers to the intake of food that aligns with the body's specific needs to support health and proper functioning. A well-balanced diet is essential not only for maintaining overall well-being but also for preventing health problems. When nutritional needs aren't met, it can weaken the immune system, slow down physical and mental growth, and reduce a person's ability to work and concentrate. From the earliest stages of life through to old age, nutrition plays a continuous and vital role in human development (EMRO, 2024). It can be defined as the science of food and its interaction with an organism to promote and maintain health. Thus nutrition is a combination of processes by which all parts of the body receive and utilize the materials needed for the growth and renewal of all the components (Joshi, 2015).

The word nutrition first appeared in 1551 and comes from the Latin word 'nutrire', meaning "to nourish." Nutrition is the sum of all processes involved in how organisms obtain nutrients, metabolize them, and use them to support all of life's processes. Nutritional science is the investigation of how an organism is nourished and incorporates the study of how nourishment affects personal health, population health, and planetary health. Nutritional science covers a wide spectrum of discipline. As a result, nutritional scientists can specialize in particular aspects of nutrition such as biology, physiology, immunology, biochemistry, education, psychology, sustainability, and sociology (Zimmerman and Snow, 2012).

2.2 Nutritional Status

Nutritional status of an individual is the result between the nutritional intake received and the nutritional demands, and allowance for the utilization of nutrients to maintain reserves and compensate for losses (Fernandez-Lazaro and Seco-Calvo, 2023). Nutritional status is the health status of individuals or population groups as influenced by their intake and utilization of nutrients (Gibson, 2002). It reflects the degree to which physiological needs for nutrients are being met (Srivastava, 2008). The health and wellness of individuals can be adversely affected by an imbalance in their nutritional status. Thus, the early identification

of an individual's nutritional status through the process of nutritional screening and assessment allows for timely intervention, which in turn helps to maintain their health and wellness and enhance quality of life (Kesari and Noel, 2023).

2.3 Malnutrition

The term malnutrition generally refers both to under nutrition and over nutrition, but the term to refer solely to a deficiency of nutrition. Many factors can cause malnutrition, most of which relate to poor diet or severe and repeated infections. Inadequate diet and disease, in turn, are closely linked to the general standard of living, the environmental conditions, and whether a population is able to meet its basic needs such as food, housing and health care. Malnutrition is thus a health outcome as well as a risk factor for disease and exacerbated malnutrition, and it can increase the risk both of morbidity and mortality (Blössner and Onis, 2005). Malnutrition means having an unhealthy balance of nutrients either too little or too much. This can include anything from serious undernourishment to excess weight, both of which impact on the body’s functions, structure, and overall health. In short, malnutrition refers to any condition where nutrition is not adequate, whether it’s due to starvation or overeating (Siddiqui *et al.*, 2020). Malnutrition is as a pathological state resulting from a relative or absolute deficiency or excess of one or more of the essential nutrients in the diet (Jelliffe, 1996).

2.3.1 Causes of Malnutrition

There are various causes of malnutrition, as described by the UNICEF casual framework, the causes of malnutrition are divided into immediate, underlying and basic causes. The UNICEF conceptual framework, developed in the 1990s and shown below in Fig 1.1 summarizes the causes of malnutrition.

a. Immediate Causes

Malnutrition at the immediate level stems from an imbalance between the body's nutritional needs and the actual intake or absorption of nutrients. This often results from two primary factors: inadequate dietary consumption and the presence of disease. When dietary intake is insufficient, or when the body struggles to absorb or retain essential nutrients due to illness, malnutrition can develop. Certain diseases can further exacerbate the issue by increasing

energy demands, reducing nutrient absorption, or causing excessive nutrient loss through symptoms like diarrhea and vomiting. This creates a vicious cycle in which poor nutrition weakens the immune system, making individuals more susceptible to infections, which in turn further compromise nutritional status. Ultimately, malnutrition arises either due to inadequate food intake, illness, or a combination of both, each factor reinforcing the other in a continuous loop of declining health (Ersado, 2023).

b. Underlying causes

The underlying cause of nutritional deficiency disorders includes food insecurity at the household level, inadequate social and caregiving environments, and limited access to healthcare and a healthy living environment. Additionally, ineffective healthcare services, poor caregiving practices, delayed or insufficient treatment of childhood illnesses, inadequate sanitation, neglect of vulnerable populations, and a lack of proper nutrition education further contribute to these issues. Moreover, rapid social and political changes are creating instability, particularly among marginalized communities. The exclusion or oppression of specific social or ethnic groups often serves as a fundamental driver of their nutritional vulnerability (Devkota *et al.*, 2015).

c. Basic Causes

The basic causes of malnutrition are deeply tied to the availability and distribution of resources, which are categorized into three key types: human resources, economic resources, and organizational resources. In this context, formal national institutions such as government systems that manage civic, political, and economic affairs play a crucial role. At the same time, informal institutions, including markets, traditional systems, and societal norms, influence power dynamics and the distribution of resources. These social structures shape how resources are shared and how malnutrition risks are distributed, especially among different groups in society. Ultimately, malnutrition is often rooted in fundamental issues like poverty, limited access to information, political and economic instability, war, lack of resources at various levels, gender inequality, and the impact of natural disasters. These underlying causes create a cycle that exacerbates malnutrition and its consequences (Ersado, 2023).

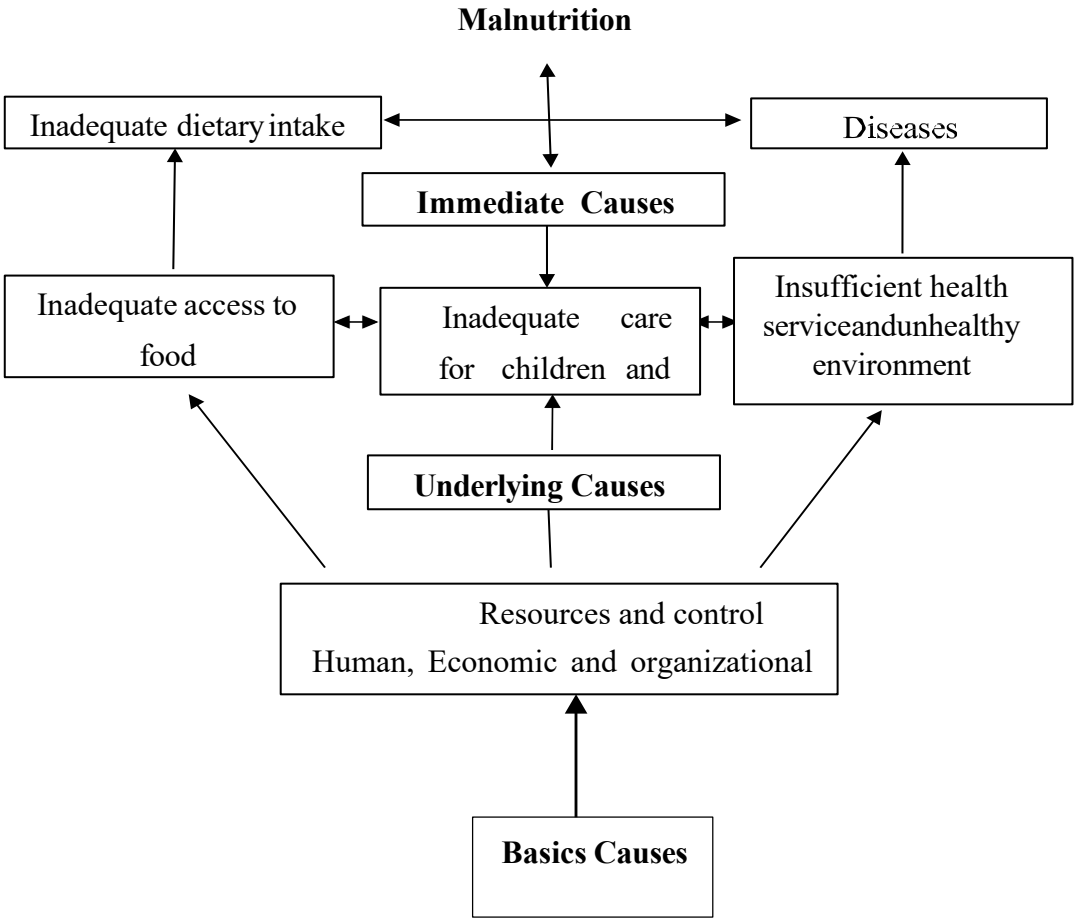

Fig 2.1: UNICEF Conceptual Framework of Malnutrition (Den Hartog *et al.*, 2006)

2.3.2 Forms of Malnutrition

Malnutrition has recently been defined as a pathological state resulting from a relative or absolute deficiency or excess of one or more essential nutrient, this state being clinically manifested or detected only by biochemical, anthropometric or physiological tests (Jelliffe, 1996).

- Undernutrition: pathological conditions caused by consuming insufficient amounts of food over an extended period is referred to as undernutrition.
- Overnutrition: This pathological condition is brought on by an increased consumption of vital nutrients, especially calories, which is a current area of concern.
- Specific deficiency: A pathological condition brought on by a partial or total absence of a particular nutrient (Joshi, 2017).

Malnutrition can also be classified as Acute, Chronic and Acute and chronic malnutrition (Dahal, 2019).

- Acute malnutrition: Acute malnutrition relates to the present state of nutrition, for example, Weight for height (wasting or thinness).
- Chronic malnutrition: chronic malnutrition relates to the past state of nutrient, and the measurable parameters are height for age (stunting or shortness).
- Acute and chronic malnutrition: A combination measure, hence it could occur as a result of wasting, stunting or both (underweight).

2.4 Occupational health, Nutrition and Productivity

Although Nepal's factory sector is expanding, workers continue to face serious challenges such as unsafe conditions, health risks, and gender inequalities, all of which can lower productivity. Factory laborers play a vital role in the country's economy, yet many work in environments that expose them to respiratory illnesses, repetitive injuries, malnutrition, and mental health issues (WHO, 2019).

Nepal's Human Development Index (HDI) stands at 0.601, placing the country in the "Medium Human Development" category and ranking 146th out of 193 countries, an improvement from 149th in 2021. Since 1990, Nepal's HDI has increased by 52.2% (from 0.395 to 0.601), with a 0.010 increase since 2021, higher than the global average of 0.004. Similarly, Gross National Income (GNI) per capita has risen by approximately 165.7% during the same period (UNDP, 2023).

Workers are a company's most important capital, relying on their talent, skills, and creativity (Rakhmawati and Boedirochminarni, 2018). Work Productivity is strongly influenced by nutritional status. A study in Indonesia found that 57.1% of production workers were unproductive, with poor nutrition significantly linked to low performance (Batu Bara *et al.*, 2024).

Nutritional status is shaped by factors such as age, ethnicity, smoking, dietary diversity, total intake, and eating frequency. Shift work further heightens the risk, with shift workers found to be 25% more likely to be overweight and 17% more likely to be obese than non-shift workers, largely due to disrupted metabolism from irregular schedules (Liu *et al.*, 2018). Nutritional status is typically classified as underweight, normal, overweight,

obese I, and obese II (Damayanti *et al.*, 2024b).

Research highlights the connection between nutrition, job performance, and workplace safety. Malnutrition reduces energy, strength, focus, and learning capacity, creating a cycle that lowers workforce efficiency, decreases productivity, and weakens institutional competitiveness. It also drives up labor costs, slows economic growth, and deepens inequality. By contrast, investing in nutrition can cut absenteeism, reduce workplace accidents, boost morale, and even raise national productivity by up to 20% (Bor, 2020).

2.5 Nutritional status of the factory workers around world

Based on dietary intake data excluding fortification and supplementation, over five billion people worldwide have insufficient consumption of key nutrients such as iodine (68%) and calcium (66%). Additionally, more than four billion individuals do not meet the recommended intake levels for iron (65%), riboflavin (55%), folate (54%), and vitamin C (53%). Calcium deficiency along with inadequate intake of riboflavin and vitamin B12 is particularly widespread in South Asia, sub-Saharan Africa (Passarelli *et al.*, 2024). In the context of Bangladesh, the garments industry is now the main economic sector. Many young workers, about 4 million, worked in the export-based garment industries in Bangladesh.

According to the research conducted in one of the garment industries in Bangladesh, normal weight, underweight, pre-obese, and obese were 46.34%, 3.14%, 38.74%, 11.78 % respectively. The study revealed that one-fourth of the female garment workers were suffering from malnutrition and amongst the female, the malnutrition was twice of the male workers, with anemia 67.2% among female workers (Khandker *et al.*, 2016). The study conducted in some selected garment factories in Dhaka City, Bangladesh shows that more than half of the participants (53.67%) had various health problems, and almost half of them (43.33%) were underweight (BMI $\leq$ 18.5 kg/m2). Among those who were underweight, about 96% of them had one or more health-related problems in the last three months (Hasnain *et al.*, 2014).

Malnutrition, including both undernutrition and overnutrition, was prevalent among industrial migrant workers in India. In the study conducted by Sanskriti *et al.* (2024), 20.62% of the participants were underweight, though only 2.06% were categorized as 'wasted.' Additionally, 17.52% of the participants were classified as overweight or obese (Sanskriti *et al.*, 2024). Beriberi, a clinical manifestation of prolonged thiamine deficiency,

was identified among factory workers in Thailand, with biochemical thiamine deficiency reported in 7.1% of Myanmar and 26.7% of Thai workers. These findings emphasize the occupational vulnerability of industrial workers to micronutrient deficiencies when dietary intake is inadequate (Nguyen *et al.*, 2014).

A cross sectional study conducted in Brazil among workers of different industries found that 6.0% and 19.0% of the females and males, respectively, were obese, and 31.0% and 42.0% of the females and males, respectively, were overweight (Bortolozo *et al.*, 2016). A study conducted among Kuwait Oil Company (KOC) employees with 85% of male participants, revealed that the overall prevalence of overweight and obesity among KOC employees was 75% where Males showed a higher level of overweight and obesity (79%) than females (56%) (T. Al-Asi, 2003).

A cross-sectional survey was conducted among 223 female workers (nulliparous, non-pregnant) at a garment factory in Phnom Penh in Cambodia. Overall, 31.4% of workers were underweight, 26.9% showed anemia, 22.1% showed iron deficiency, while 46.5% had marginal iron stores (Makurat *et al.*, 2016). The study results show a prevalence of overweight, especially in males regarding abdominal obesity, and that energy intake varies by gender and type of work in Colombia (Aparecida *et al.*, 2016). The analysis was based on data from 202 adult workers (of 243 employees) at a cosmetics factory located in a highly urbanized and industrialized region of São Paulo, Brazil. The overall prevalence of overweight was 43%, similar to that reported for the Brazilian population (41%) (Lipi *et al.*, 2010).

2.6 Nutritional status of the factory workers in Nepal

Overweight and obesity are major serious public health problems, since their prevalence is accelerating rapidly not only in developed but also in developing countries. An industry-based analytical cross-sectional study conducted among the 271 male workers in iron and steel industries in Bara district has presented high prevalence of overweight/ obesity. The prevalence of overweight and obesity was 22.1% and 5.2%, respectively in this study (Sangroula *et al.*, 2020). Overweight/obesity was significantly associated with the age of the participants in both bivariate and multi variate analyses. In multivariate, participants of age more than or equal to 40 were 2.54 (1.346–4.823) times more likely to be overweight/obese than the participants below 40 years of age (Sangroula *et al.*, 2020).

Men's nutritional Status according to 2022 NDHS among adolescent men aged 15-19 demonstrated 41% are thin and 7% are overweight or obese according to BMI-for-age. Among men aged 20-49, 7% are thin and 32% are overweight or obese according to BMI. Overweight/obesity among women aged 20-49 is higher in urban areas (38%) than in rural areas (26%). The 2022 NDHS also took weight and height measurements of women aged 15–49. Among adolescent women aged 15-19, 26% are thin according to body mass index for age (BMI-for-age) and 6% are overweight or obese. Among women aged 20-49, 10% are thin according to BMI and 35% are overweight or obese (NDHS, 2022).

Micronutrient deficiencies (MNDs) negatively affect both physical and mental health, ultimately limiting individual productivity and national development. They contribute to a persistent cycle of poor health, reduced economic growth, and diminished social well-being (Bhandari and Banjara, 2015) as shown in fig 2.2.

2.7 Interlinkage among the causes of Micronutrient Deficiencies (MNDs) in Nepal

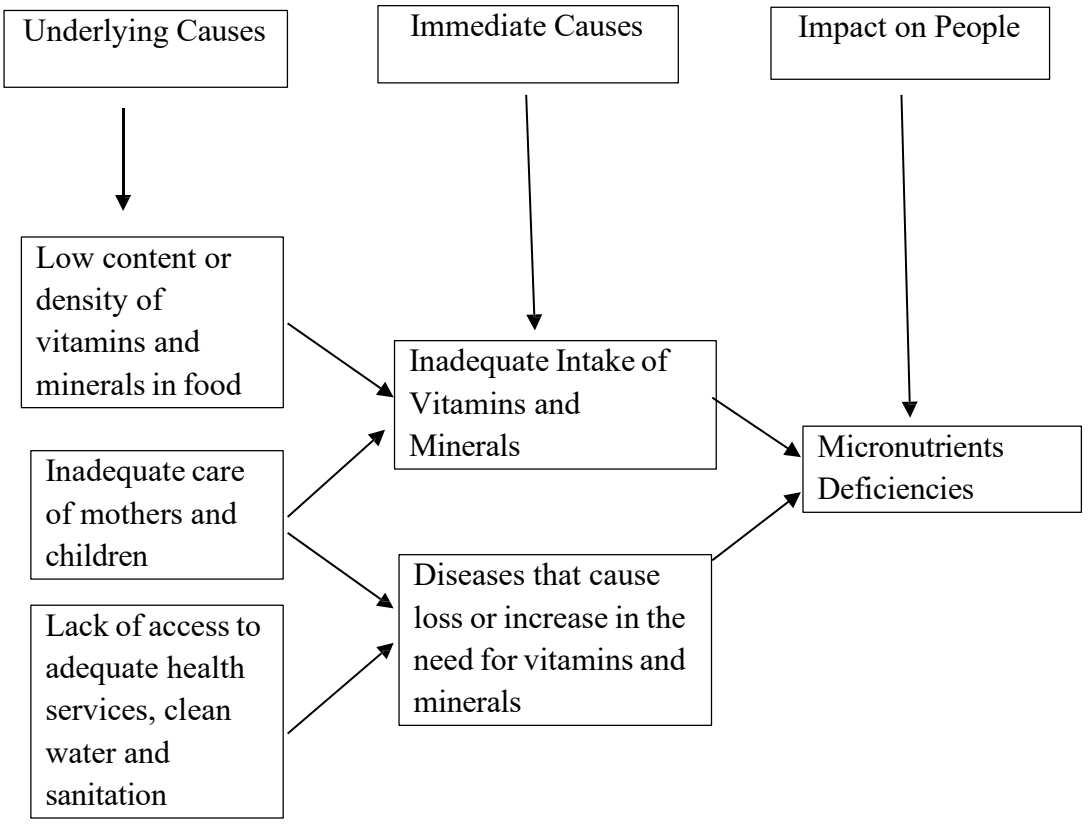

Fig 2.2: Interlinkage among the causes of Micronutrient Deficiencies (MNDs) in Nepal (Bhandari and Banjara, 2015)

2.8 The vicious cycle of MNDs

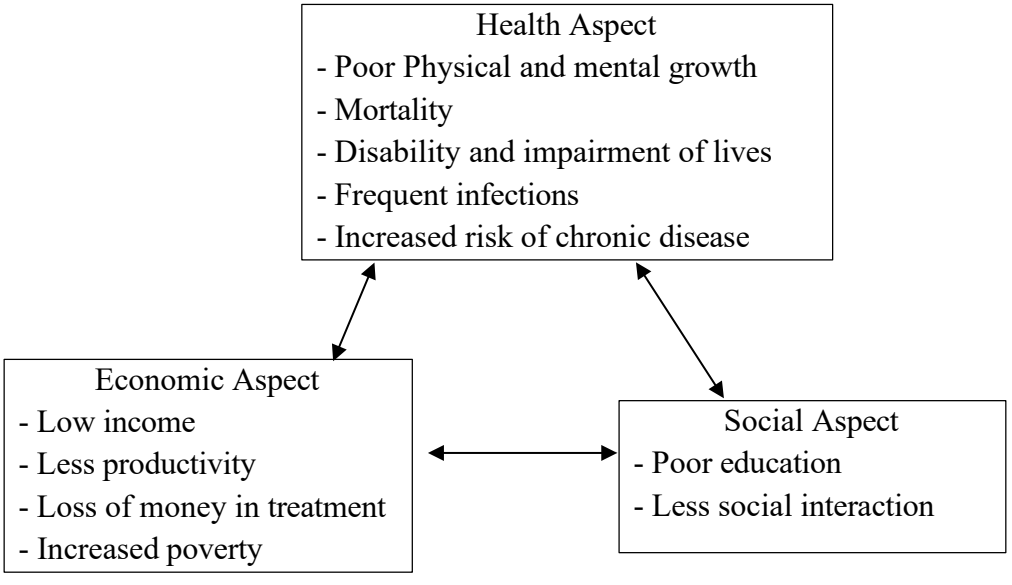

Fig 2.3 The vicious cycle of MNDs (Bhandari and Banjara, 2015)

2.9 Factors Affecting Nutritional Status

2.9.1 Age

Aging in humans is a natural and ongoing process that happens over time. It's a complex and personal journey that affects us biologically, psychologically, and socially. Biologically, aging involves gradual changes in our metabolism and the structure of our cells, which can reduce our ability to self-regulate and repair, leading to changes in the tissues and organs. Ageing is an irreversible process. Psychologically, aging is about how we become aware of and adapt to the changes that come with getting older (Dziechciaz and Filip, 2014). As people age, changes such as reduced taste and smell, chewing or swallowing difficulties, chronic illnesses, medication use, and cognitive decline can affect nutrition. Social and economic factors like limited income, lower education, living alone, or poor living conditions further increase the risk of malnutrition (Kucukerdonmez *et al.*, 2017).

A study among female garment workers in Bangladesh found that age significantly influences BMI and waist circumference. As workers grow older, both body weight and abdominal fat tend to increase, highlighting how aging contributes to changes in body composition and elevates the risk of obesity and related health issues (Sharmin *et al.*, 2020). A research study conducted in Bara among the factory workers revealed that, as people age, their chances of being overweight or obese increase. Specifically, individuals aged 40 and above were more than twice as likely to have excess weight compared to those under 40, even when other factors were taken into account (Sangroula *et al.*, 2020).

2.9.2 Gender

As per the study conducted in Bangladesh, reveals significant gender differences in nutritional status among RMG workers, around 44% of the ready-made garment workers were found to be overweight or obese according to the Asian BMI standards, with women showing a higher rate (46.6%) compared to men (40.2%) (Afrin et al., 2025). A cross sectional research conducted among Bangladeshi adults indicates that women face a higher risk of obesity compared to men, with a greater prevalence of obesity found in women (Islam et al., 2018). According to the research conducted among the workers in Indonesia, Female workers were found to be more obese than their male counterparts, suggesting that gender plays a role in determining nutritional status (Damayanti et al., 2024a).

2.9.3 Ethnicity

Nutrition is influenced by the social and cultural meanings attached to food. It reflects social identity, including factors such as class, ethnicity, and lifestyle. Eating is a daily activity that often serves as a social event. Religious beliefs also play a significant role in shaping food practices and, consequently, nutritional habits. Across cultures, it is common to offer prayers for food production or to bless the food before consumption (Anderson, 2014). A study conducted among the male workers of steel and iron industries found that Brahmin/Chhetri workers had 6.14 times higher odds of being overweight/obese compared to Dalit/Janajati workers. Madhesi workers had 4.64 times higher odds compared to Dalit/Janajati workers (Sangroula *et al.*, 2020).

2.9.4 Dietary Intake

Dietary intake is a crucial factor influencing nutritional status, as both the quantity and quality of consumed nutrients directly affect individual health outcomes. Adequate intake of macronutrients and micronutrients is essential for maintaining physiological functions and preventing malnutrition. Conversely, imbalanced diets resulting from inadequate caloric intake or limited nutrient diversity can lead to undernutrition or overnutrition, both of which are associated with various health risks (Wieringa *et al.*, 2016; Sangroula *et al.*, 2020).

Furthermore, dietary diversity plays a vital role in shaping nutritional status. Studies have shown that individuals with greater dietary diversity often consume more energy, which can lead to either improved nutritional outcomes or increased risk of overweight and obesity, depending on the quality of foods consumed. A varied diet may include both nutrient-rich and calorie-dense foods, influencing overall health outcomes (Asghari *et al.*, 2017). A study conducted among female garment workers in Cambodia reported that 31.4% were underweight, 26.9% were anemic, highlighting the prevalence of micronutrient deficiencies even among those with normal BMI (Wieringa *et al.*, 2016). A study among male factory workers in Nepal reported that inadequate intake of micronutrients such as iron and vitamin C was prevalent, contributing to compromised nutritional status. These deficiencies were linked to limited dietary diversity and insufficient consumption of nutrient-rich foods, emphasizing the importance of balanced diets in preventing micronutrient-related health issues (Sangroula *et al.*, 2020).

2.9.5 Physical Activity

Energy balance is a process through which the body attempts to establish homeostasis. The two components of the equation for weight management are energy intake and energy output and an imbalance in this energy results in weight gain/ loss. Physical Activity is the key to weight loss and weight maintenance. Physical activity is all movements that create energy expenditure whereas exercise is planned, structured physical activity (Cox, 2017). Research conducted among Malaysian adult highlights a gender-based difference in the relationship between physical activity and body weight. While men engaging in vigorous exercise showed a higher prevalence of overweight and obesity, women who participated in moderate activity experienced similar trends (Chan *et al.*, 2017).

Several studies have highlighted the significant relationship between physical activity and nutritional status among factory workers. For instance, a cross-sectional study involving 239 manufacturing workers found that low physical workload and poor exercise habits were associated with increased rates of overweight and obesity (Lutfiya *et al.*, 2025). WHO recommends that adults aged 18-64 should engage in at least 150–300 minutes of moderate-intensity aerobic exercise, 75–150 minutes of vigorous-intensity aerobic exercise, or an equivalent mix of moderate- and vigorous-intensity activity throughout the week (WHO, 2020b).

Metabolic equivalents, or METs, are a way to estimate the intensity of physical activity. One MET represents the number of calories expended while sitting still for one minute. This equates to around one calorie per every 2.2 pounds of body weight per hour for the typical adult. To assess how active people are in relation to their health, the International Physical Activity Questionnaire (IPAQ) was developed. The short version of the IPAQ has been thoroughly tested and is now widely used in research across the globe. It focuses on four main activity areas for adults aged 18 to 65: physical activity during transportation, at work, while doing household chores or gardening, and during leisure time, such as exercise or sports. Two main outcome measures are considered MET-hours per week; and Total hours of moderate to vigorous activity reported per week. To calculate weekly physical activity, the number of hours spent on each type of activity is multiplied by that activity's specific MET value (Hagstromer *et al.*, 2006).

Table 2.1 MET values Computation

MET values	Formula for computation
Walking MET minutes/week	3.3 × walking minutes × walking days
Moderate MET minutes/week	4 × moderate-intensity activity minutes × moderate days
Vigorous MET minutes/week	8 × vigorous-intensity activity minutes × vigorous intensity days
Total MET minutes/week	Walking + Moderate + Vigorous MET-minutes/week scores

Source:(IPAQ, 2004)

After calculating each participant's total MET score, physical activity levels are classified following the IPAQ guidelines into three categories:

a) Low activity: Individuals whose total physical activity amounts to less than 600 MET minutes per week are placed in this category.

b) Moderate activity: This level includes people who meet any one of the following:

- Engage in vigorous activities on at least 3 days per week, with each session lasting at least 20 minutes.
- Are active for 30 minutes or more on 5 or more days through walking or moderate-intensity activities.
- Achieve a combined total of at least 600 MET-minutes per week from walking, moderate, or vigorous activities over 5 or more days.

c) High activity: A person is considered highly active if they meet either of these:

- Perform vigorous activity on 3 or more days per week, totaling at least 1500 MET-minutes.
- Combine walking, moderate, and/or vigorous activities over 7 days, adding up to a total of 3000 MET-minutes or more per week.

Moderate-intensity physical activities are those that use about three to six times more energy than the body would use while sitting quietly. In contrast, vigorous-intensity exercises demand even more effort, burning over six times that amount of energy (IPAQ, 2004).

2.9.6 Education

Education strongly influences socio-economic status and career opportunities. Higher education generally leads to better financial stability and living standards. Conversely, low education contributes to undernutrition, early marriage, and health risks for both individuals and future generations (Sanjay, 2014). Since nutritional education plays a key role in shaping a person's understanding of healthy eating, those with limited knowledge about nutrition are more likely to develop unhealthy habits and poor dietary choices. However, individuals with greater nutritional awareness tend to adopt healthier diets, eating more fiber, consuming less meat, and reducing their intake of sugary drinks (Damayanti *et al.*, 2024a).

2.9.7 Marital Status

Marital status, whether married, single, divorced, or widowed can affect body weight. Married individuals often weigh more than those unmarried or divorced. Divorce may lead to temporary weight loss. Both men and women experience similar weight changes with marital transitions, though men gain weight more slowly. Marriage can also reduce physical activity, change eating habits, and shift focus from appearance, while providing social support (Bhandari, 2018).

Research indicates that married people are more prone to obesity than those who are unmarried. For instance, a study in Greece found that married men and women were over twice as likely to be obese, suggesting that marriage may influence eating habits and lifestyle, contributing to higher obesity risk (Tzotzas *et al.*, 2010). This is also in line with cohort research using China Health and Nutrition Survey data on 36,310 individuals in China. This research shows that someone who is married has twice the risk of becoming obese (Damayanti *et al.*, 2024a).

2.9.8 Smoking and alcohol consumption

Smoking can have a serious impact on a person's nutritional health. Smokers often eat less and tend to choose less healthy foods, such as fast food, while consuming fewer fruits, vegetables, dairy products, and whole grains. Nicotine plays a key role in these dietary patterns, as it can lead to weight loss, increase the metabolic rate by up to 10% in a single

day, and suppress appetite. When cigarettes are burned, around 25% of the nicotine enters the bloodstream and reaches the brain within 15 seconds. There, it interacts with acetylcholine-nicotine receptors, stimulating the brain's dopaminergic system in the reward pathway. This process contributes to appetite suppression, ultimately increasing the risk of malnutrition (Rachman, 2018). As a result, smoking indirectly influences a person's nutritional status. The more frequently a person smokes, the poorer their dietary choices become, which can further contribute to malnutrition (Damayanti *et al.*, 2024b).

Excessive alcohol consumption can provide calories but often results in malnutrition and anemia. While small amounts of alcohol may stimulate appetite, larger quantities tend to suppress hunger, depriving the body of essential nutrients. Research has also shown that heavy alcohol intake reduces lipid oxidation, leading to fat accumulation in the body. Additionally, alcohol interferes with the absorption and storage of essential vitamins, particularly B vitamins and vitamin A. As a diuretic, alcohol increases urine output, causing the loss of important water-soluble minerals such as zinc, magnesium, and potassium, Zinc deficiency is a significant concern, as it can impair taste and smell, further reducing food intake. Moreover, excessive alcohol consumption can hinder weight gain by depleting NAD+, which is necessary for converting pyruvate into acetyl-CoA, a key step in energy production (Bhandari, 2018).

2.9.9 Food Habits

Food habits reflect how individuals select, prepare, serve, and consume the food available to them. While personal taste plays a role, these choices are also significantly shaped by broader cultural, social, and economic influences (Paroi et al., 2020). Vegetarians are defined as people who don't eat any meat, poultry or fish. They may be sub-classified as lacto-ovo-vegetarians who eat dairy products and/or eggs and vegans who do not eat any animal products while non-vegetarians consume both plant and animal based foods. Although vegetarians make up a smaller portion of the global population, the number has been steadily rising, especially among young people. This shift is largely driven by the belief that a vegetarian diet can offer various health advantages (Appleby and Key, 2016).

According to a study done in Malaysia, it was found that more vegetarians were underweight than nonvegetarians, while prevalence of overweight and obesity was higher

among the non-vegetarians. A higher proportion of non-vegetarians had an unhealthy range of body fat percentage and significantly higher risk of abdominal obesity than the vegetarians (Gan *et al.*, 2018).

2.9.10 Timing and skipping meals

When we eat during the day it helps coordinate various organs like stomach, liver, intestines, pancreas and fatty tissues that play roles in digesting and metabolizing food. This means that our meal timing can significantly affect how our body stores and breaks down fat, as well as how successful weight-loss efforts are. Timing is an important factor when it comes to fighting obesity. For instance, skipping breakfast is closely linked to a higher risk of obesity, and eating lunch late in the day after 3 p.m. can make it harder to lose weight (Lopez *et al.*, 2019).

2.9.11 Sanitation Facilities and drinking water sources

Access to safe drinking water and proper sanitation is vital for health and nutrition. Many people without reliable water sources are forced to use unsafe options like surface water, unprotected wells, or vendor-supplied water of uncertain quality. Similarly, improved sanitation that safely separates human waste is essential, yet billions still rely on shared latrines or practice open defecation. Globally, over 4.2 billion people lack access to safe sanitation (WHO and UNICEF, 2019).

Promoting proper hygiene is regarded as one of the most cost-effective public health interventions (Black *et al.*, 2016). Illnesses related to water and sanitation can have major economic impacts, with productivity losses reaching up to 5% of GDP in some developing countries. Providing universal access to safe drinking water and proper hygiene could reduce the global disease burden by around 10% (WHO, 2012). The importance of Water, Sanitation and hygiene (WASH) is highlighted in Sustainable Development Goal 6, which calls for universal and equitable access to these services. This reflects how essential WASH is for public health and sustainable development (UN, 2015). Moreover, the United Nations General Assembly formally recognized access to safe drinking water and sanitation as a human right in 2010, reinforcing its essential role in human dignity and well-being (Assembly, 2010).

2.10 Nutritional Requirements of Adult men and women

2.10.1 Nutritional Requirements of Adult men

The nutrient requirements for adult men and women aren't the same across the board, they vary based on factors like age, physical activity level, and health conditions such as illness, (in case of women pregnancy, or breastfeeding) (ICMR, 2024). Table 2.2 and Table 2.3 outlines the RDA for adult men and adult women respectively as set by (ICMR, 2024) which is based on the RDA derived for a reference man and woman.

Table 2.2 Recommended Dietary Allowance (RDA) for adult men

	Sedentary	**Moderate**	**Heavy**
Nutrients			
Carbohydrates (% total calorie)	50-60	50-60	50-60
Protein (g/kg)	0.83	0.83	0.83
Protein (g/day)	54	54	54
Fat (% total calorie)	20-30	20-30	20-30
Fat (g/day)	25	30	40
Iron (mg/day)	19	19	19
Calcium (mg/day)	1000	1000	1000
Magnesium (mg/day)	440	440	440
Zinc (mg/day)	17	17	17
Iodine (µg/day)	140	140	140
Thiamine (mg/day)	1.4	1.8	2.3
Riboflavin (mg/day)	2	2.5	3.2
Niacin (mg/day)	14	18	23
Vitamin B6 (mg/day)	1.9	2.4	3.1
Folate (µg/day)	300	300	300
Vitamin B12 (µg/day)	2.2	2.2	2.2
Vitamin C (mg/day)	80	80	80
Vitamin A (µg/day)	1000	1000	1000
Vitamin D (IU/day)	600	600	600

Source:(ICMR-NIN, 2024)

Caloric requirements were estimated based on participants' physical activity levels, with adjustments for age and body weight, following recommended dietary guidelines. Basal Metabolic Rate (BMR) was calculated using the FAO/WHO/UNU (2004) equations and adjusted by reducing the value by 10% to better reflect the population characteristics. Physical Activity Level (PAL) values were assigned as follows: 1.40 for sedentary, 1.80 for moderate, and 2.50 for heavy activity. Total Energy Expenditure (TEE) or Estimated Average Requirement (EAR) was then computed as BMR × PAL(ICMR-NIN, 2024).

2.10.2 Nutritional Requirements of Adult women

Table 2.3 Recommended Dietary Allowance (RDA) for adult women

	Sedentary	**Moderate**	**Heavy**
Nutrients			
Carbohydrates (% total calorie)	50-60	50-60	50-60
Protein (g/kg)	0.83	0.83	0.83
Protein (g/day)	46	46	46
Fat (% total calorie)	20-30	20-30	20-30
Fat (g/day)	20	25	30
Iron (mg/day)	29	29	29
Calcium (mg/day)	1000	1000	1000
Magnesium (mg/day)	370	370	370
Zinc (mg/day)	13.2	13.2	13.2
Iodine (µg/day)	140	140	140
Thiamine (mg/day)	1.4	1.7	2.2
Riboflavin (mg/day)	1.9	2.4	3.1
Niacin (mg/day)	11	14	18
Vitamin B6 (mg/day)	1.9	1.9	2.4
Folate (µg/day)	220	220	220
Vitamin B12 (µg/day)	2.2	2.2	2.2
Vitamin C (mg/day)	65	65	65
Vitamin A (µg/day)	840	840	840
Vitamin D (IU/day)	600	600	600

Source:(ICMR-NIN, 2024)

(ICMR, 2024) has also provided the minimum and maximum or Tolerable Upper Limits (TUL) for various nutrients. The minimum recommended carbohydrate intake for adult is 100-130 g/day. The maximum total fat recommended for adult is fat intake equivalent to 30% of total calories. The TUL for Iron in adult women is 45 mg/day.

2.11 Assessment of Nutritional Status

Nutrition assessment is a systematic method for obtaining, verifying, and interpreting data needed to identify nutrition-related problems, their causes, and significance (Raymond and Morrow, 2021). Nutrition assessment is typically followed by nutritional diagnosis, implementing an intervention, and monitoring and evaluating the individual's nutritional status (AND, 2022). Nutrition assessment delivers prompt, reliable, high quality and evidence-based data to support target setting, designing, planning, monitoring, and evaluating programs focused on eliminating hunger and lessening the impact of all forms of malnutrition (FAO, 2024).

As per the American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines, a comprehensive nutritional assessment involves a thorough clinical examination (history and physical examination), anthropometric measurements, diagnostic tests, and dietary assessments (Mueller *et al.*, 2011). Analyzing nutritional status enables the identification of nutrition-related issues, supports the planning of corrective measures, and facilitates the assessment of their effectiveness (Shrivastava *et al.*, 2014).

The assessment of the nutritional status involves two methods (Joshi, 2015):

a) Direct method

- Deals with individuals and measures the objective criteria and

summarized as ABCD method as given below:

- Anthropometric methods
- Biochemical methods
- Clinical methods
- Dietary evaluation methods

b) Indirect method

- Uses community health indices reflecting nutritional influences.

- Ecological factors
- Vital health statistics

2.11.1 Anthropometry

Anthropometry helps assess the various components of the human body. Body composition describes the structure of the body in terms of bone, muscle, fat, and water. A single measure will not provide a comprehensive overview of the person's condition and so several measurements are required to form a more reasoned assessment. Measures like BMI, WC, WHR, skin-fold thickness, etc. can be incorporated (BAPEN, 2022).

2.11.2 Biochemical Method

In a nutrition assessment, blood test results are considered along with clinical findings, medical history, and any medications the person is taking. This combined information helps guide a nutritional diagnosis. For example, sodium levels can indicate hydration status and how well the kidneys are working, a high level may point to dehydration (BAPEN, 2022).

2.11.3 Clinical Method

A person's disease state may increase the risk of malnutrition due to increased energy requirements; reduced energy intake; or increased nutritional losses. Inversely, malnutrition itself can cause visible signs and symptoms in the body that can be picked up during a clinical check-up. For example, low iron levels might lead to koilonychia (spoon-shaped nails) (BAPEN, 2022).

2.11.4 Dietary Assessment

An estimation of the total daily calorie intake, as well as the overall quality of diet should be assessed. Asking the individual about their daily dietary intake will help us understand patterns of eating, portion sizes, cooking methods and types of food and drink taken. Various methods can be used for dietary assessment, such as the 24-hour dietary recall, food frequency questionnaires, and weighed food records (BAPEN, 2022).

2.12 Anthropometric Assessment

2.12.1 Height

Height or stature can be measured using different methods. A simple approach involves fixing a measuring tape or stick to a flat, vertical surface like a wall and using a right-angled headboard for accurate reading. However, in field settings, it may not always be easy to find such a surface. In such cases, portable devices like a stadiometer such as the Harpenden or other similar types—can be used. It's important to ensure proper technique and accuracy, recording the measurement to the nearest 0.1 cm (Lee and Nieman, 2012; NHS, 2013; CDC, 2023).

2.12.2 Weight

Body weight is a key measurement in nutritional assessment as it helps in predicting caloric expenditure and assessing body composition (Lee and Nieman, 2012). Properly calibrated scales should be placed on a level surface for weighing. The individual should stand on the scale after removing any heavy clothing. To ensure accuracy, two measurements can be taken, and the weight should be recorded to the nearest 0.1 kg (NHS, 2013).

2.13 Assessment of Individual Food Consumption

Diet plays a crucial role as a modifiable risk factor in the development of various chronic diseases. Evaluating dietary intake can be approached through subjective methods, such as self-reported surveys—including 24-hour dietary recalls, dietary records, dietary histories, and food frequency questionnaires (FFQs)which may be administered independently or with assistance from trained interviewers. Alternatively, objective methods involve direct observation techniques like the duplicate diet method, where participants provide identical portions of their consumed foods for analysis, or food consumption records maintained by trained researchers to assess dietary intake accurately (Shim *et al.*, 2014).

Dietary assessment involves the collection of detailed information on the quantity, and usually frequency of foods and drink consumed over a specified time, and using food composition table (FCT) for the estimation of energy and nutrient intakes. It aims to measure food consumption or to estimate the intake of nutrients or non-nutrients in

individuals or groups (Bates *et al.*, 2017). Dietary assessment methods are broadly categorized into two types: prospective and retrospective. Prospective methods involve recording food and beverage intake at the time of consumption, capturing current dietary habits. Examples include weighed food records, estimated food records, and the duplicate meal method. These approaches can be labor-intensive and require participants to have good literacy and numeracy skills. In contrast, retrospective methods rely on individuals recalling their past food and beverage consumption, depending heavily on memory and the ability to estimate portion sizes over a specific time frame (FAO, 2018).

2.13.1 Diet History Method

The diet history method, introduced by Burke in 1947, is used to assess a person's typical dietary intake over a long period. In this approach, individuals are asked to complete tools like a 24-hour recall, a 3-day food diary, and a list of foods they usually eat. A detailed interview is then conducted by a well-trained professional to gather more information about their regular eating patterns. Since the interview takes about 90 minutes and requires skilled staff, this method is rarely used in large-scale epidemiological research due to the time and resources involved (Shim *et al.*, 2014).

2.13.2 Food Diary Method

A food diary, also known as a diet record, involves the respondent documenting all food and beverages consumed over a specified period. Ideally, entries are made immediately after consumption to reduce recall bias. Participants record details such as the food item, preparation method, and portion size, either estimated using household measures or measured with a kitchen scale. Several consecutive days are usually recorded, covering both weekdays and weekends. In some cases, an interviewer may assist in reviewing the records to ensure accuracy. This method is considered one of the most precise approaches for assessing short-term dietary intake (Thompson and Subar, 2017).

2.13.3 24-hour Recall Method

The 24-hour dietary recall method is one of the most widely used techniques for assessing dietary intake in individuals and populations. In this approach, a trained interviewer asks the respondent to recall all food and beverages consumed over the previous 24 hours,

typically from midnight to midnight. The recall is conducted through a structured interview process, often using a "multiple pass" technique. This involves several stages: a quick initial list of consumed items, a detailed follow-up to gather information on quantities and preparation methods, and a final review to minimize the risk of forgotten items. This structured format helps improve the completeness and accuracy of the data (Lee and Nieman, 2012; Joshi, 2017).

Food quantities are generally reported using household measures such as cups or tablespoons or estimated with the help of food models or photographic aids. In some cases, respondents may also use standard weights and measures. The data collected are later coded assigning specific identifiers to each food item which allows for the estimation of nutrient intake using food composition tables. For accurate coding and probing, interviewers must be familiar with the local food habits and dietary patterns (Bates *et al.*, 2017).

One of the main advantages of the 24-hour recall is that it is relatively quick to administer and does not place a recording burden on the respondent. It is also well-tolerated, requiring only short-term memory, and is generally accepted by participants. However, like any recall-based method, it is subject to memory lapses, underreporting, or overreporting due to social desirability or misunderstanding. Single day recalls also do not account for daily variations in dietary intake, which limits their reliability for estimating long-term nutrient intake. Therefore, researchers must be aware of these limitations when interpreting the data (Thompson and Subar, 2017).

2.13.4 Food Frequency Questionnaire

A Food Frequency Questionnaire (FFQ) is a widely used dietary assessment tool designed to capture an individual's usual food intake over a specified time frame, such as a month, six months, or a year. It consists of a structured list of foods and beverages, with respondents indicating how often they consume each item using frequency categories like daily, weekly, or monthly intake (FAO, 2018). FFQs can be administered either by interviewers or completed by individuals themselves, depending on the study's needs. The food list included should be carefully developed to align with research goals, ensuring it covers key foods or nutrients of interest and captures meaningful differences in

consumption between individuals (Gurinovic *et al.*, 2017).

Depending on whether portion sizes are estimated, FFQs can be qualitative (no portion sizes), semiquantitative (reference portion sizes provided), or quantitative .While FFQs aim to reflect overall dietary patterns rather than precise nutrient quantities, they are valuable for ranking individuals based on intake and examining diet–health relationships in large populations (Bates *et al.*, 2017; Thompson and Subar, 2017). Despite potential limitations, such as recall bias, underreporting, or omission of unlisted foods, properly designed and validated FFQs remain an efficient and practical method for dietary assessment, especially when compared to more labor-intensive methods like food diaries (Bates *et al.*, 2017).

2.14 Indicators of nutritional status

2.14.1 BMI

Body Mass Index (BMI) is a simple calculation that uses a person's weight and height to help determine their weight status. It's calculated by dividing weight in kilograms by height in meters squared. While it doesn't directly measure body fat, it generally reflects body fat levels and is often used because it's quick, affordable, and easy to apply on a large scale. Despite its simplicity, BMI tends to show a similar connection with health risks and metabolic diseases as more precise body fat measurements (WHO, 2021; CDC, 2023). The consultation's findings show that a significant number of Asians are at high risk for type 2 diabetes and heart disease even at BMIs lower than the WHO's standard overweight cutoff of about 25 kg/m² (Barba *et al.*, 2004). As a result, Asians have redefined obesity using cut-offs that are marginally lower than those used by WHO. The interpretation of BMI is shown in Table 2.1.

Table 2.4: Interpretation of BMI

Interpretation	Asian BMI Range (kg/m2)	International BMI Range (kg/m2)
Underweight	<18.5	<18.5
Normal	18.5-22.9	18.5-24.9
Overweight	≥ 23.0 – 24.9	≥ 25.0 – 29.9
Obese	≥ 25.0	≥ 30.0

Source : (WHO, 2000a)

Like any other measure, BMI has certain limitations. It depends solely on height and weight and does not account for differences in body fat (Adiposity) based on age, gender, or physical activity levels. As a result, it may sometimes overestimate or underestimate an individual's actual adiposity (WHO, 2010).

2.14.2 Waist and Hip Circumference and Waist-Hip ratio

Waist circumference is a widely used anthropometric measurement that offers a simple, non-invasive, and practical method to assess central adiposity and the associated health risks (CDC, 2023). It specifically reflects the accumulation of visceral fat, which is more metabolically active and harmful than subcutaneous fat. Studies have shown that inflammation in mesenteric adipose tissue, a type of visceral fat, is more closely linked to the metabolic consequences of obesity, such as insulin resistance and cardiovascular disease (Kranendonk *et al.*, 2015).

Regularly measuring waist and hip circumference helps monitor fat distribution and serves as an early indicator of potential health risks (CDC, 2023). Waist circumference should be measured at the midpoint between the lower edge of the lowest palpable rib and the top of the iliac crest, using a stretch-resistant tape that applies a consistent tension of 100 grams. Hip circumference is measured around the widest part of the buttocks, with the tape held parallel to the floor. For both measurements, the person should stand with feet close together, arms at their sides, body weight evenly distributed, and wearing minimal clothing. The person should be relaxed, and measurements should be taken at the end of a normal breath out. Each measurement should be taken twice; if the two measurements are within 1 cm, the average is recorded. If the difference is more than 1 cm, the measurements should be repeated (WHO, 2011).

The WHO Expert Consultation on Obesity in 1997 recognized the critical role of abdominal fat, often referred to as central or visceral obesity, which can vary widely among individuals with similar total body fat and BMI. The consultation also emphasized the necessity of using additional measures alongside BMI to accurately identify those at increased risk of obesity-related health complications due to abdominal fat accumulation (WHO, 2000b). The waist-to-hip ratio is another method used to assess how body fat is distributed. It is calculated by dividing the waist measurement by the hip measurement,

both taken in the same units. This ratio reflects both subcutaneous and internal abdominal fat and is considered more reliable than skinfold measurements. A non-elastic tape that is held horizontally and unrestricted at the spot that produces the maximum diameter over the buttocks is used to measure the Hip Circumference (WHO, 2011). The cut-off points for waist circumference and waist to hip ratio given by WHO are:

Table 2.5 WHO waist-circumference and Waist-Hip ratio cut-offs

Indicators	Cutt-offs	Metabolic Risk
Waist Circumference	>94 cm (M); >80 cm (W)	Increased
Hip Circumference	>102 cm (M); >88 cm (W)	Substantially increased
Waist to Hip ratio	≥0.90 cm (M); ≥0.85 cm (W)	Substantially increased

Source:(WHO, 2011)

Where, M: Men, and W: women

PART III

Materials and methods

3.1 Study site

The study was conducted in Khanar Area, a prominent industrial town located in Ward No. 10 of Itahari Sub-Metropolitan City, within the Sunsari District of Koshi Province, Nepal. Khanar spans an area of approximately 25 square kilometers and lies in the eastern Terai region, which is one of Nepal's most economically active zones. Strategically situated along the East-West Highway, Khanar is home to a dense cluster of factories, including textile, food processing, plastic, metal, and other manufacturing industries. Industrial areas like Khanar contribute to employment and manufacturing (Nepalog, 2021).

3.2 Study population

The population under study was 19-59 years old factory workers in Khanar Area, Sunsari.

3.3 Criteria for sample selection

a) Inclusion criteria: The factory workers of age group 19-59 years from Khanar Area, Sunsari was selected for survey.
b) Exclusion criteria: The study participants who were seriously ill or whose health conditions were not well during the survey were not selected.

3.4 Research Design

A community-based cross-sectional descriptive study was conducted among male and female factory workers aged 19–59 years in Khanar Area, Ward No. 10 of Itahari Sub-Metropolitan City, Sunsari. The study aimed to assess nutritional status (based on BMI and WHR) and examine associated socio-demographic, economic, and dietary factors. Data was collected through face-to-face interviews using a semi-structured questionnaire. This included demographic details, lifestyle behaviors, 24-hour dietary recall, food frequency questionnaire, IPAQ and anthropometric measurements.

3.5 Sample size

The sample size was determined by using a single proportion formula assuming the prevalence rate of malnutrition to be 50 % in the survey area. Similarly, confidence interval (CI) of 95% was taken, 7 % margin of error (d) and 10% non-response rate was added to the total calculated sample size (Sangroula *et al.*, 2020).

Prevalence of malnutrition (p) = 0.5

Z value at 0.05 level of significance (Z)=1.96

Margin of error (d) = 0.07

Sample size (N) = $Z^2 \times p \times q / d^2$

$N = (1.96)^2 \times 0.5 \times 0.5 / (0.07)^2$

$N = 196$

The adjusted sample size considering 10% non-response rate was calculated as below: - Final sample size = N + 10 % of N

$= 196+10/100\times196$

$=215.6$ (216)

Considering the non-response rate as 10%, the adjusted sample size was calculated to be 216.

3.6 Sampling Technique

All operational industries in Khanar during the study period were first approached through official letters and personal visits to introduce the research and seek participation. Of these, 11 industries responded positively and agreed to collaborate. From these, six industries were selected using simple random sampling (lottery method). The choice of six industries was considered optimal as it ensured workplace diversity while remaining feasible within the available time and resources. Selecting fewer industries would have limited variation, whereas including more would have led to extended data collection and higher logistical costs.

Within each selected industry, participants were recruited using simple random sampling. During workers' tiffin breaks or after their shifts, all available workers were listed or numbered, and a lottery method was applied to select participants. This process minimized selection bias and gave each worker an equal chance of inclusion. To maintain gender balance, approximately 18 male and 18 female workers were recruited from five

industries. In one industry, however, only 17 female workers met the eligibility criteria. To preserve the target sample size of 36 participants per industry, 19 male workers were selected instead of 18. This minor adjustment-maintained consistency in total sample size while reflecting the actual gender distribution in that workplace.

Eligibility criteria included being between 19 and 59 years of age and being in adequate health at the time of data collection. Written informed consent was obtained from all participants prior to their inclusion. This two-stage random sampling strategy, first at the industry level and then at the individual worker level helped ensure that the sample was both representative of the factory worker population in Khanar and practical to collect within the available timeframe and resources.

3.7 Research Instrument

Instruments used for the research work were:

1. Weighing Scale: A digital weighing balance with maximum capacity of 180 kgs and having the least count of 0.1 kg was used for measuring weight.
2. Height Measuring Scale or Stadiometer: A wooden plank stadiometer of maximum capacity for measurement of 197 cm and having the least count of 0.1 cm was used to measure the height of the study population
3. Measuring Tape: A non-stretchable flexible measuring tape with the least count of 1 mm of measurement of was used for the measurement of waist and hip circumference.
4. Measuring Cups: 1 set of measuring cups was used as a reference for estimation of the food intake of the survey population during the dietary assessment.
5. Questionnaire: A meticulously structured and pre-examined set of questionnaires was employed to collect information from individual participants.

3.8 Study Variables

3.8.1 Dependent Variables

The dependent variables under study were:

1. Body Mass Index:

BMI of less than 18.5 kg/m² was classified underweight, 18.5 to 24.9 kg/m² was classified as normal, equal to and greater than 25.0 kg/m² was classified as overweight/obese; based on WHO standards of classification whereas Asian BMI cut-offs classified with BMI of

less than 18.5 kg/m² was classified underweight, BMI 23 to 24.9 kg/m² as overweight and greater than or equal to 25 kg/m² as obese (Pan and Yeh, 2008; WHO, 2021).

2. Waist Circumference

Waist circumference above 80 cm was identified as being abdominally obese for women and For men waist circumference above 94 cm was identified as being abdominally obese (WHO, 2011).

3. Waist Hip Ratio:

Waist to hip ratio of women equal to and greater than 0.85 was considered as abdominally obese and waist hip ratio of men equal to and greater than 0.90 was considered abdominally obese (WHO, 2011).

3.8.2 Independent Variables

1. Socio-economic and demographic variables

Age, ethnicity, religion, marital status, income, education level, family size, family type.

Income was recorded in Nepali rupees as reported by the participants. For analytical purposes, income was categorized into two groups based on a cut-off point of NPR 17,500, which represented the median (Q2) value of the reported income distribution.

2. Physical activity

Based on the scores calculated from each individual's responses to the IPAQ-short questionnaire, physical activity levels were categorized into three groups: low, moderate, and high. These classifications were aligned with the international physical activity and health guidelines provided by the World Health Organization (IPAQ, 2004).

3. Dietary intake

Dietary intake among the participants was assessed using a Food Frequency Questionnaire and a 24-hour dietary recall. The information gathered was then used to calculate their intake of key macronutrients, and micronutrients. To evaluate whether their nutrient intake was adequate, the Recommended Dietary Allowance (RDA) was followed (ICMR-NIN, 2024).

4. Behavioral characteristics

Food habits, medical help, smoking, alcohol intake, skipping breakfast.

5.Environmental Characteristics

Main source of drinking water, Condition of toilet facilities at workplace.

3.9 Pre-Testing

The tools used in this study were pre-tested among Few participants within the specified age group, selected from a similar population but outside the main study area. These pre-test participants were not included in the final sample. The pre-testing aimed to assess the accuracy, clarity, and consistency of the questionnaire items, ensuring that questions were interpreted uniformly and identifying any ambiguous or confusing items. While the questionnaire itself required no changes, feedback from the pre-test helped improve other aspects of the data collection process, such as timing and participant approach, to enhance overall efficiency and participant comfort. All insights gained from the pre-test were reviewed thoroughly, and necessary adjustments were made prior to administering the tools in the main study.

3.10 Validity and Reliability

Validity refers to how accurately the data collection tools measure what they are intended to measure, while reliability relates to the consistency and dependability of the collected data. To ensure validity, standard anthropometric instruments were used. The weighing balance's accuracy was confirmed by comparing its readings with standard reference weights, and it was reset to zero before each measurement. Similarly, the stadiometer's measurements were validated by comparing them against those from a UNICEF-calibrated stadiometer. The measuring tape was calibrated using the stadiometer to maintain accuracy. All instruments were checked and recalibrated daily to guarantee consistent data quality.

The questionnaire and food frequency questionnaire were pre-tested on a small group similar to the study population to confirm clarity and appropriateness of questions. The pre-test results showed no significant differences in key measurements, supporting tool validity. During the main study, the questionnaires were regularly reviewed for completeness, clarity, and consistency, with close supervision maintained during data collection to uphold reliability. These steps ensured that the tools used were both valid and reliable for capturing accurate and consistent information throughout the study.

3.11 Data Collection Techniques

Data for this study were collected through a two-step process. Initially, a preliminary semi-structured interview was conducted using a questionnaire to gather essential information

from each participant. This was followed by anthropometric measurements to assess physical health indicators. Prior to data collection, informed consent was obtained from all participants to ensure voluntary participation. The data collection involved the following methods:

1. Socio-Demographic Information:

Participants were asked about their age, ethnicity, religion, marital status, occupation, education level, parity, family size, family type and monthly income. This information helped to provide a comprehensive background context for analyzing nutritional status and lifestyle factors.

2. Anthropometric Measurements:

Weight: Weight was measured using a portable digital weighing scale placed on a flat, stable surface. Participants were asked to remove their shoes and heavy accessories before stepping onto the scale. They stood upright with their feet apart, looking straight ahead, remaining relaxed yet still during the measurement. To ensure accuracy, weight was recorded in kilograms and measured three times for each participant. The weighing scale was calibrated daily to maintain measurement precision as per standard procedure (Lee and Nieman, 2012; WHO, 2017).

Height: Height was measured using a portable, standardized stadiometer placed on a firm, flat surface. Participants were asked to remove their shoes, and hair accessories, and to tie their hair back if necessary. They stood on the measurement board facing the interviewer with their feet together and heels touching the backboard. Participants were instructed to keep their knees straight and maintain an upright posture with their head, shoulders, knees, and heels aligned against the board. They were also directed to keep their heads level, looking straight ahead with eyes focused forward. Height was recorded in centimeters (WHO, 2017).

Body Mass Index (BMI): BMI was calculated using the formula: weight in kilograms divided by the square of height in meters. For data analysis and discussion, both the Asian-specific BMI cut-off points and the international BMI standards were applied (WHO, 2000b).

Waist and Hip Circumference: Waist circumference was measured at the midpoint between the lower edge of the rib cage and the top of the hip bone using a special tape that applies a consistent 100-gram tension, keeping the tape level and parallel to the floor. Hip circumference was taken at the widest part of the buttocks. The tape was placed comfortably around the body without squeezing too tightly. Measurements were done as participants stood upright with their arms relaxed by their sides, feet close together, weight evenly balanced, and breathing normally. The measurements were recorded to the nearest 0.1 cm (WHO, 2011).

2. Dietary Assessment:

Dietary assessment was carried out using both a Food Frequency Questionnaire (FFQ) and the 24-hour dietary recall method. The FFQ was used to gather information on the types and frequency of foods consumed over the past few days, providing insight into participants' usual dietary patterns. The 24-hour recall involved asking participants to report all foods and beverages consumed the previous day, from the first item in the morning to the last before bedtime. Standardized measuring cups were used to estimate portion sizes, which were then converted into gram equivalents. Nutrient intake including carbohydrates, protein, fat, thiamine, riboflavin, niacin, calcium, and iron, was calculated using a food composition table. The adequacy of both macronutrient and micronutrient intake was assessed according to the Recommended Dietary Allowances (RDA) set by (ICMR, 2024).

3. Physical Activity Assessment:

To assess the physical activity levels of the participants, the short form of the International Physical Activity Questionnaire (IPAQ) was used. This tool captures self-reported data on the type, frequency, duration, and intensity of physical activities performed over the past seven days across various domains such as work, household tasks, transportation, and leisure. Given the physically demanding nature of factory work, the IPAQ short form provided a practical and time-efficient means of evaluating overall activity levels. Activities were converted into Metabolic Equivalent Task (MET) minutes using the IPAQ scoring protocol, and total physical activity was expressed as a combination of walking, moderate, and vigorous intensity activity scores (IPAQ, 2004).

3.12 Data analysis

Before analysis, all collected data were manually reviewed, compiled, categorized, and coded to ensure completeness, consistency, and accuracy. Qualitative responses were labeled and transcribed for appropriate categorization. Microsoft Excel was used initially for manual data entry and organization, while the dataset was carefully checked for missing values and inconsistencies. Following this, the cleaned data were exported to IBM SPSS Statistics (Version 20) for statistical analysis. Descriptive statistics such as mean, standard deviation (SD), median, were used for continuous variables, while frequencies and percentages were calculated for categorical variables to describe the socio-demographic characteristics, physical activity levels, dietary patterns, and behavioral traits of the participants.

Bivariate analysis was conducted to explore associations between explanatory variables and nutritional status. The Chi-square test was applied for categorical variables. A p-value of less than 0.05 was considered statistically significant for all analyses.

3.13 Ethical considerations

The study was initiated only after receiving formal approval from the Central Campus of Technology, Dharan, along with official permission from the Itahari Sub-Metropolitan City and consent from the respective factory offices. Before data collection, participants were clearly informed about the purpose of the study, and both written and verbal consent were obtained from them voluntarily. Throughout the research process, every effort was made to ensure the participants' privacy, maintain confidentiality, and make them feel comfortable and respected during their involvement in the study.

PART IV

Results and Discussion

The cross-sectional study was conducted to assess the nutritional status and its associated risk factors among factory workers aged 19–59 years in Khanar Area, Sunsari. The study evaluated a range of variables including anthropometric indicators such as Body Mass Index (BMI), Waist Circumference (WC), and Waist-to-Hip Ratio (WHR), alongside dietary intake, food frequency, physical activity, and sociodemographic characteristics. The data collected were entered and processed using Microsoft Excel and analyzed in IBM SPSS Statistics version 20. The findings of the study are presented under the following sub-headings:

4.1 Demographic and socio-economic characteristics

The data and information on demographic and socio-economic characteristics are demonstrated below:

4.1.1 Chronological Age distribution of study population

The average age of the respondents was 33.62 ± 10.37 years, with 46.8% in the 19–30 years category and 53.2% in the 31–59 years category, indicating a relatively balanced representation of younger and older adults in the study population. This age profile aligns with the findings of (Pandeya *et al.*, 2021), who reported a mean age of 32.67 ± 10.35 years among cement factory workers in Nepal. Such a distribution is beneficial for analyzing age-related differences in nutritional and lifestyle factors within the working population. The distribution of the study population according to chronological age is shown in Table 4.1.

Table 4.1 Distribution by the chronological age of the respondents (n=216)

Age Group	Frequency	Percent (%)
19-30	101	46.8
31-59	115	53.2

4.1.2 Gender wise distribution of study population

Table 4.2 Distribution by the Gender of the respondents (n=216)

Gender	Frequency	Percent (%)
Male	109	50.5
Female	107	49.5

This study included a total of 216 participants, with the gender distribution nearly balanced between males and females. Males comprised 50.5% of the sample, while females accounted for 49.5%. Table 4.2 presents the detailed distribution, indicating that the sample represents both genders almost equally, which allows for gender-based comparative analyses in subsequent sections.

4.1.3 Religion and Ethnicity distribution of study population

Table 4.3 Distribution by the religion and ethnicity of the respondents (n=216)

Variables	Frequency	Percent (%)
Religion		
Hindu	186	86.1
Muslim and others	30	13.9
Ethnicity		
Brahmin	39	18.1
Chhetri	42	19.4
Janajati	38	17.6
Madhesi	57	26.4
Others	40	18.5

Table 4.3 shows that most participants identified as Hindu (86.1%), while Muslims and others accounted for 13.9%, reflecting the dominant religious composition of the Terai region. However, the proportion of Muslims in this study was higher than the national average of 5.09%, as reported by the Central Bureau of Statistics (CBS, 2021c). Ethnically, Madhesi participants formed the largest group (26.4%), followed by Chhetri (19.4%), Brahmin (18.1%), and Janajati (17.6%).

This distribution is consistent with demographic data from Sunsari District, which is home to a diverse population including Tharu, Yadav, Brahmin, Chhetri, Rajbanshi, and various indigenous and Madhesi communities. The higher proportion of Madhesi respondents in this factory-based sample likely reflects the demographic makeup of Sunsari District, where Madhesi communities are more concentrated and actively engaged in factory-based labor (Nepalog, 2021).

4.1.4 Marital Status

Among 216 respondents, 69.0% were married, while 31.0% were unmarried. This finding is in line with national trends where marriage occurs early in adulthood, particularly among working populations. Similar patterns have been observed in factory-based studies across Nepal. A study at Udayapur Cement Factory found that 96.3% of workers were married (Singh *et al.*, 2019), while research from Rupandehi District reported that 78.9% were married and only 21.1% were unmarried (Paudel *et al.*, 2021). These findings suggest that marriage is common among industrial workers, likely due to cultural norms and age-related factors. The slightly lower proportion of married individuals in the present study may reflect regional differences or greater employment opportunities for younger, unmarried individuals in Sunsari District. The detailed distributions of marital status are presented in Table 4.4 below.

Table 4.4 Distribution by the marital status of the respondents (n =216)

Marital Status	Frequency	Percent (%)
Married	149	69.0
Unmarried	67	31.0

4.1.5 Family Size and Family Type

The study population exhibited notable diversity in both family size and family type. Among the 216 respondents, 55.6% belonged to families with four or fewer members, indicating that slightly more than half of the participants came from smaller family units. Regarding family structure, 50.9% lived in nuclear families, 23.6% in joint families, and the remaining 25.5% lived alone or in other arrangements, such as factory-provided accommodations away from their families. This distribution aligns with national trends

reported in the National Population and Housing Census 2021, which recorded that 60.1% of Nepalese households are nuclear and 39.9% are joint families (NSO, 2021). Additionally, the average household size across Nepal has declined from 5.4 in 2001 to 4.4 in 2021, reflecting a demographic shift toward smaller families. Urban households, which average 4.3 members, tend to be smaller than rural ones (4.5), a trend that is relevant given the urban-industrial context of the current study.

In the Terai region, where Sunsari District is located, 22.6% of households have four members and 17.9% have five members, further supporting the prevalence of medium to smaller family sizes in the area. These patterns suggest that ongoing urbanization, increased labor mobility, and evolving socio-economic dynamics are reshaping traditional household structures (NSO, 2021). Table 4.5 presents the detailed distribution of family size and family type among the respondents.

Table 4.5 Distribution by the Family size and Family type of the respondents (n=216)

Variables	Frequency	Percent (%)
Family size		
Less than or equal to 4	120	55.6
More than 4	96	44.4
Family type		
Nuclear	110	50.9
Joint	51	23.6
Other	55	25.5

4.1.6 Type of medical help

Table 4.6 Distribution by the Type of medical help utilized by the respondents (n=216)

Type of medical help	Frequency	Percent (%)
Government	68	31.5
Private	73	33.8
Public and Private	75	34.7

This study examined the kinds of medical help participants typically sought when they needed healthcare. The findings showed an even split about one-third of respondents

preferred government healthcare facilities (31.5%), another third opted for private providers (33.8%), and the remaining group used a mix of public-private partnership facilities (34.7%), as detailed in Table 4.6. This variety in healthcare utilization reflects Nepal's complex and diverse healthcare system, which includes a wide network of public hospitals, primary health care centers, and health posts, alongside an increasing number of private healthcare establishments (MOHP, 2020). These preferences suggest that factors such as accessibility, cost, and trust play important roles in where individuals choose to seek care within Nepal's healthcare landscape.

4.1.7 Socio-economic status

Table 4.7 Distribution of the respondents by socio-economic factors (n-216)

Variables	Frequency	Percent (%)
Monthly Income		
<17,500	90	41.7
≥17,500	126	58.3
Education level		
Informal	75	34.7
Primary	72	33.3
Secondary and higher	69	31.9

As presented in Table 4.7, 41.7% of respondents earned less than NPR 17,500 per month, and nearly 68% had only informal or primary-level education, with more than one-third having no formal schooling. These findings reveal a clear overlap between limited education and low income, highlighting entrenched socio-economic inequalities within the factory workforce. This disparity is particularly striking when compared to broader literacy indicators. The literacy rate in Sunsari District is 85.3%, significantly higher than the national average of 76.2% (CBS, 2021b).

At the national level, 28.7% of individuals complete primary education and 19.5% attain higher education. In contrast, none of the workers in this study had pursued education beyond the secondary level. Despite residing in a relatively literate district, factory workers appear to remain excluded from educational progress, likely due to early school dropout, financial hardship, or limited access to vocational and continuing education opportunities.

These observations align with earlier studies. Adhikari (2020) reported that informal urban workers in Nepal generally earn wages close to the national minimum and that education significantly influences earning capacity. Likewise, Huynh and Kapsos (2015) found that over 80% of the poor in South Asia had not progressed beyond primary education, reinforcing a regional pattern of education-related economic vulnerability..

4.1.8 Diet Preferences

In this study, 61.1% of factory workers reported being non-vegetarian, while 38.9% followed a vegetarian diet as shown in table 4.8. This indicates a predominance of non-vegetarian food habits among industrial workers in Khanar. Cultural food preferences, occupational demands, and economic factors may contribute to this pattern.

Table 4.8 Distribution of the respondents by Food habit (n=216)

Food habit	Frequency	Percent (%)
Non-vegetarian	132	61.1
Vegetarian	84	38.9

4.2 Behavioral Characteristics

This study among factory workers in Khanar revealed several concerning lifestyle habits. Over half of the participants (51.9%) regularly skipped breakfast. Skipping meals results not only in reduced calorie intake but also leads to lower nutrient consumption and a decline in overall diet quality (Zeballos and Todd, 2020). Although skipping meals might not lead to weight loss, it can contribute to an increased risk of overweight and obesity through various mechanisms (Ma *et al.*, 2020b).

About 54.6% reported frequently smoking, and 49.1% reported consuming alcohol as shown in Table 4.9. These behaviors reflect patterns observed in similar labor-intensive groups in, a study of tea industry workers in Assam, India found that more than half of the workers used both tobacco and alcohol (Medhi *et al.*, 2006), which aligns closely with our findings. Alcohol consumption directly affects weight, metabolism, and overall nutritional health. Similarly, smoking has been shown to independently contribute to poor nutritional status and worsen clinical outcomes in patients (Gariballa and Forster, 2009; Toffolo *et al.*, 2012). Given that over half of the workers in this study reported smoking and nearly half

consumed alcohol, these habits could be important factors influencing their nutritional well-being.

Table 4.9 Distribution of the respondents by behavioral characteristics (n=216)

Variables	Frequency	Percent (%)
Skipping Breakfast		
Yes	112	51.9
No	104	48.1
Smoking		
Yes	118	54.6
No	98	45.4
Alcohol Intake		
Yes	106	49.1
No	110	50.9

4.3 Environmental Conditions

In this study, 38.4% of factory workers reported relying on tubewells as their primary source of drinking water, while 33.8% used piped water. The remaining 27.8% depended on other sources, including well water, boring water, river water, and jar water as shown in table 4.10. This distribution highlights a significant reliance on groundwater sources among the industrial workforce in khanar. According to the 2021 National Population and Housing Census (CBS, 2021a) approximately 40.0% of households in Koshi Province, which includes Khanar, use tubewells or hand pumps for drinking water, while 54.4% have access to piped water. The tubewell usage reported in this study closely aligns with the provincial average, underscoring the critical role groundwater plays in the region's water supply.

However, the notably lower access to municipal water among factory workers compared to the general population (33.8% vs. 54.4%) suggests possible geographical, infrastructural, or workplace-related barriers affecting water accessibility in industrial settings. Regarding sanitation facilities, only one-third of respondents (33.3%) reported access to properly maintained toilets with a reliable water supply at their workplace. A slightly larger proportion (66.7%) indicated that toilets were available but not clean or hygienically maintained.

Table 4.10 Distribution of the respondents by environmental characteristics (n=216)

Variables	Frequency	Percent (%)
Source of drinking water		
Municipal water	73	33.8
Tubewell	83	38.4
Other	60	27.8
Condition of Toilet Facilities at workplace		
Properly maintained with water supply	72	33.3
Toilets are available but not clean	144	66.7

4.4 Physical Activity

The physical activity levels of the participants were assessed using the short version of the IPAQ. Based on IPAQ scoring guidelines, respondents were categorized into three groups: sedentary, moderate, or heavy physical activity. This study revealed that 34.3%, 35.6% and 30.1% of factory workers were sedentary, moderate, and heavy physical activity respectively as shown in table 4.11. According to the WHO, physical inactivity is a major risk factor for non-communicable diseases and is often overlooked in occupational settings where "work" is presumed to be physically active (WHO, 2020a).

Table 4.11 Distribution of the respondents by physical activity pattern (n=216)

Variables	Frequency	Percent (%)
Working Hours		
8 hours	101	46.8
>8 hours	115	53.2
Physical Activity		
Sedentary	74	34.3
Moderate	77	35.6
Heavy	65	30.1

4.5 Dietary Intake

4.5.1 Food Consumption Pattern

The food habits of the respondents were assessed using a Food Frequency Questionnaire (FFQ). Based on the frequency of intake, consumption was categorized as “frequent” (at least once daily), “regular” (2–4 times per week), and “rare” (less than once per week), in accordance with previously published literature (Sato *et al.*, 2010). In addition, “never” were included as separate categories, as such patterns were observed during the pre-testing phase for certain food items. In the current study, most respondents reported frequent consumption of pulses and legumes, with a slightly higher proportion among males than females. These findings underscore the cultural and economic reliance on ‘daal’ as an accessible and affordable protein source in Nepal. However, many participants reported consuming pulses only once per day, which may limit their overall protein intake.

The consumption of green leafy vegetables (GLVs) was comparatively modest. Only 9.7% consumed them frequently, while 43.1% consumed them regularly. Despite being rich sources of iron, calcium, and fiber, low intake may be attributed to perishability, long preparation time, taste preferences, and limited availability, especially among younger and male respondents. In contrast, other vegetables featured more prominently in daily meals, with 62% consuming them frequently and 25% regularly. This may reflect greater availability and affordability of commonly used vegetables such as bottle gourd, pumpkin, and tomatoes. Roots and tubers emerged as staple components in the diet, with the highest frequent intake (77.3%), owing to their affordability, long shelf life, and high satiety, particularly beneficial for physically active factory workers.

Fruit consumption, however, was limited. Only 7.4% consumed fruits frequently. High cost, seasonal availability, and prioritization of staple foods over nutrient-rich options were likely contributing factors. Milk and milk products were frequently consumed by 61.6% of respondents, with males (69.7%) consuming more than females (53.3%). This trend may be driven by regular tea habits. However, disparities in household income likely influence consistent access to these products.

Egg consumption was also relatively low, with only 7.9% reporting frequent intake, and 38.9% never consuming them. Religious beliefs, cost, and limited availability around

factory zones may help explain this pattern. Animal-source foods such as red meat, poultry, and fish were less commonly consumed. Approximately 39.8% never consumed red meat, 39.4% never consumed poultry, and 39.4% also never consumed fish. These trends may reflect cultural dietary practices, financial constraints, or poor availability in industrial locations. Similarly, consumption of nuts and seeds was limited, over half (50.5%) of respondents reported never consuming them. These items are often considered non-essential and unaffordable, especially for lower-income groups.

Conversely, sugar and confectionery items were the most frequently consumed, with 78.2% reporting daily intake. This may be linked to their role in milk tea and as quick energy boosters during long shifts. Caffeinated beverages such as coffee were largely avoided by most participants (77.3%), likely in favor of milk tea due to cost and cultural preference. Carbonated beverage consumption showed moderate popularity, particularly among younger males.

Finally, packaged foods such as instant noodles and processed snacks were frequently consumed by 42.1% of respondents, and 37% consumed them regularly. Their popularity may be attributed to affordability, easy access, and time constraints, despite their low nutritional value. In summary, the dietary pattern among factory workers is characterized by high intake of carbohydrate-rich staples and processed foods, but limited consumption of nutrient-dense foods like fruits, animal-source foods, and nuts. This suggests a pattern that is energy-dense yet poor in micronutrients and dietary diversity. A detailed breakdown of the food consumption pattern is presented in Table 4.12.

Table 4.12 Distribution of the respondents by food consumption patterns (n=216)

Variables	Frequency			Percent (%)
	Male	Female	Total	
Pulses and Legumes				
Frequently	65(59.6%)	51(47.7%)	116	53.7
Regularly	38(34.9%)	46(43.0%)	84	38.9
Rarely	6(5.5%)	10 (9.3%)	16	7.4
GLV's				
Frequently	10(9.2%)	11(10.3%)	21	9.7
Regularly	49(45.0%)	44(41.1%)	93	43.1
Rarely	41(37.6%)	40(37.4%)	81	37.5
Never	9(8.3%)	12(11.2%)	21	9.7
Other vegetables				
Frequently	63(57.8%)	71(66.4%)	134	62.0
Regularly	31(28.4%)	23(21.5%)	54	25.0
Rarely	15(13.8%)	13(12.1%)	28	13.0
Roots and Tubers				
Frequently	88(80.7%)	79(73.8%)	167	77.3
Regularly	13(11.9%)	14(13.1%)	27	12.5
Rarely	8 (7.3%)	14(13.1%)	22	10.2
Fruits				
Frequently	8 (7.3%)	8 (7.5%)	16	7.4
Regularly	28(25.7%)	32(29.9%)	60	27.8
Rarely	60(55%)	57(53.3%)	117	54.2
Never	13(11.9%)	10 (9.3%)	23	10.6
Milk and milk products				
Frequently	76(69.7%)	57(53.3%)	133	61.6
Regularly	15(13.8%)	29(27.1%)	44	20.4
Rarely	18(16.5%)	21(19.6%)	39	18.1

Egg				
Frequently	9(8.3%)	8(7.5%)	17	7.9
Regularly	41(37.6%)	43(40.2%)	84	38.9
Rarely	12(11.0%)	19(17.8%)	31	14.4
Never	47(43.1%)	37(34.6%)	84	38.9
Red meat				
Rarely	67(61.5%)	63(58.9%)	130	60.2
Never	47(43.1%)	39(36.4%)	86	39.8
Poultry				
Frequently	7(6.4%)	12(11.2%)	19	8.8
Regularly	30(27.5%)	24(22.4%)	54	25.0
Rarely	33(30.3%)	25(23.4%)	58	26.9
Never	39(35.8%)	46(43.0%)	85	39.4
Fish				
Regularly	30(27.5%)	32(29.9%)	62	28.7
Rarely	36(33.0%)	33(30.8%)	69	31.9
Never	43(39.4%)	42(39.3%)	85	39.4
Nuts and seeds				
Regularly	11(10.1%)	14(13.1%)	25	11.6
Rarely	34(31.2%)	48(44.9%)	82	38
Never	64(58.7%)	45(42.1%)	109	50.5
Sugar and Confectionary				
Frequently	89(81.7%)	80(74.8%)	169	78.2
Regularly	20(18.3%)	27(25.2%)	47	21.8
Caffeinated beverages				
Rarely	26(23.9%)	23(21.5%)	49	22.7
Never	83(76.1%)	84(78.5%)	167	77.3
Carbonated beverages				
Regularly	15(13.8%)	18(16.8%)	33	15.3
Rarely	70(64.2%)	61(57%)	131	60.6
Never	24(22.0%)	28(26.2%)	52	24.1

Packaged food				
Frequently	45(41.3%)	46(43.0%)	91	42.1
Regularly	43(39.4%)	37(34.6%)	80	37.0
Rarely	21(19.3%)	24(22.4%)	45	20.8

4.5.2 Dietary Intake in the Preceding day

The dietary intake of the study participants was assessed using the 24-hour dietary recall method, wherein respondents were asked to recall all foods and beverages they had consumed in the previous 24 hours. The collected data were analyzed to estimate total energy intake, macronutrients (carbohydrates, protein, and fat), and selected micronutrients, including calcium, iron, thiamine, riboflavin, and niacin. To evaluate the nutritional adequacy of the participants' diets, observed nutrient intakes were compared against the Recommended Dietary Allowances (RDA) set by the Indian Council of Medical Research–National Institute of Nutrition (ICMR, 2024). Nutrient adequacy was calculated as a percentage of the observed intake relative to the respective RDA. Based on this, nutrient intakes were classified as follows:

i. Low adequacy: < 90% of the RDA
ii. Adequate: 90% – 110% of the RDA
iii. High adequacy: >110% of the RDA

This classification framework offers a systematic approach to assess whether participants' dietary intakes met, fell below, or exceeded recommended nutritional standards (Bhattacherjee *et al.*, 2016). The adequacy of energy and all the nutrients were calculated based on the physical activities of the participants as given in the RDA assessed using the International Physical Activity Questionnaire (IPAQ) and aligned with ICMR-NIN (2024) energy requirements. Carbohydrate adequacy was evaluated based on the proportion of total energy derived from carbohydrates, with 50–60% considered adequate. Protein adequacy was determined according to the recommendation of 0.83 g per kilogram of body weight. Fat intake was considered adequate if it contributed 20–30% of the total caloric intake. Micronutrients, adequacy were assessed using the RDA as per ICMR guidelines (2024). The mean nutrient intake of the study population is presented in Table 4.13, while a detailed classification of nutrient adequacy levels is shown in Table 4.14.

Table 4.13 Distribution of average nutrient intake among the respondent(n=216)

Nutrient	Mean ± SD
Energy (kcal/day)	2307.10 ± 434.41
Protein (g/day)	54.82 ± 12.97
Carbohydrates (g/day)	383.03 ± 90.64
Fat (g/day)	53.83 ± 16.16
Calcium (mg/day)	600.82 ± 237.37
Iron (mg/day)	19.80 ± 5.10
Thiamine (mg/day)	1.60 ± 0.29
Riboflavin (mg/day)	2.32 ± 0.42
Niacin (mg/day)	14.80 ± 4.60

Table 4.14 Distribution by adequacy of nutrient intake of the respondents(n=216)

Variables	Frequency			Percent (%)
	Male	Female	Total	
Calorie				
High	31(28.4%)	33 (30.8%)	64	29.6
Adequate	38(34.9%)	45 (42.1%)	83	38.4
Low	40(36.7%)	29 (27.1%)	69	31.9
Protein				
Low	50(45.9%)	43(40.2%)	93	43.1
Adequate	34(31.2%)	38(35.5%)	72	33.3
High	25(22.9%)	26(24.3%)	51	23.6
Carbohydrate				
Low	28(25.7%)	25(23.4%)	53	24.5
Adequate	31(28.4%)	26(24.3%)	57	26.4
High	50(45.9%)	56(52.3%)	106	49.1
Fat				
Low	29(26.6%)	36(33.6%)	65	30.1
Adequate	38(34.9%)	38(35.5%)	76	35.2
High	42(38.5%)	33(30.8%)	75	34.7

Calcium				
Low	84(77.1%)	93(86.9%)	177	81.9
Adequate	25(22.9%)	14(13.1%)	39	18.1
Iron				
Low	72(66.1%)	87(81.3%)	159	73.6
Adequate	30(27.5%)	14(13.1%)	44	20.4
High	7(6.4%)	6(5.6%)	13	6.0
Thiamine				
Low	83(76.1%)	87(81.3%)	170	78.7
Adequate	26(23.9%)	20(18.7%)	46	21.3
Riboflavin				
Low	81(74.3%)	77(72.0%)	158	73.1
Adequate	28(25.7%)	30(28.0%)	58	26.9
Niacin				
Low	61(56.0%)	70(65.4%)	131	60.6
Adequate	48(44.0%)	37(34.6%)	85	39.4

The dietary intake analysis of the study population revealed a pronounced disparity in nutrient adequacy across both macronutrients and micronutrients. While 38.4% of participants met the recommended calorie intake, a substantial proportion exhibited either excess (31.9%) or insufficient (29.6%) energy consumption. Protein intake adequacy was observed in only one-third of respondents, with a notable 43.1% failing to meet the minimum requirement, indicating potential risks for compromised protein status. Carbohydrate intake was predominantly excessive, with nearly half (49.1%) surpassing the recommended threshold, suggesting dietary imbalances. Fat consumption showed a relatively even distribution among low, adequate, and high intake categories.

In a research conducted in Bangladesh by Khan and Ahmed (2005), reported notable deficiencies in energy and nutrient intake among adolescent RMG workers, highlighting inadequate consumption of protein-rich and micronutrient-dense foods like eggs, milk, and leafy vegetables. Micronutrient inadequacy emerged as a major concern in this study, with 81.9% of factory workers found to have inadequate dietary calcium intake. Dietary calcium is essential for maintaining bone metabolism, muscle function, and physical endurance

factors directly linked to workers productivity and overall well-being. In physically demanding occupations like factory work, chronic calcium deficiency can increase the risk of fractures, joint issues, and accelerated bone loss, ultimately compromising a worker's ability to perform daily tasks efficiently (Cashman, 2002). Iron deficiency affected nearly three-quarters (73.6%) of the population. Iron deficiency is strongly linked to reduced physical performance, fatigue, absenteeism, and diminished productivity, especially among labor-intensive occupations.

A synthesis of 12 studies revealed consistent evidence that low hemoglobin levels negatively impact work efficiency, with several studies showing significant improvements in productivity following iron supplementation. The physiological basis lies in anemia's impact on oxygen delivery, impairing both muscular and cognitive performance (Marcus *et al.*, 2021). Deficiencies in thiamine (78.7%), riboflavin (73.1%), and niacin (60.6%) further suggest a lack of essential B-vitamins critical for energy metabolism and neurological function (Kennedy, 2016). This inadequate dietary intake, combined with workplace-related risks, leads to poor physical health, increased absenteeism, and lower productivity among workers (Grimani *et al.*, 2019).

4.6 Nutritional Status of the study population

4.6.1 Nutritional status based on WHO BMI classification

This study assessed the nutritional status of 216 factory workers in Khanar, using the WHO BMI classification. The mean BMI was 25.86 ± 4.71 kg/m², with males and females showing similar averages (25.68 ± 4.56 and 26.05 ± 4.87 kg/m², respectively). As illustrated in Table 4.1, 60.2% of participants were overweight or obese (38.0% overweight, 22.2% obese), while 8.3% were classified as thin. Females exhibited higher rates of overweight (41.1%) and obesity (26.2%) compared to males (34.9% and 18.3%, respectively).

The prevalence of overweight and obesity in this study was notably higher than that observed among male workers in iron and steel industries in Bara District, Nepal, where 27.3% were overweight or obese (Sangroula *et al.*, 2020). This difference may be due to gender composition, variations in work intensity, and lifestyle and dietary factors. Among male participants, 41.3% had normal BMI, while 34.9% were overweight and 18.3% obese.

This overweight/obesity prevalence (53.2%) is notably higher than the 27.3%. Yeasmin *et al.* (2022) reported 50.5% pre-obese/obese among female garment workers in Bangladesh, but also a higher proportion of normal BMI and lower underweight prevalence compared to our findings, highlighting regional and occupational differences. Afrin *et al.* (2025) observed lower obesity prevalence, both studies consistently demonstrate a significant burden of overweight and obesity among factory workers. The observed differences may be attributed to variations in socioeconomic status, geographical context, dietary patterns, and the nature of occupational physical activity, which likely influence BMI outcomes in each population.

Bortolozo *et al.* (2016) found substantial proportions of overweight and obese workers, similar to the current findings, although slight differences may arise from variations in physical activity levels, dietary habits, and work conditions between the two populations. Al-Asi (2003) reported a higher combined prevalence of 75% overweight and obesity among Kuwait Oil Company (KOC) employees. The higher rates in the KOC study may be partly attributed to the inclusion of both field and office workers, whereas the current study focused exclusively on manual labor-based factory workers. Office workers typically engage in more sedentary routines, potentially contributing to higher weight gain. Additionally, differences in geographic setting, lifestyle, socioeconomic factors, and dietary patterns between the two populations may further explain the variation in findings.

These findings underscore the presence of a double burden of malnutrition within the study population, characterized by the coexistence of both undernutrition and overnutrition. A visual representation of the gender-specific nutritional status distribution, based on the WHO BMI classification, is presented in Figure 4.1.

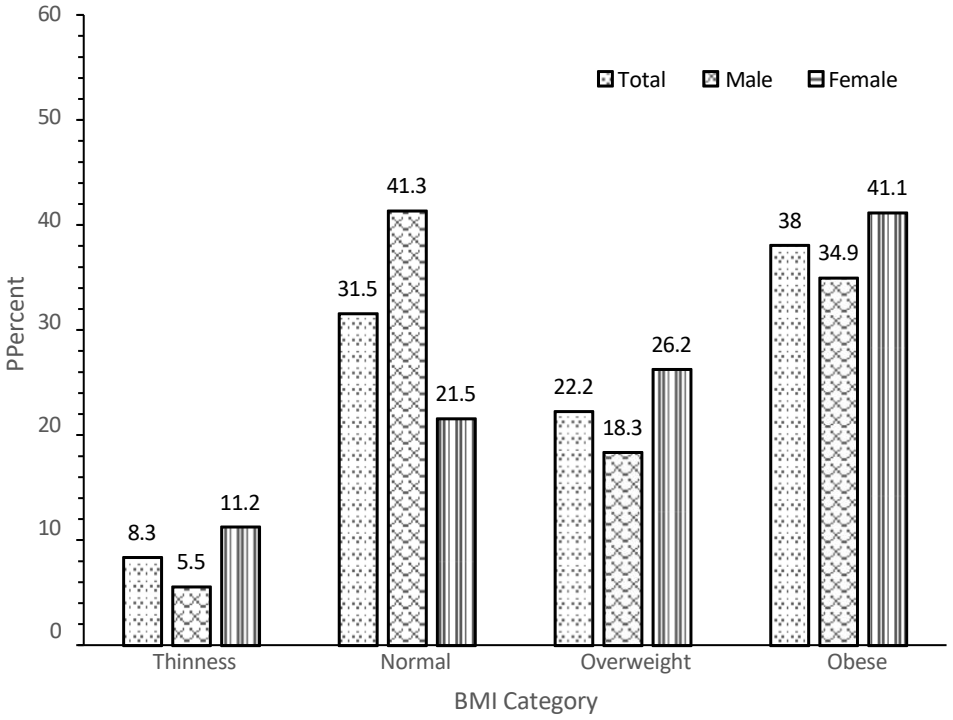

Fig. 4.1 Nutritional status based on WHO BMI cut-off among the study population (n=216)

4.6.2 Nutritional Status based on Asian BMI classification

According to the Asian-specific BMI classification, a substantial proportion of the study population exhibited excess body weight, with 35.6% overweight and 37.0% obese, while only 19.0% fell within the normal range and 8.3% were categorized under thinness category. This indicates that nearly three-fourths of participants were overweight or obese. As illustrated in Figure 4.2, gender-based differences were evident females showed a higher prevalence of both overweight (40.2%) and obesity (36.4%) compared to males (31.2% and 37.6%, respectively), while thinness was also more pronounced among females (11.2%) than males (5.5%). This pattern underscores the presence of a double burden of malnutrition, disproportionately affecting women. Chee *et al.* (2004b) reported that 37.4% of participants were overweight (mean BMI 24.2 ± 5.4 kg/m²), which closely aligns with the present study's overweight prevalence of 35.6% using the Asian BMI classification.

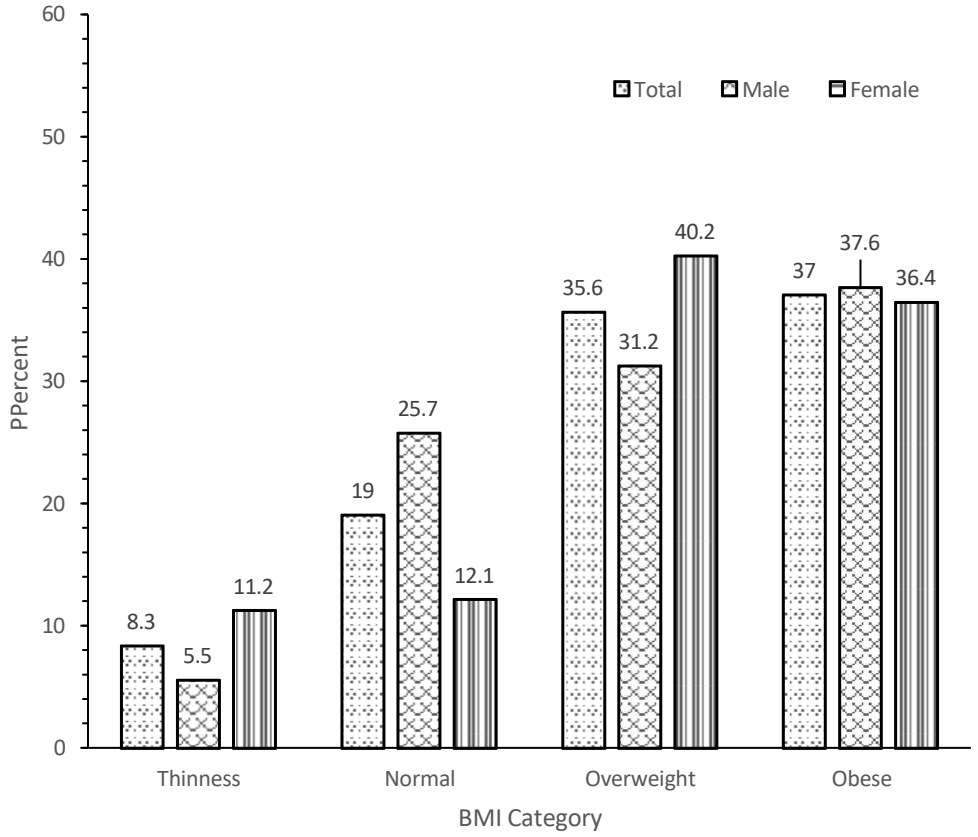

Fig. 4.2 Nutritional status based on Asian BMI cut-off among the study population (n=216)

4.6.3 Nutritional Status based on Waist Circumference

Waist circumference analysis revealed that 47.2% of participants had abdominal obesity, while 52.8% were within normal limits. A clear gender disparity was observed. As shown in Figure 4.3, 72.9% of females had abdominal obesity, compared to 22.0% of males. Conversely, 78.0% of males and 27.1% of females fell within the normal waist circumference range. The overall mean waist circumference was 86.66 ± 9.84 cm, with males and females having similar values (86.99 ± 10.16 cm and 86.31 ± 9.53 cm, respectively). Despite similar means, more females were classified as obese due to lower cut-off values, highlighting the importance of gender-specific thresholds.

A study among Malaysian industrial workers reported abdominal obesity in 60.9% of women and 54.3% of men, (Shafiee *et al.*, 2022). While both studies highlight a greater burden of central obesity among females, the gender disparity observed in our study is more pronounced. This could reflect differences in work roles, physical activity patterns, or

sociocultural influences between the two populations. Sharmin *et al.* (2020) reported a high prevalence of abdominal obesity (75.8%) among healthy female garment workers in Bangladesh using the Asian waist circumference cut-off of ≥80 cm. This finding closely aligns with the elevated rates of central adiposity commonly observed in industrial female workers in khanar.

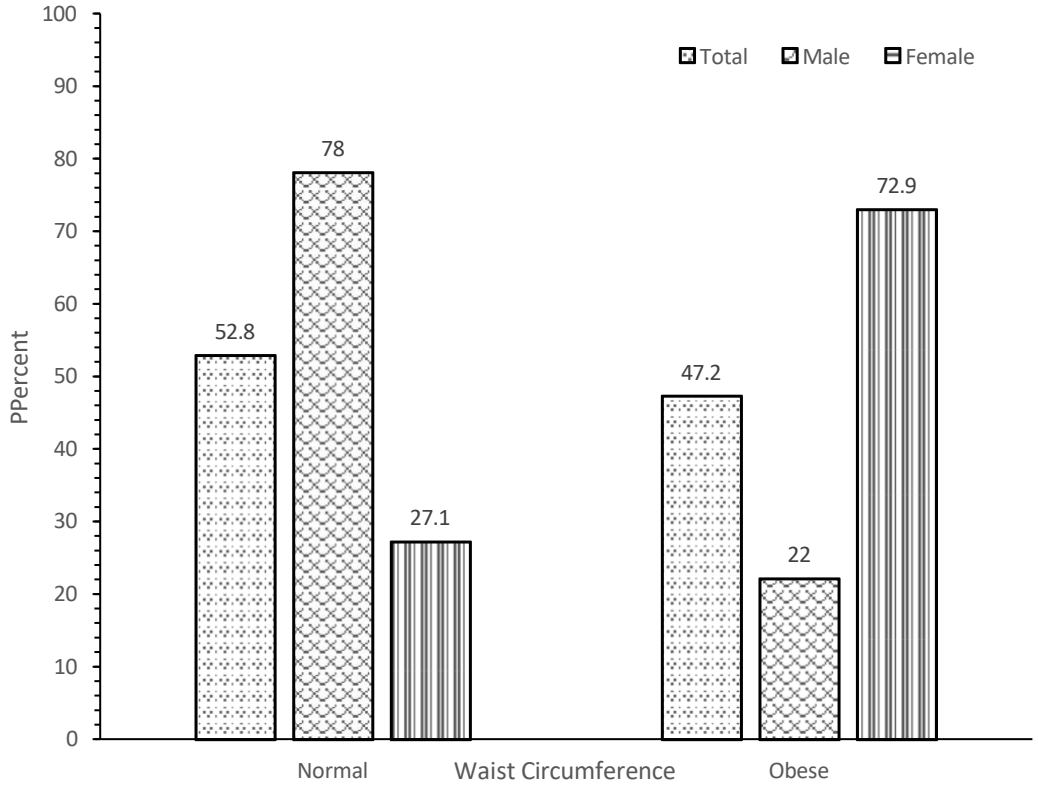

Fig. 4.3 Nutritional status based on Waist Circumference (n=216)

4.6.4 Nutritional Status based on Waist to Hip ratio

Assessment of abdominal adiposity using waist-to-hip ratio (WHR) revealed that 69.9% of participants exhibited central obesity, with a clear gender disparity, 81.3% of females were classified as abdominally obese compared to 58.7% of males as shown in fig 4.4. Despite this difference in prevalence, mean WHR values were relatively similar between males (0.919 ± 0.071) and females (0.914 ± 0.074), suggesting comparable patterns of fat distribution across genders. The overall mean WHR of the study population was 0.92 ± 0.073. This disproportionate prevalence may reflect gender-specific factors such as differences in physical activity, occupational roles, and hormonal influences.

The Malaysian study reported 65.0% of females and 16.1% of males exceeding WHR cut-offs, whereas the present study found a higher overall prevalence as elevated prevalence observed in this study may be partly attributed to the socioeconomic status, work intensity, food habits (Shafiee *et al.*, 2022). A study in Chennai by Sanskriti *et al.* (2024) reported 54% abdominal obesity among industrial migrant workers. This difference may stem from variations in occupational roles, lifestyle behaviors, and regional dietary patterns.

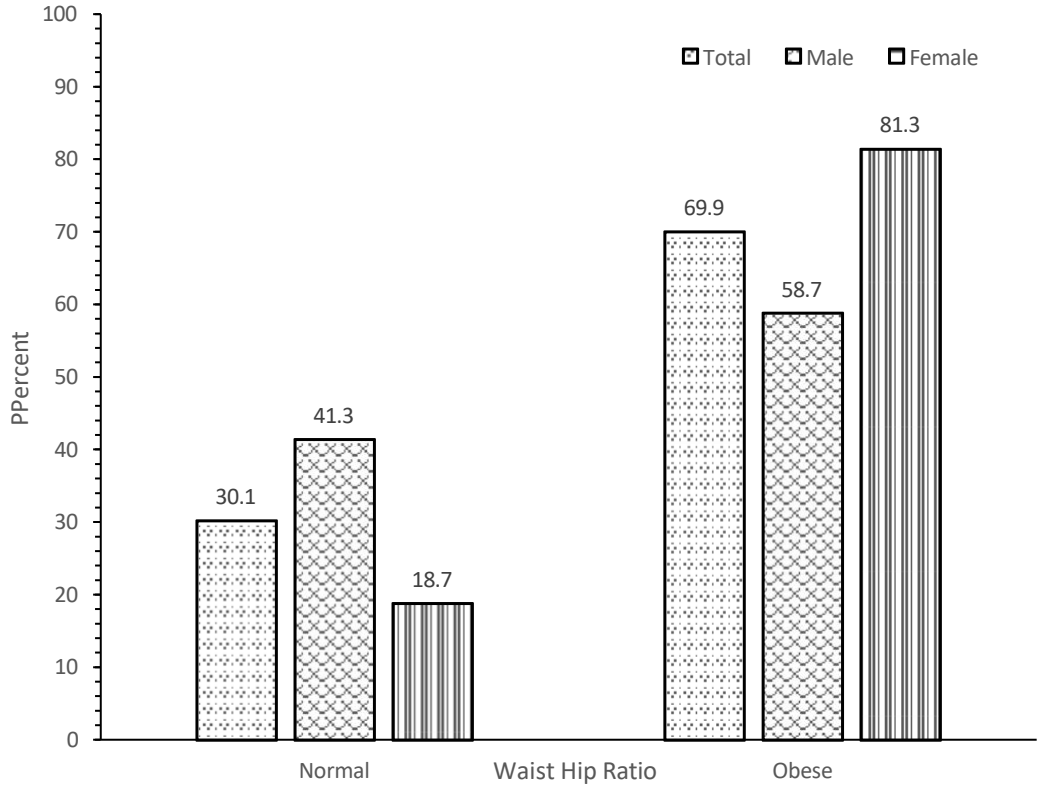

Fig. 4.4 Nutritional status based on Waist to hip ratio (n=216)

4.7 Factors associated with nutritional status among the respondents

4.7.1 Factors associated with BMI status (WHO cut-off) among the respondents

4.7.1.1 Sociodemographic and socioeconomic factors associated with BMI status

Table 4.15 presents the associations between BMI status and selected sociodemographic and socioeconomic factors among the study participants, classified according to WHO guidelines. In this study, BMI status was significantly associated with age, gender, marital status, educational attainment, and income level. Older participants, females, married individuals, and those with lower educational levels were more likely to be overweight or obese. The study revealed a clear age-related pattern in nutritional status, older workers were more often overweight or obese, while younger workers had higher rates of underweight and normal BMI. Similar associations between age and BMI were also reported among factory workers in Bara (Sangroula *et al.*, 2020). Another study conducted by (Ishizaki *et al.*, 2004) found significant association of BMI with age, educational status and marital status.

This study found gender to be significantly linked with nutritional status, as women showed both higher rates of overweight/obesity and underweight compared to men, reflecting a double burden of malnutrition. Similar trends have been reported in Bangladesh and Indonesia, where women showed higher rates of obesity than men, emphasizing the influence of gender on nutritional outcomes (Islam *et al.*, 2018; Damayanti *et al.*, 2024a). Similar patterns have been reported globally, where women in low- and middle-income countries face overlapping risks of undernutrition and excess weight. (Alem *et al.*, 2023) found that across 52 countries, significant proportions of women were either underweight or overweight/obese, reflecting this dual challenge. Such outcomes are often linked to gender inequality, limited access to nutritious food, and changing lifestyles due to industrialization. These findings highlight the urgent need for workplace-based nutrition strategies tailored to women.

In the present study, marital status was significantly associated with BMI, with married individuals more likely to have higher body weight while unmarried workers are more likely to be underweight or maintain a normal BMI. This finding is consistent with previous studies, which have also highlighted marriage as a risk factor for obesity. For example, research in Greece reported that married men and women were more than twice

as likely to be obese compared to unmarried individuals (Tzotzas *et al.*, 2010). Similarly, evidence from the China Health and Nutrition Survey indicated that married individuals had nearly double the risk of developing obesity (Damayanti *et al.*, 2024a). Such findings suggest that lifestyle and behavioral changes associated with marriage, including altered dietary habits and reduced physical activity, may contribute to weight gain among married populations.

Education was also found to be associated with BMI similar to other studies conducted by (Alcacera *et al.*, 2008; G *et al.*, 2014). The study shows that people with no formal education are more likely to be overweight or obese whereas higher education is linked with a relatively better distribution across normal weight and overweight categories. The study findings align with previous research, which suggests that higher education can help protect against obesity by shaping healthier habits and lifestyles. Limited education may reduce access to knowledge about nutrition and health, increasing the risk of weight gain (Johnson *et al.*, 2011).

In this study, income was found to be significantly associated with nutritional status. Workers with higher incomes showed a greater prevalence of overweight and obesity, while lower-income workers had higher rates of thinness. This suggests that economic resources can influence food access, dietary quality, and overall energy intake, ultimately affecting body weight. These findings are consistent with the study by (Chee *et al.*, 2004a) among women workers in electronics factories in Peninsular Malaysia, which reported that age, marital status, Income and lower education were significant predictors of overweight.

Table 4.15 Socio-demographic and socioeconomic factors associated with BMI status among the respondents (n=216)

Factors	Category	Frequency (%)			Chi-square	p-value
		Thinness	Normal	Overweight and obese		
Age	19–30 years	15(14.9)	35 (34.7)	51 (50.5)	13.238	0.001*a
	31–59 years	3 (2.6)	33 (28.7)	79 (68.7)		
Gender	Male	6 (5.5)	45 (41.3)	58 (53.2)	10.608	0.005*a
	Female	12 (11.2)	23 (21.5)	72 (67.3)		
Religion	Hindu	15 (8.1)	56 (30.1)	115(61.8)	-	0.394 e
	Muslim and others	3 (10.0)	12 (40.0)	15 (50.0)		
Type of Family	Nuclear	6 (5.5)	35 (31.8)	69 (62.7)	-	0.373 e
	Joint	4 (7.8)	18 (35.3)	29 (56.9)		
	Other	8 (14.5)	15 (27.3)	32 (58.2)		
Ethnic Group	Brahmin	5 (12.8)	13 (33.3)	21 (53.8)	-	0.574 e
	Chhetri	2 (4.8)	16 (38.1)	24 (57.1)		
	Janajati	3 (7.9)	8 (21.1)	27 (71.1)		
	Madhesi	5 (8.8)	15 (26.3)	37 (64.9)		
	Others	3 (7.5)	16 (40.0)	21 (52.5)		
Family Size	≤4	7 (5.8)	33 (27.5)	80 (66.7)	5.269	0.072 a
	>4	11 (11.5)	35 (36.5)	50 (52.1)		
Marital Status	Married	8 (5.4)	41 (27.5)	100(67.1)	11.295	0.004*a
	Unmarried	10 (14.9)	27 (40.3)	30 (44.8)		
Educational Level	No formal Education	6 (8.0)	13 (17.3)	56 (74.7)	12.117	0.017*a
	Primary Education	5 (6.9)	30 (41.7)	37 (51.4)		
	Secondary and higher	7 (10.1)	25 (36.2)	37 (53.6)		

Income	<17,500	13 (14.4)	27 (30.0)	50 (55.6)	7.571	0.023*a
	≥17,500	5 (4.0)	41 (32.5)	80 (63.5)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

4.7.1.2 Lifestyle and behavioral factors associated with BMI status

The findings of this study indicate a significant relationship between physical activity and nutritional status among factory workers. Notably, workers engaged in heavy physical activity exhibited the highest prevalence of overweight and obesity, whereas underweight was more common among those with sedentary or moderate activity levels. This pattern suggests that physical activity alone does not necessarily ensure optimal nutritional status; factors such as dietary habits, lifestyle practices, and the specific demands of occupational tasks likely contribute to the observed variations in body weight. Comparatively, a cross-sectional study conducted among manufacturing workers in Indonesia by (Lutfiya *et al.*, 2025) reported that physical workload, in combination with personal factors, significantly influenced nutritional outcomes, with variations in overweight and obesity prevalence across low, moderate, heavy, and very heavy workload categories. These findings underscore the context-dependent and multifactorial nature of the relationship between physical activity and nutritional status.

Overall, the results highlight the importance of integrated workplace interventions that not only promote appropriate physical activity but also support healthy dietary practices and lifestyle behaviors, thereby fostering improved nutritional well-being among industrial workers. Table 4.16 presents the associations between BMI status and selected lifestyle and behavioral factors among the study participants, classified according to WHO guidelines.

Table 4.16 Lifestyle and behavioral factors associated with BMI status among the respondents (n=216)

Factors	Category	Frequency (%)			Chi-square	p-value
		Thinness	Normal	Overweight and obese		
Smoking	No	4 (4.1)	30 (30.6)	64 (65.3)	4.716	0.095 a
	Yes	14 (11.9)	38 (32.2)	66 (55.9)		
Alcohol consumption	No	10 (9.1)	38 (34.5)	62 (56.4)	1.367	0.505 a
	Yes	8 (7.5%)	30 (28.3)	68 (64.2)		
Working hours	8 hours	11 (10.9)	34 (33.7)	56 (55.4)	2.484	0.289 a
	>10 hours	7 (6.1)	34 (29.6)	74 (64.3)		
Physical Activity	Sedentary	10 (13.5)	26 (35.1)	38 (51.4)	9.805	0.044*a
	Moderate	5 (6.5)	28 (36.4)	44 (57.1)		
	Heavy	3 (4.6)	14 (21.5)	48 (73.8)		
Diet Preferences	Non-vegetarian	10 (7.6)	48 (36.4)	74 (56.1)	3.763	0.152 a
	Vegetarian	8 (9.5)	20 (23.8)	56 (66.7)		
Skipping Breakfast	No	10 (9.6)	33 (31.7)	61 (58.7)	0.478	0.788 a
	Yes	8 (7.1)	35 (31.2)	69 (61.6)		
Main Source of Drinking Water	Municipal water	7 (9.6)	30 (41.1)	36 (49.3)	6.658	0.155 a
	Tubewell	5 (6.0)	21 (25.3)	57 (68.7)		
	Other Sources	6 (10.0)	17 (28.3)	37 (61.7)		
Condition of Toilet Facilities	Properly maintained toilets with water supply	8 (11.1)	21 (29.2)	43 (59.7)	1.188	0.552 a
	Toilets are available	10(6.9)	47 (32.6)	87 (60.4)		

	but not clean					
Type of Medical help	Government	7 (10.3)	22 (32.4)	39 (57.4)	4.167	0.384 a
	Private	5 (6.8)	28 (38.4)	40 (54.8)		
	Public	6 (8.0)	18 (24.0)	51 (68.0)		
	Private					

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

4.7.1.3 Dietary Factors associated with BMI status

Among dietary factors, the frequency of consumption of pulses and legumes, roots and tubers, red meat, fish showed significant relationships with BMI. The analysis showed a significant association between pulses and legumes consumption and nutritional status. Workers who consumed pulses and legumes frequently had the highest rates of overweight and obesity, while moderate intake was linked to a greater prevalence of normal nutritional status and thinness was generally low. Although legumes are rich in protein and fiber, their impact on BMI depends on portion size, preparation, and overall dietary habits. Tucker (2023) reported that higher legume intake was associated with lower BMI and less weight gain over 10 years, largely due to fiber content. This highlights that it is not only the consumption of legumes but also how they are incorporated into the diet that influences body weight.

In the context of factory workers, frequent consumption of pulses and legumes may contribute to higher BMI when total calorie intake is not balanced or when other lifestyle factors, such as low physical activity, are present. The study found that factory workers who frequently consumed roots and tubers were more likely to have higher BMI, with overweight and obesity observed in over 60% of frequent consumers. This is consistent with Horodyska *et al.* (2021) who reported that tuber consumers in Brazil had 16% higher daily energy intake, largely from carbohydrates, which increased the risk of overweight and obesity. In the context of factory workers, frequent consumption of starchy foods such as roots and tubers may contribute more strongly to weight gain. These findings underscore the importance of promoting balanced diets and moderating high-starch foods to prevent overweight and obesity within this workforce.

The study found that overweight and obesity were nearly consistent across all levels of red meat consumption, affecting about one-third of workers, while thinness was disproportionately high among those who never consumed red meat. This suggests that complete avoidance of red meat may increase the risk of undernutrition, whereas its effect on overweight and obesity appears limited in this population. Comparative evidence reflects the complexity of this relationship: Rouhani *et al.* (2014) reported that higher red meat intake was associated with greater BMI and waist circumference, while Daneshzad *et al.* (2021) found no significant overall link with obesity. Taken together, these findings indicate that the impact of red meat on body weight is context-dependent, with undernutrition posing greater concern than obesity among factory workers who avoid it without adequate dietary alternatives.

The study found that regular fish consumption was associated with a lower prevalence of overweight and obesity among factory workers, while thinness was disproportionately high among those who never consumed fish (77.8%). This suggests that including fish in the diet may support healthier body composition and overall metabolic health, likely due to its high-quality protein and omega-3 fatty acids. These findings are consistent with (Zaribaf *et al.*, 2014), who reported that higher fish intake reduced the risk of metabolic syndrome, and Gibson *et al.* (2020), who found significant links between fish consumption and BMI. Overall, these results indicate that regular fish consumption may help prevent undernutrition and promote optimal nutritional status in industrial workers, whereas complete avoidance without adequate alternatives may increase susceptibility to thinness.

The study found that factory workers who regularly consumed nuts and seeds exhibited a lower prevalence of overweight and obesity, aligning with findings by Balakrishna *et al.* (2022), who reported that higher nut intake was associated with reduced risk of cardiovascular disease, metabolic disorders, and mortality. Nuts and seeds are rich in protein, fiber, and healthy fats, which promote satiety and support overall metabolic health, contributing to healthier body composition. Conversely, workers who rarely or never consumed nuts and seeds showed a higher prevalence of thinness, suggesting that complete avoidance of these nutrient-dense foods may increase the risk of undernutrition. These findings underscore the importance of including nuts and seeds in the diet to support balanced nutritional status and prevent both overweight and undernutrition among

industrial workers.

Table 4.17 presents the associations between BMI status and selected dietary factors among the study participants, classified according to WHO guidelines.

Table 4.17 Dietary factors associated with BMI status among the respondents (n=216)

Factors	Category	Frequency (%)			Chi-square	p-value
		Thinness	Normal	Overweight and obese		
Pulses and	Frequently	11 (9.5)	27 (23.3)	78 (67.2)	-	0.027*e
Legumes	Regularly	5 (6.0)	37 (44.0)	42 (50.0)		
	Rarely	2 (12.5)	4 (25.0)	10 (62.5)		
GLV's	Frequently	2 (9.5)	6 (28.6)	13 (61.9)	-	0.129 e
Consumption	Regularly	8 (8.6)	39 (41.9)	46 (49.5)		
	Rarely	7 (38.9)	19 (27.9)	55 (42.3)		
	Never	1 (4.8)	4 (19.0)	16 (76.2)		
Other veg	Frequently	9 (6.7)	46 (34.3)	79 (59.0)	-	0.705 e
Consumption	Regularly	6 (11.1)	14 (25.9)	34 (63.0)		
	Rarely	3 (10.7)	8 (28.6)	17 (60.7)		
Roots and	Frequently	6 (3.6)	58 (34.7)	103 (61.7)	-	0.000*e
Tubers	Regularly	3 (11.1)	7 (25.9)	17 (63.0)		
	Rarely	9 (40.9)	3 (13.6)	10 (45.5)		
Fruit	Frequently	1 (6.2)	4 (25.0)	11 (68.8)	-	0.122 e
Consumption	Regularly	9 (15.0)	15 (25.0)	36 (60.0)		
	Rarely	5 (27.8)	44(64.7)	68 (52.3)		
	Never	3 (13.0)	5 (21.7)	15 (65.2)		
Milk	Frequently	11 (61.1)	46 (67.6)	76 (58.5)	-	0.626 e
Consumption	Regularly	5 (27.8)	12 (17.6)	27 (20.8)		
	Rarely	2 (11.1)	10 (14.7)	27 (20.8)		
Egg	Frequently	0 (0.0)	6 (8.8)	11 (8.5)	-	0.270 e
Consumption	Regularly	5 (27.8)	36 (52.9)	43 (33.1)		
	Rarely	5 (27.8)	9 (13.2)	17 (13.1)		
	Never	8 (44.4)	17 (25.0)	59 (45.4)		

Red meat	Rarely	4 (22.2)	40 (58.8)	86 (66.2)	12.811	0.002*a
	Never	14 (77.8)	28 (41.2)	44 (33.8)		
Poultry	Frequently	3 (16.7)	8 (11.8)	8 (6.2)	-	0.256 e
	Regularly	2 (11.1)	21 (30.9)	31 (23.8)		
	Rarely	5 (27.8)	18 (26.5)	35 (26.9)		
	Never	8 (44.4)	21 (30.9)	56 (43.1)		
Fish	Regularly	3 (16.7)	22 (32.4)	37 (28.5)	13.012	0.011*a
Consumption	Rarely	1 (5.6)	22 (32.4)	46 (35.4)		
	Never	14 (77.8)	24 (35.3)	47 (36.2)		
Nuts and	Regularly	0 (0.0)	7 (10.3)	18 (13.8)	-	0.055e
Seeds	Rarely	6 (33.3)	34 (50)	42 (32.3)		
	Never	12 (66.7)	27 (39.7)	70 (53.8)		
Sugar	Frequently	16 (88.9)	50 (73.5)	103 (79.2)	-	0.371 e
Consumption	Regularly	2 (11.1)	18 (26.5)	27 (20.8)		
Caffeinated	Rarely	3 (16.1)	16 (23.5)	30 (23.1)	-	0.907 e
Beverages	Never	15 (83.3)	52 (76.5)	100 (76.9)		
Carbonated	Regularly	5 (27.8)	9 (13.2)	19 (14.6)	-	0.197e
Beverages	Rarely	11(61.1)	41(60.3)	79 (60.8)		
	Never	2 (11.1)	18 (26.5)	32 (24.6)		
Packaged	Frequently	8 (44.4)	25 (36.8)	58 (44.6)	-	0.810 e
Food	Regularly	6 (33.3)	29 (42.6)	45 (34.6)		
	Rarely	4 (22.2)6	14 (20.6)	27 (20.8)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

4.7.1.4 Nutritional Factors associated with BMI status

This study found a significant association between energy adequacy and BMI among factory workers (p = 0.008). Thinness was most prevalent among those with low energy intake, whereas overweight and obesity occurred across all intake levels, indicating that calorie adequacy alone does not fully determine nutritional status. While Rashidi et al. (2018) Rashidi *et al.* (2018) also observed a link between energy intake and BMI, broader

evidence from the IARC Working Group (Romieu *et al.*, 2017) and (Hussain *et al.*, 2024) highlights that weight regulation depends not only on calories but also on diet quality, metabolic efficiency, physical activity, and occupational lifestyle. In this industrial setting, the coexistence of undernutrition and overweight may reflect the combined influence of irregular meals, limited dietary diversity, and demanding work conditions, underscoring the need for interventions that go beyond calorie adequacy to improve overall dietary balance and health outcomes.

Table 4.18 presents the associations between BMI status and selected nutritional factors among the study participants, classified according to WHO guidelines.

Table 4.18 Nutritional factors associated with BMI status among the respondents (n=216)

Factors	**Category**	**Frequency (%)**			**Chi-square**	**p-value**
		Thinness	**Normal**	**Overweight and obese**		
Energy	Low	11 (17.2)	14 (21.9)	39 (60.9)	13.852	0.008*a
Adequacy	Adequate	5 (6.0)	25 (30.1)	53 (63.9)		
	High	2 (2.9)	29 (42.0)	38 (55.1)		
Protein	Low	11 (61.1)	26 (38.2)	56 (43.1)	-	0.080 e
Adequacy	Adequate	2 (11.1)	21 (30.9)	49 (37.7)		
	High	5 (27.8)	21 (30.9)	25 (19.2)		
Fat Adequacy	Low	10 (55.6)	22 (32.4)	33 (25.4)	7.173	0.127 a
	Adequate	4 (22.2)	24 (35.3)	48 (36.9)		
	High	4 (22.2)	22 (32.4)	49 (37.7)		
Carbohydrate	Low	4 (22.2)	13 (19.1)	36 (27.7)	-	0.322 e
Adequacy	Adequate	4 (22.2)	15 (22.1)	38 (29.2)		
	High	10 (55.6)	40 (58.8)	56 (43.1)		
Calcium	Low	13 (72.2)	61 (89.7)	103(79.2)	-	0.094 e
Adequacy	Adequate	5 (27.8)	7 (10.3)	27 (20.8)		
Iron	Low	12 (66.7)	50 (73.5)	97 (74.6)	-	0.064 e
Adequacy	Adequate	6 (33.3)	17 (25.0)	21 (16.2)		
	High	0 (0.0)	1 (1.5)	12 (9.2)		

Thiamine	Low	13 (72.2)	50 (73.5)	107(82.3)	-	0.276 e
Adequacy	Adequate	5 (27.8)	18 (26.5)	23 (17.7)		
Riboflavin	Low	16 (88.9)	46 (67.6)	96 (73.8)	-	0.189 e
Adequacy	Adequate	2 (11.1)	22 (32.4)	34 (26.2)		
Niacin	Low	10 (7.6)	47 (35.9)	74 (56.5)	2.995	0.224 a
Adequacy	Adequate	8 (9.4)	21 (24.7)	56 (65.9)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

4.7.2 Factors associated with Waist circumference among the respondents

4.7.2.1 Sociodemographic and socioeconomic factors associated with WC

A statistically significant relationship was found between WC and age group, gender, marital status. Waist circumference in this study was significantly associated with both age and gender. Older workers had a higher prevalence of abdominal obesity compared to younger workers, reflecting the natural accumulation of central fat with age due to metabolic and hormonal changes (Stevens *et al.*, 2010; Barzin *et al.*, 2022).

Female workers showed a markedly higher prevalence of abdominal obesity than males, consistent with evidence that women generally have higher overall body fat and tend to store fat centrally due to hormonal influences such as estrogen, parity, and menopause (Stevens *et al.*, 2010). Lifestyle factors, including physical activity, meal patterns, and occupational stress, likely interact with these biological differences, contributing to the observed gender disparities in abdominal obesity among factory workers.

In the research conducted , married factory workers had a significantly higher prevalence of abdominal obesity (54.4%) compared to unmarried workers (31.3%). This pattern is consistent with findings from Greece, where married adults were at greater risk of abdominal obesity (Tzotzas *et al.*, 2010). Evidence from the China Health and Nutrition Survey also supports this, showing that marriage increased the likelihood of being overweight or obese, a risk that did not diminish even after marital transitions (Damayanti *et al.*, 2024a). Similarly, a study in Korea found a higher prevalence of obesity among

married individuals compared to those who were single (Lee *et al.*, 2020). Together, these studies underline that the link between marriage and obesity is observed across different cultural and demographic contexts. Marriage may influence health through shifts in diet, physical activity, and stress management.

Table 4.19 demonstrates the association between waist circumference (WC) status and selected sociodemographic, lifestyle, and dietary factors among the study participants

Table 4. 19 Socio-demographic and socioeconomic factors associated with WC among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Non-obese	Obese		
Age	19–30	68 (67.3)	33 (32.7)	16.112	<0.001*a
	31–59	46 (40.0)	69 (60.0)		
Gender	Male	85 (78.0)	24 (22.0)	56.083	<0.001*a
	Female	29 (27.1)	78 (72.9)		
Religion	Hindu	100 (53.8)	86 (46.2)	0.522	0.470 a
	Muslim and others	14 (46.7)	16 (53.3)		
Family Type	Nuclear	53 (48.2)	57 (51.8)	3.600	0.165 a
	Joint	26 (51.0)	25 (49.0)		
	Other	35 (63.6)	20 (36.4)		
Ethnic Group	Brahmin	17 (43.6)	22 (56.4)	3.973	0.410 a
	Chhetri	23 (54.8)	19 (45.2)		
	Janajati	22 (57.9)	16 (42.1)		
	Madhesi	27 (47.4)	30 (52.6)		
	Others	25 (62.5)	15 (37.5)		
Family Size	≤ 4	67 (55.8)	53 (44.2)	1.011	0.315 a
	> 4	47 (49.0)	49 (51.0)		
Marital Status	Married	68 (45.6)	81 (54.4)	9.826	0.002*a
	Unmarried	46 (68.7)	21 (31.3)		
Educational Level	No formal Education	37 (49.3)	38 (50.7)	0.869	0.648 a
	Primary	41 (56.9)	31 (43.1)		
	Secondary and higher	36 (52.2)	33 (47.8)		
Income	<17,500	43 (47.8)	47 (52.2)	1.548	0.213 a
	≥17,500	71 (56.3)	55 (43.7)		

*denotes p value significant at 0.05 level
a Tested by Chi-square Test

4.7.2.2 Lifestyle and behavioral factors associated with WC

In this study, working hours were significantly associated with abdominal obesity. Factory workers with longer shifts had a lower prevalence of abdominal obesity compared to those working standard 8-hour shifts. This contrasts with much of the existing literature, where extended working hours are often linked to higher obesity risk; for example, NHANES 2015–2016 data indicated that adults working 40 hours or more per week had greater odds of obesity (Doerrmann *et al.*, 2020). Workplace reviews also emphasize that occupational activity, work intensity, and shift schedules influence body weight outcomes (Shrestha *et al.*, 2016). The divergence in our findings likely reflects the physically demanding nature of industrial labor, where high energy expenditure may offset the typical risks associated with longer working hours, highlighting the unique lifestyle context of factory workers.

In this study, skipping breakfast was significantly associated with overweight and obesity, with 55.8% of workers who skipped breakfast being overweight or obese compared to 39.3% of those who ate breakfast regularly. Similarly, waist circumference tended to be higher among workers who skipped breakfast, indicating greater central fat accumulation. This aligns with previous research suggesting that breakfast skipping may contribute to higher body weight and abdominal obesity by affecting appetite regulation, energy intake, and metabolism (Ma *et al.*, 2020a). Comparable trends have been observed in Ghana, where age, marital status, and gender were also significantly associated with overweight and obesity, highlighting the multifactorial nature of body weight regulation (Addo *et al.*, 2015). Table 4.20 presents the associations between WC and selected lifestyle and behavioral factors among the study participants, classified according to WHO guidelines.

Table 4.20 Lifestyle and behavioral factors associated with WC status among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Non-obese	Obese		
Smoking	No	57 (58.2)	41 (41.8)	2.088	0.148 a
	Yes	57 (48.3)	61 (51.7)		
Alcohol Consumption	No	63 (57.3)	47 (42.7)	1.817	0.178 a
	Yes	51 (48.1)	55 (51.9)		
Working Hours	8 hours	44 (43.6)	57 (56.4)	6.461	0.011*a
	>10 hours	70 (60.9)	45 (39.1)		
Physical Activity	Sedentary	36 (48.6)	38 (51.4)	1.603	0.449 a
	Moderate	45 (58.4)	32 (41.6)		
	Heavy	33 (50.8)	32 (49.2)		
Diet Preferences	Non-vegetarian	72 (54.5)	60 (45.5)	0.426	0.514 a
	Vegetarian	42 (50.0)	42 (50.0)		
Skipping Breakfast	No	46 (44.2)	58 (55.8)	5.879	0.015*a
	Yes	68 (60.7)	44 (39.3)		
Main Source of Drinking Water	Municipal water	38 (52.1)	35 (47.9)	1.139	0.566 a
	Tubewell	41 (49.4)	42 (50.6)		
	Other	35 (58.3)	25 (41.7)		
Condition of Toilet Facilities at Work	Properly maintained toilets with water	32 (44.4)	40 (55.6)	3.009	0.086 a
	Toilets are available but not clean	82 (56.9)	62 (43.1)		

Type of medical Help	Government	37 (54.4)	31 (45.6)	0.106	0.948 a
	Private	38 (52.1)	35 (47.9)		
	Public-Private	39 (52.0)	36 (48.0)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

4.7.2.3 Dietary factors associated with WC

Table 4.21 presents the associations between WC status and selected dietary factors among the study participants, classified according to WHO guidelines.

Table 4.21 Dietary factors associated with WC among the respondents (n=216)

Factors	**Category**	**Frequency (%)**		**Chi-square**	**p-value**
		Non-obese	**Obese**		
Pulses and Legumes	Frequently	63 (54.3)	53 (45.7)	0.447	0.800 a
	Regularly	42 (50.0)	42 (50.0)		
	Rarely	9 (56.2)	7 (43.8)		
GLVs	Frequently	13 (61.9)	8 (38.1)	13.683	0.786a
	Regularly	48 (51.6)	45 (48.4)		
	Rarely	41 (36)	40(39.2)		
	Never	12 (57.1)	9 (42.9)		
Other Vegetables	Frequently	67 (50.0)	67 (50.0)	1.332	0.514 a
	Regularly	32 (59.3)	22 (40.7)		
	Rarely	15 (53.6)	13 (46.4)		
Roots & Tubers	Frequently	87 (52.1)	80 (47.9)	2.878	0.237 a
	Regularly	12 (44.4)	15 (55.6)		
	Rarely	15 (68.2)	7 (31.8)		
Fruits Consumption	Frequently	8 (50.0)	8 (50.0)	3.614	0.461 a
	Regularly	33 (55.0)	27 (45.0)		
	Rarely	57 (50.0)	60 (58.8)		
	Never	16 (69.6)	7 (30.4)		

Milk	Frequently	71 (53.4)	62 (46.6)	3.326	0.244 a
	Regularly	19 (43.2)	25 (56.8)		
	Rarely	24 (21.1)	15(14.7)		
Egg	Frequently	10 (58.8)	7 (41.2)	0.659	0.883 a
	Regularly	42 (50.0)	42 (50.0)		
	Rarely	16 (51.6)	15 (48.4)		
	Never	46 (54.8)	38 (45.2)		
Red Meat	Rarely	67(58.8)	63 (61.8)	0.68	0.678 a
	Never	47 (54.7)	39 (45.3)		
Poultry	Frequently	9 (47.4)	10 (52.6)	2.278	0.517 a
	Regularly	29 (53.7)	25 (46.3)		
	Rarely	35 (60.3)	23 (39.7)		
	Never	41 (48.2)	44 (51.8)		
Fish	Regularly	31 (50.0)	31 (50.0)	0.774	0.679 a
	Rarely	35 (50.7)	34 (49.3)		
	Never	48 (56.5)	37 (43.5)		
Nuts & Seeds	Regularly	9 (36.0)	16 (64.0)	4.006	0.135 a
Consumption	Rarely	42(36.8)	40 (39.2)		
	Monthly	24 (54.5)	20 (45.5)		
	Never	63 (57.8)	46 (42.2)		
Sugar	Frequently	94 (82.5)	75 (73.5)	-	0.112 e
	Regularly	20 (17.5)	27 (26.5)		
Caffeinated	Rarely	27 (23.7)	22 (21.6)	0.137	0.747 a
Beverages	Never	87 (76.3)	80 (78.4)		
Carbonated	Regularly	17 (14.9)	16 (15.7)	1.397	0.498 a
Beverages	Rarely	73 (64)	58 (56.9)		
	Never	24 (21.1)	28 (27.5)		
Packaged food	Frequently	45 (39.5)	46 (45.1)	1.170	0.557 a
consumption	Regularly	46 (40.4)	34 (33.3)		
	Rarely	23 (20.2)	22 (21.6)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

4.7.2.4 Nutritional factors associated with WC

The analysis revealed a significant association between energy adequacy and nutritional status among factory workers. Those with adequate energy intake exhibited the highest prevalence of overweight and obesity, while workers with low or high energy intake showed lower proportions of overweight and obesity. This suggests that simply meeting but not necessarily exceeding caloric requirements may be linked with higher body weight, whereas insufficient or excessive intake does not correspond as strongly to overweight or obesity. These findings underscore that total calorie intake alone does not fully determine nutritional status; factors such as diet quality, physical activity, and the demands of industrial work likely interact to influence body weight outcomes.

Consistent with previous research, this study found that adequate calcium and iron intake was significantly associated with a lower prevalence of overweight and obesity. Calcium has been shown to promote fat oxidation and inhibit lipogenesis, while iron contributes to energy metabolism and supports physical activity, both of which influence body weight regulation. Conversely, inadequate iron intake may indirectly increase the risk of overweight or obesity due to reduced metabolic efficiency and fatigue-related inactivity (Brooks *et al.*, 2006; Abbaspour *et al.*, 2014). Table 4.16 presents the associations between BMI status and selected lifestyle and behavioral factors among the study participants, classified according to WHO guidelines.

Table 4.22 presents the associations between WC status and selected nutritional factors among the study participants, classified according to WHO guidelines.

Table 4.22 Nutritional factors associated with WC among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Non-obese	Obese		
Energy	Low	41 (36.0)	23 (22.5)	6.235	0.044*a
Adequacy	Adequate	36 (31.6)	47 (46.1)		
	High	37 (32.5)	32 (31.4)		
Protein	Low	55 (48.2)	38 (37.3)	2.970	0.227 a
Adequacy	Adequate	33 (28.9)	39 (38.2)		
	High	26 (22.8)	25 (24.5)		
Carbohydrate	Low	31 (27.2)	22 (21.6)	2.630	0.268 a
Adequacy	Adequate	33 (28.9)	24 (23.5)		
	High	50 (43.9)	56 (54.9)		
Fat Adequacy	Low	37 (32.5)	28 (27.5)	5.491	0.064 a
	Adequate	32 (28.1)	44 (43.1)		
	High	45 (39.5)	30 (29.4)		
Calcium	Low	85 (74.6)	92 (90.2)	8.894	0.003*a
Adequacy	Adequate	29 (25.4)	10 (9.8)		
Iron	Low	79 (69.3)	80 (78.4)	8.653	0.013*a
Adequacy	Adequate	31 (27.2)	13 (12.7)		
	High	4 (3.5)	9 (8.8)		
Thiamine	Low	84 (73.7)	86 (84.3)	3.629	0.057 a
Adequacy	Adequate	30 (26.3)	16 (15.7)		
Riboflavin	Low	86 (75.4)	72 (70.6)	0.645	0.422 a
Adequacy	Adequate	28 (24.6)	30 (29.4)		
Niacin	Low	66 (57.9)	65 (63.7)	0.767	0.381 a
Adequacy	Adequate	48 (42.1)	37 (36.3)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

4.7.3 Factors associated with WHR among the respondents

4.7.3.1 Sociodemographic and socioeconomic factors associated with WHR

Table 4.23 presents the association between WHR and various sociodemographic and socioeconomic factors among the respondents. A statistically significant relationship was observed between WHR and age, gender, family size, marital status. The present study found that waist-to-hip ratio (WHR) risk was significantly associated with age and marital status among respondents. Older participants demonstrated a higher proportion of WHR risk compared to younger participants, indicating that central adiposity tends to increase with age. Similarly, married respondents exhibited a notably higher WHR risk. These findings are consistent with Ishizaki *et al.* (2004) who reported significant associations of WHR with both age and marital status, highlighting similar patterns of central fat accumulation across different populations. The observed trends may reflect age-related metabolic changes as well as lifestyle adaptations following marriage.

A significant gender difference in WHR risk was evident in study findings, with a greater proportion of females (81.3%) classified at risk compared to males (58.7%). This disparity likely reflects a combination of biological, hormonal, and lifestyle influences. Women, particularly in middle age, experience hormonal shifts most notably the decline in estrogen during menopause which tend to redistribute fat from the hips and thighs to the abdominal region, thereby increasing WHR (Koceva *et al.*, 2024). Additionally, variations in physical activity, dietary patterns, and other lifestyle behaviors may further contribute to the higher central obesity risk observed among females in this population.

The study findings showed that family size was significantly linked to WHR risk. People from smaller families were more likely to have higher WHR compared to those from larger families. Although there isn’t much research directly on this, one possible explanation could be that in smaller households, individuals may have less shared responsibility for cooking, chores, or daily activities. Additionally, meal distribution in smaller families may be less structured, potentially leading to irregular eating patterns or larger portion sizes, which could further contribute to higher WHR. On the other hand, living in a larger family may encourage more movement, shared meals, and daily routines that help maintain a healthier body composition.

Table 4. 23 Socio-demographic and socioeconomic factors associated with WHR among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Normal	Risk		
Age	19–30	39 (38.6)	62 (61.4)	6.548	0.011*a
	31–59	26 (22.6)	89 (77.4)		
Gender	Male	45 (41.3)	64 (58.7)	13.101	0.001*a
	Female	20 (18.7)	87 (81.3)		
Religion	Hindu	56 (30.1)	130 (69.9)	0.000	0.990 a
	Muslim and others	9 (30.0)	21 (70.0)		
Family Type	Nuclear	32 (29.1)	78 (70.9)	0.740	0.691 a
	Joint	14 (27.5)	37 (72.5)		
	Other	19 (34.5)	36 (65.5)		
Ethnic Group	Brahmin	9 (23.1)	30 (76.9)	4.396	0.355 a
	Chhetri	9 (21.4)	33 (78.6)		
	Janajati	15 (39.5)	23 (60.5)		
	Madhesi	19 (33.3)	38 (66.7)		
	Others	13 (32.5)	27 (67.5)		
Family Size	≤4 members	29 (24.2)	91 (75.8)	4.507	0.034*a
	>4 members	36 (37.5)	60 (62.5)		
Marital Status	Married	23 (15.4)	126 (84.6)	49.049	<0.001*a
	Unmarried	42 (62.7)	25 (37.3)		
Educational Level	No formal Education	17 (22.7)	58 (77.3)	4.674	0.097 a
	Primary Education	21 (29.2)	51 (70.8)		
	Secondary and higher	27 (39.1)	42 (60.9)		
Income	<17500	34 (37.8)	56 (62.2)	4.332	0.037 a
	≥17500	31 (24.6)	95 (75.4)		

a Tested by Chi-square Test

4.7.3.2 Lifestyle and behavioral factors associated with WHR

In the present study, alcohol consumption was significantly associated with WHR, a larger proportion of alcohol consumers were classified in the WHR risk category, compared to non-consumers. These findings suggest that individuals who consume alcohol are more likely to accumulate fat around the abdominal region, placing them at greater cardiometabolic risk. Excessive alcohol intake, while providing additional calories, often disrupts normal metabolism and promotes fat deposition, particularly in the central region. Mechanistically, alcohol reduces lipid oxidation, interferes with nutrient absorption and storage especially B vitamins and vitamin A and, as a diuretic, increases urinary loss of essential minerals such as zinc, magnesium, and potassium. These metabolic alterations can contribute to central fat accumulation even in individuals with otherwise normal body weight. This observation is consistent with previous research highlighting the role of alcohol in abdominal fat gain and central obesity (Bhandari, 2018).

The present study found that workers with longer shifts (>10 hours) were more likely to have normal waist-to-hip ratios, suggesting a lower risk of central obesity compared to those working standard 8-hour shifts. This finding highlights the potential role of work characteristics in influencing body fat distribution. Supporting this, Ishizaki *et al.* (2004) emphasized that work-related factors, including shift work and sedentary job characteristics, are significantly associated with both BMI and WHR. While their study focused on shift and sedentary work, it aligns with the notion that the nature and duration of work can impact central fat accumulation.

Possible explanations include higher levels of physical activity during longer work hours, differences in occupational energy expenditure, and variations in job-related movement patterns, which may help reduce central adiposity. These results underscore the importance of considering work characteristics when assessing risk factors for central obesity in industrial settings.

Table 4.24 presents the associations between WHR and selected lifestyle and behavioral factors among the study participants.

Table 4. 24 Lifestyle and behavioral factors associated with WHR among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Normal	Risk		
Smoking	No	34 (34.7)	64 (65.3)	1.805	0.179 a
	Yes	31 (26.3)	87 (73.7)		
Alcohol	No	40 (36.4)	70 (63.6)	4.190	0.041*a
Consumption	Yes	25 (23.6)	81 (76.4)		
Working	8 hours	23 (22.8)	78 (77.2)	4.832	0.028*a
Hours	>10 hours	42 (36.5)	73 (63.5)		
Type of	Sedentary	16 (21.6)	58 (78.4)	4.115	0.128 a
Physical	Moderate	28 (36.4)	49 (63.6)		
Activity	Heavy	21 (32.3)	44 (67.7)		
Diet	Non-vegetarian	40 (30.3)	92 (69.7)	0.007	0.933 a
Preferences	Vegetarian	25 (29.8)	59 (70.2)		
Skipping	No	37 (35.6)	67 (64.4)	2.868	0.090 a
Breakfast	Yes	28 (25.0)	84 (75.0)		
Source of	Municipal water	22 (30.1)	51 (69.9)	0.125	0.939 a
Drinking	Tubewell	24 (28.9)	59 (71.1)		
Water	Other	19 (31.7)	41 (68.3)		
Toilet	Properly	27 (37.5)	45 (62.5)	4.839	0.089 a
Facilities at	maintained with				
Workplace	water				
	Toilets are available but not clean	38 (26.4)	106 (73.6)		
Type of	Government	18 (26.5)	50 (73.5)	1.043	0.594 a
medical help	Private	25 (34.2)	48 (65.8)		
	Public Private	22 (29.3)	53 (70.7)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

4.7.3.3 Dietary factors associated with WHR

A significant association was found between the frequency of pulse and legume consumption and WHR among the respondents. Those who consumed pulses and legumes more frequently tended to have a lower risk of central obesity compared to those who consumed them regularly or rarely. This indicates that incorporating pulses and legumes more often in the diet may play a positive role in maintaining healthier fat distribution. These foods are naturally rich in dietary fiber, plant-based protein, and essential micronutrients, all of which contribute to improved satiety, better regulation of lipid metabolism, and prevention of excess fat accumulation. Supporting this, Ferreira *et al.* (2021) highlighted that regular pulse consumption enhances metabolic health and body composition by promoting energy balance and reducing adiposity.

The study findings also revealed a significant association between the frequency of roots and tubers consumption and WHR risk. Respondents who consumed roots and tubers frequently had a higher proportion at risk of elevated WHR compared to those who consumed them regularly or rarely. While there is limited direct literature on this association, these results may suggest that overconsumption of starchy foods, which are typically high in carbohydrates, could contribute to central fat accumulation and an increased waist-to-hip ratio. This highlights the potential importance of dietary patterns and portion control in influencing central obesity among the respondents. A significant association was also found between fruit consumption and WHR. Normal nutritional status was observed among most factory workers who consumed fruits regularly. Higher risk was observed among majority of factory workers who never consumed fruits in their regular diet.

Table 4.25 presents the association between dietary factors and WHR among the respondents.

Table 4. 25 Dietary factors associated with WHR among the respondents (n=216)

Factors	Category	Frequency (%)		Chi-square	p-value
		Normal	Risk		
Pulses &	Frequently	42 (36.2)	74 (63.8)	-	0.003*e
Legumes	Regularly	15 (17.9)	69 (82.1)		
	Rarely	8 (50.0)	8 (50.0)		
GLV's	Frequently	9 (42.9)	12 (57.1)	4.53	0.209 a
	Regularly	23 (24.7)	70 (75.3)		
	Rarely	24 (36.9)	57(37.7)		
	Never	9 (42.9)	12 (57.1)		
Other	Frequently	35 (26.1)	99 (73.9)	2.80	0.247 a
Vegetables	Regularly	19 (35.2)	35 (64.8)		
	Rarely	11 (39.3)	17 (60.7)		
Roots and	Frequently	38 (22.8)	129 (77.2)	19.145	0.001*a
Tubers	Regularly	14 (51.9)	13 (48.1)		
	Rarely	13 (59.1)	9 (40.9)		
Fruit	Frequently	6 (37.5)	10 (62.5)	-	0.038* e
Consumption	Regularly	26 (43.3)	34 (56.7)		
	Rarely	27 (41.5)	90 (59.6)		
	Never	6 (26.1)	17 (73.9)		
Milk	Frequently	34 (25.6)	99 (74.4)	4.736	0.094 a
	Regularly	14 (31.8)	30 (68.2)		
	Rarely	17 (26.2)	22 (14.6)		
Eggs	Frequently	7 (41.2)	10 (58.8)	2.49	0.478 a
	Regularly	21 (25.0)	63 (75.0)		
	Rarely	11 (35.5)	20 (64.5)		
	Never	26 (31.0)	58 (69.0)		
Red Meat	Rarely	43 (66.2)	87 (57.6)	1.38	0.289 a
	Never	22 (25.6)	64 (74.4)		
Poultry	Frequently	7 (36.8)	12 (63.2)	4.70	0.195 a
	Regularly	10 (18.5)	44 (81.5)		
	Rarely	19 (32.8)	39 (67.2)		

	Never	29 (34.1)	56 (65.9)		
Fish	Regularly	16 (25.8)	46 (74.2)	3.82	0.148 a
	Rarely	17 (24.6)	52 (75.4)		
	Never	32 (37.6)	53 (62.4)		
Nuts & Seeds	Regularly	9 (36.0)	16 (64.0)	0.89	0.643 a
	Rarely	22 (33.8)	34 (52.3)		
	Never	34 (31.2)	75 (68.8)		
Sugar	Frequently	52 (30.8)	117 (69.2)	0.17	0.681 a
Consumption	Regularly	13 (27.7)	34 (72.3)		
Caffeinated	Rarely	16 (24.6)	33(21.9)	0.19	0.724 a
Beverages	Never	49 (29.3)	118 (70.7)		
Carbonated	Regularly	10 (30.3)	23 (69.7)	0.339	0.844 a
Beverages	Rarely	41 (63.1)	90 (59.6)		
	Never	14 (26.9)	38 (73.1)		
Packaged	Frequently	28 (30.8)	63 (69.2)	0.92	0.630 a
foods	Regularly	26 (32.5)	54 (67.5)		
consumption	Rarely	11 (24.4)	34 (75.6)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

4.7.3.4 Nutritional factors associated with WHR

A significant association was found between carbohydrate intake and WHR among the respondents. Participants with high carbohydrate consumption had a greater risk of central obesity (55.6%) compared to those with low (21.2%) or adequate (23.2%) intake, indicating that excessive carbohydrate intake may contribute to abdominal fat accumulation. This aligns with the understanding that consuming large amounts of carbohydrates, particularly refined ones, can increase insulin secretion and promote fat storage around the waist, leading to higher WHR.

The findings revealed that participants with adequate fat consumption had a higher proportion of WHR risk (43.0%) compared to those with low (25.2%) or high (31.8%) intake, indicating that both the amount and balance of dietary fat may play a role in central

fat accumulation. Fat is an essential nutrient that contributes to energy balance and body composition, but consuming too little or too much, especially from unhealthy sources, can promote abdominal fat deposition. These findings highlight the importance of maintaining a balanced fat intake to support healthier waist-to-hip ratios and reduce the risk of central obesity.

The analysis revealed a significant association between calcium adequacy and WHR risk ($p < 0.001$), with participants having low calcium intake showing a higher proportion at risk of elevated WHR (76.3%) compared to those with adequate intake (41.0%). These findings are supported by previous research suggesting that adequate dietary calcium promotes fat oxidation and inhibits lipogenesis, thereby reducing abdominal fat accumulation (Brooks *et al.*, 2006). This underscores the importance of ensuring sufficient calcium intake as part of dietary strategies to prevent central obesity and maintain health. Table 4.26 presents the associations between WHR and nutritional factors among the study participants.

Table 4. 26 Nutritional factors associated with WHR among the respondents (n=216)

Factors	**Category**	**Frequency (%)**		**Chi-square**	**p-value**
		Normal	**Risk**		
Energy	Low	22 (33.8)	42 (27.8)	1.569	0.456 a
Adequacy	Adequate	21 (32.3)	62 (41.1)		
	High	22 (33.8)	47 (31.1)		
Protein	Low	27 (41.5)	66 (43.7)	3.689	0.158 a
Adequacy	Adequate	27 (41.5)	45 (29.8)		
	High	11 (16.9)	40 (26.5)		
Carbohydrate	Low	21 (32.3)	32 (21.2)	8.641	0.013*a
Adequacy	Adequate	22 (33.8)	35 (23.2)		
	High	22 (33.8)	84 (55.6)		
Fat Adequacy	Low	27 (41.5)	38 (25.2)	14.105	0.001*a
	Adequate	11 (16.9)	65 (43.0)		
	High	27 (41.5)	48 (31.8)		
Calcium	Low	42 (23.7)	135 (76.3)	18.872	0.000*a
Adequacy	Adequate	23 (59.0)	16 (41.0)		

Iron	Low	45 (28.3)	114 (71.7)	-	0.582 e
Adequacy	Adequate	15 (34.1)	29 (65.9)		
	High	5 (38.5)	8 (61.5)		
Thiamine	Low	50 (29.4)	120 (70.6)	0.176	0.675 a
Adequacy	Adequate	15 (32.6)	31 (67.4)		
Riboflavin	Low	53 (33.5)	105 (66.5)	3.332	0.068 a
Adequacy	Adequate	12 (20.7)	46 (79.3)		
Niacin	Low	34 (26.0)	97 (74.0)	2.710	0.100 a
Adequacy	Adequate	31 (36.5)	54 (63.5)		

*denotes p value significant at 0.05 level

a Tested by Chi-square Test

e Tested by Fisher's Exact Test

Age, Gender and Marital Status were found to be commonly associated with BMI, Waist circumference, and WHR. A study among female garment factory workers in Bangladesh highlighted that age is an important determinant of both BMI and waist circumference. Findings indicate that with increasing age, BMI tends to rise, accompanied by a parallel increase in waist circumference, reflecting greater fat accumulation around the abdomen. While socio-economic conditions also influence BMI, the evidence suggests that age-related changes in body composition contribute to a higher risk of obesity and associated health complications (Sharmin *et al.*, 2020).

The elevated risk of obesity among married individuals may be attributed to lifestyle changes post-marriage, such as shared eating patterns, reduced physical activity, and social norms. This finding is consistent with the meta-analysis by Nikolic Turnic *et al.* (2024), which reported significantly higher odds of obesity among married adults. Gender plays an important role in body weight and fat distribution.

In this study, differences were observed in BMI, waist circumference, and waist-to-hip ratio between men and women. Similar findings were reported by Murmu *et al.* (2025) in India, where women were more affected by central obesity and its related health problems, while men showed higher levels of overweight. These differences are shaped not only by biology, such as hormones and fat distribution, but also by social and cultural

factors. For example, women often face lifestyle restrictions and heavier household responsibilities, while men may be more exposed to risk behaviors like alcohol use and unhealthy diets. Such patterns highlight the need for gender-sensitive strategies when addressing obesity and related diseases.

PART V

Conclusions and Recommendations

5.1 Conclusions

This study was conducted to assess the nutritional status and associated factors of factory workers aged 19–59 years in Khanar Area, Sunsari. The main conclusions drawn from the findings are as follows:

a) The mean BMI of the study population was 25.86 ± 4.71 kg/m², indicating a predominance of overweight and obesity. Only 31.5% of participants had a normal BMI, while 38.0% were overweight and 22.2% obese. Thinness was observed in 8.3%, with females showing higher rates of overweight, obesity, and thinness compared to males, reflecting a double burden of malnutrition among factory workers.

b) Food frequency data revealed high consumption of Carbohydrate-rich staples, but limited intake of nutrient-dense foods such as fruits, animal-source foods, and nuts. The 24-hour dietary recall showed that energy and carbohydrate intakes were often above recommended levels, whereas protein and fat intakes were variable. A significant proportion of participants exhibited an inadequate intake of essential micronutrients including calcium, iron, thiamine, riboflavin, and niacin.

c) Overweight and obesity were significantly associated with female gender, older age, marital status, lower educational attainment, higher income, calorie intake, and red food consumption. These findings emphasize the socioeconomic and dietary determinants influencing overall nutritional status.

d) Central obesity was significantly linked to older age, female gender, marital status, longer working hours, skipping breakfast, and higher consumption of calories, carbohydrates, and fats. These results highlight the multifactorial nature of abdominal obesity beyond simple anthropometric measures.

5.2 Recommendations

Based on the findings of this study, the following recommendations could be made:

a) Establish periodic anthropometric and dietary assessments for early identification of both undernutrition and overnutrition.
b) Provide personalized nutritional counseling, especially for individuals with central obesity or micronutrient deficiencies, to promote sustainable dietary and lifestyle modifications.
c) Considering the high prevalence of inadequate calcium, iron, and B-vitamin intake, implement targeted interventions such as supplementation, food fortification, and promotion of diverse diets rich in micronutrients, particularly for female workers who are more vulnerable to these deficiencies.
d) Support longitudinal studies to assess the effectiveness of interventions and explore deeper causal links between work environment, dietary patterns, and nutritional outcomes. Continuous monitoring will help refine strategies and ensure sustainability.

Summary

Nutrition plays a fundamental role in sustaining life, supporting physiological functions, enabling growth and development, and strengthening immunity. While a balanced and diverse diet ensures optimal health, inadequate or excessive intake of nutrients can contribute to a range of health complications, including both undernutrition and overnutrition.

This community-based cross-sectional study was conducted among factory workers aged 19–59 years in Khanar Area, Sunsari, with the aim of assessing their nutritional status and identifying associated dietary, sociodemographic, and lifestyle factors. Anthropometric indicators such as BMI, WC, and WHR were used to evaluate nutritional status, while dietary patterns were assessed using a 24-hour dietary recall and FFQ. Data analysis was performed using Microsoft Excel and SPSS version 20, with chi-square tests applied to determine significant associations.

The study revealed a high prevalence of overweight and obesity, with only 31.5% of participants falling within the normal BMI range, while 60.2% were overweight or obese and 8.3% were underweight according to WHO standards. Abdominal obesity was also widespread, affecting 50.5% of participants based on waist circumference and 69.9% based on waist-to-hip ratio, with females disproportionately affected. Using the Asian BMI classification, over 72% of the cohort were classified as overweight or obese, underscoring the severity of excess adiposity.

Significant associations were observed between nutritional indicators and various factors. BMI was linked to gender, age, marital status, education level, income, calorie intake, and frequency of flesh food consumption. Central obesity measured by waist circumference was associated with gender, age, marital status, working hours, breakfast skipping, green leafy vegetable consumption, calorie intake, and calcium and iron adequacy. WHR correlated significantly with gender, age, marital status, family size, working hours, alcohol use, intake of roots and tubers, carbohydrate and fat consumption, as well as calcium adequacy.

These findings highlight a double burden of malnutrition (DBM) characterized by both overnutrition and micronutrient deficiencies among factory workers. The results call for targeted nutritional interventions that promote balanced diets, improve micronutrient intake, and encourage healthier lifestyle behaviors.

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Appendices

Appendix A

Date ……..

INFORMED CONSENT

Namaste!

I, Miss Simran Chaudhary, a undergraduate student of Nutrition and Dietetics in Central Campus of Technology, Dharan; am going to conduct dissertation work in Khanar for the award of bachelor's degree in nutrition and Dietetics. The topic for the study is 'NUTRITIONAL STATUS AND IT'S ASSOCIATED FACTORS AMONG FACTORY WORKERS AGED 19-59 YEARS IN KHANAR AREA, SUNSARI'. Under this study, nutritional status and risk factors associated with it will be surveyed among the adult Factory workers working in industries situated in khanar, Nepal.

This study will provide information about the nutritional status and risk factors associated with it among 19-59 years age factory workers working in industries located in khanar area, Sunsari. During the study height and weight, waist circumference, waist-hip ratio of the participants will be measured and socio demographic and economic factors, behavioral factors, physical activity, dietary factors and health related factors will be assessed.

You have been selected for the study; you will be asked some questions, and some physical measurements will be taken. This study will help you know about your nutritional status. Some questions may be personal, all the information you provide will be important and the privacy of information will be maintained, and it will not be misused. Your participation in this study will be voluntary. You may not answer some or all questions if you feel them personal or sensitive. But I hope you will participate in this study.

Do you want to get participated in this study? Yes, I want to participate in the study and permit to take all measurements and ask the questions required for the study.

Signature of participant: **Signature of surveyor:**

Date: **Date:**

Place: **Place:**

Letter from Central Campus of Technology

Tribhuvan University
त्रिभुवन विश्वविद्यालय

Institute of Science & Technology
CENTRAL CAMPUS OF TECHNOLOGY, DHARAN

विज्ञान तथा प्रविधि अध्ययन संस्थान
केन्द्रीय प्रविधि क्याम्पस, धरान

प.सं.: .....
Ref No.: CC2/2071/72

मिति : २०८१/१२/१७

श्रीमान् नगर प्रमुखज्यू,
ईटहरी उपमहानगरपालिका
सुनसरी, नेपाल ।

विषय : **आवश्यक सहयोग गरिदिने सम्बन्धमा ।**

महोदय,

उपर्युक्त सम्बन्धमा राष्ट्रिय योजना आयोगले प्राथमिकता तोके बमोजिम यस क्याम्पसमा शैक्षिक सत्र २०६७/०६८ देखि नेपालमै पहिलो पटक स्नातक तहमा **बि.एस्सी.न्यूट्रिशन एण्ड डाईटेटिक्स** विषयको शैक्षिक कार्यक्रम संचालन भईरहेको व्यहोरा श्रीमान्मा अवगत गराउन चाहन्छु। सो विषयको पाठ्यक्रममा समाविष्ट भए बमोजिम **चौथो वर्ष आठौ शत्रमा ३०० पूर्णाङ्क**को डिजर्टेशन/शोध कार्य **(Thesis)** गर्नुपर्ने भएकोले हाल **बि.एस्सी.न्यूट्रिशन एण्ड डाईटेटिक्स चौथो वर्ष आठौ शत्र**मा अध्ययनरत विद्यार्थी श्री **सिमरन चौधरी**ले **"Assessment of Nutritional Status and its Associated Factors among Factory Workers Aged 19 to 59 Years in Khanar, Nepal"** विषयमा ईटहरी उपमहानगरपालिका भित्रका विभिन्न स्थानहरुमा डाटा कलेक्सन गर्न गईरहेकोले उक्त शोधकार्यको लागि अनुमति प्रदान गर्दै त्यस नगरपालिकाबाट अन्य आवश्यक सहयोग उपलब्ध गराईदिनु हार्दिक अनुरोध गर्दछु । यस क्याम्पसको शैक्षिक उन्नयनको लागि त्यहाँबाट प्राप्त हुने सहयोगको लागि हार्दिक धन्यवाद ज्ञापन गर्न चाहन्छु ।

भवदीय,

.....
(प्रा.बसन्त कुमार राई)
क्याम्पस प्रमुख
क्याम्पस प्रमुख

धरान-१४, सुनसरी, नेपाल
Tel: 025-570228, 025-576530
email: info@cct.tu.edu.np
website: https://cct.tu.edu.np

Letter from Itahari Sub-metropolitan office

इटहरी उप-महानगरपालिका

नगर कार्यपालिकाको कार्यालय

इटहरी, सुनसरी

०२५-५८००४६
०२५-५८२३१५
०२५-५८२८१५
०२५-५८२१६५

कोशी प्रदेश, नेपाल

प.सं. : ०८१।०८२

च.नं. : ५६१४

मिति : २०८१/१२/३१

बिषय : अनुमति प्रदान गरिएको ।

यो जो जस संग सम्बन्धित छ ।

प्रस्तुत विषयमा केन्द्रीय प्रविधि क्याम्पस, विज्ञान तथा प्रविधि अध्ययन संस्थान, धरानको च.न.८८२ मिति २०८१/१२/१७ को प्राप्त पत्रअनुसार उक्त अध्ययन संस्थानमा स्नातक तहमा वि. एस्सी. न्युट्रिसन एण्ड डाइटेटिक्समा चौथो वर्षमा अध्ययनरत छात्रा सिमरन चौधरीलाई आफ्नो अध्ययनको शिलशिलामा **"Assessment of Nutritional Status and its Associated Factors Among Factory Workers aged 19 to 59 years in Khanar, Nepal"** विषयक अनुसन्धनात्मक कार्यको लागि यस इटहरी उपमहानगरपालिका क्षेत्रमा सम्बन्धित निकाय, संस्थाको समन्वय र सम्बन्धित लक्षित समुहको पुर्व स्वीकृतिको आधारमा अनुसन्धनात्मक कार्य गर्न अनुमति प्रदान गरिएको जनाकारी अनुरोध छ ।

दिपक पोडेल
अधिकृत दर्शाै

Appendix B

Questionnaire

Nutritional Assessment form

Department of Nutrition and Dietetics

Central campus of technology

Tribhuvan University

Dharan, Nepal

Participant's code _____ **Date of interview (B.S)** _____

GENERAL INFORMATION

1) Name: _____

2) Date of birth (B.S)_____ **3) Age (years)** ____

4) Gender

a) Male b) Female

5) Religion (NSO, 2024)

a) Hindu b) Muslim c) Buddhist d) Christian e) Others

6) Caste/Ethnicity

a. Brahmin b) Chettri c)Janajati d). Madhesi e) Dalit f) Others

7) Marital Status

a).Unmarried b). Married

8) Monthly Expenditure on Food_

9) Address _____ **Ward no:** _____

FAMILY INFORMATION

10) Number of family members_____

11) Number of female members _____

12) Number of male members_____

. . .

13) Type of family

a) Nuclear b) Joint c) Others

14) Educational level

a). No formal education b). Primary c). Secondary

15) Monthly income level (Rs) ____

16) Family Income monthly_____

ANTHROPOMETRIC INFORMATION

	Reading a	Reading b	Mean reading
Weight (kg)			
Height (cm)			
Waist circumference (cm)			
Hip circumference (cm)			
BMI			

OCCUPATIONAL AND WORKRELATED INFORMATION

17) Job Type in the Factory:

a) Manual labor b) Machine operation c) Supervisory d) Other

18) How often does your job require you to sit for long periods of time during your work-shift? (Sangroula *et al.*, 2020)

a) all b) most c) some d) little of the time e) never

20) Working Hours per Day:

a) 8 hours b) > 8hours

21) Do you get regular breaks for meals at work?

a) Yes b) No

PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ-Short form)

22) During the last 7 days, on how many days did you do vigorous physical activities (heavy lifting, digging, aerobics, or fast bicycling for more than 10 minutes)?

_____Days per week b) Don't Know/Not Sure

22) How much time did you usually spend doing vigorous physical activities on one of those days?

_____Hours per day___Minutes per day b) Don't Know/Not Sure

23) During the last 7 days, on how many days did you do moderate physical activities (Carrying light loads, bicycling at a regular pace, or double tennis. NO walking)?

_____Days per week b) Don't Know/Not Sure

24) How much time did you usually spend doing moderate physical activities on one of those days?

___Hours per day _____Minutes per day b) Don't Know/Not Sure

25) During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

_____Days per week b) Don't Know/Not Sure

26) How much time did you usually spend walking on one of those days?

___Hours per day _____Minutes per day b) Don't Know/Not Sure

27) During the last 7 days, how much time did you usually spend sitting on a weekday?

___Hours per weekday_____Minutes per weekday b) Don't Know/Not Sure

BEHAVIORAL FACTORS

28) Do you smoke/ chew tobacco or not?

a) Yes b) No

29) Do you drink Alcoholic beverages?

a) Yes b) No

DIETARY QUESTIONAIRE

30) What are you?

1.3.1.1 Vegan b) Lacto-Ovo vegetarian c) Lacto-vegetarian d) non-vegetarian

32) How much oil do you use monthly while cooking?___Liters

33) Which cooking oil do you use for cooking?

a) Animal fat b) Vegetable oil c) Ghee d) Combination

DIETARY HABBITS AND FOOD CONSUMPTION PATTERN

34) How often do you have feasts?

a) Once a week b)Twice a week c)Sometimes

35) Do you have breakfast?

a) Yes b) No c) Sometimes

36) How many meals do you eat per day?

a) 1 b) 2 c) 3 d)More than 3

37) Do you skip meals?

a) Yes b)No

38) If yes, how often? ☐Daily ☐ Few times a week ☐ Rarely

39) Do you have the same eating time every day? ☐Yes ☐No

24-hour Recall

Meals	Description	Amount
Breakfast		
Lunch		
Snacks		
Dinner		
Before Bed		

WATER HYGIENE AND SANITATION

40) What is the source of drinking water?

a) Piped water b) Bottled water c) Tubewell d)Other

41) Any purification method used?

42) How often do you wash your hands before meals at work?

a) Always b) Sometimes c) Rarely d) Never

43) What type of toilet facilities are available at your workplace?

a) Properly maintained toilets with water supply b) Toilets available but not clean

44) How often do you take a bath or shower?

a) Daily b) Every 2-3 days c) Once a week d) Less than once a week

45) Does your Company provide any kind of health Insurances?

a) Yes b)No

46) Do you have any kind of medical insurance?

a) Yes b)No

47) Where do you seek medical help?

a) Gov.Health facilities b) Private health facilities c

d) Public private health facilities

48) When was the last time you felt sick?

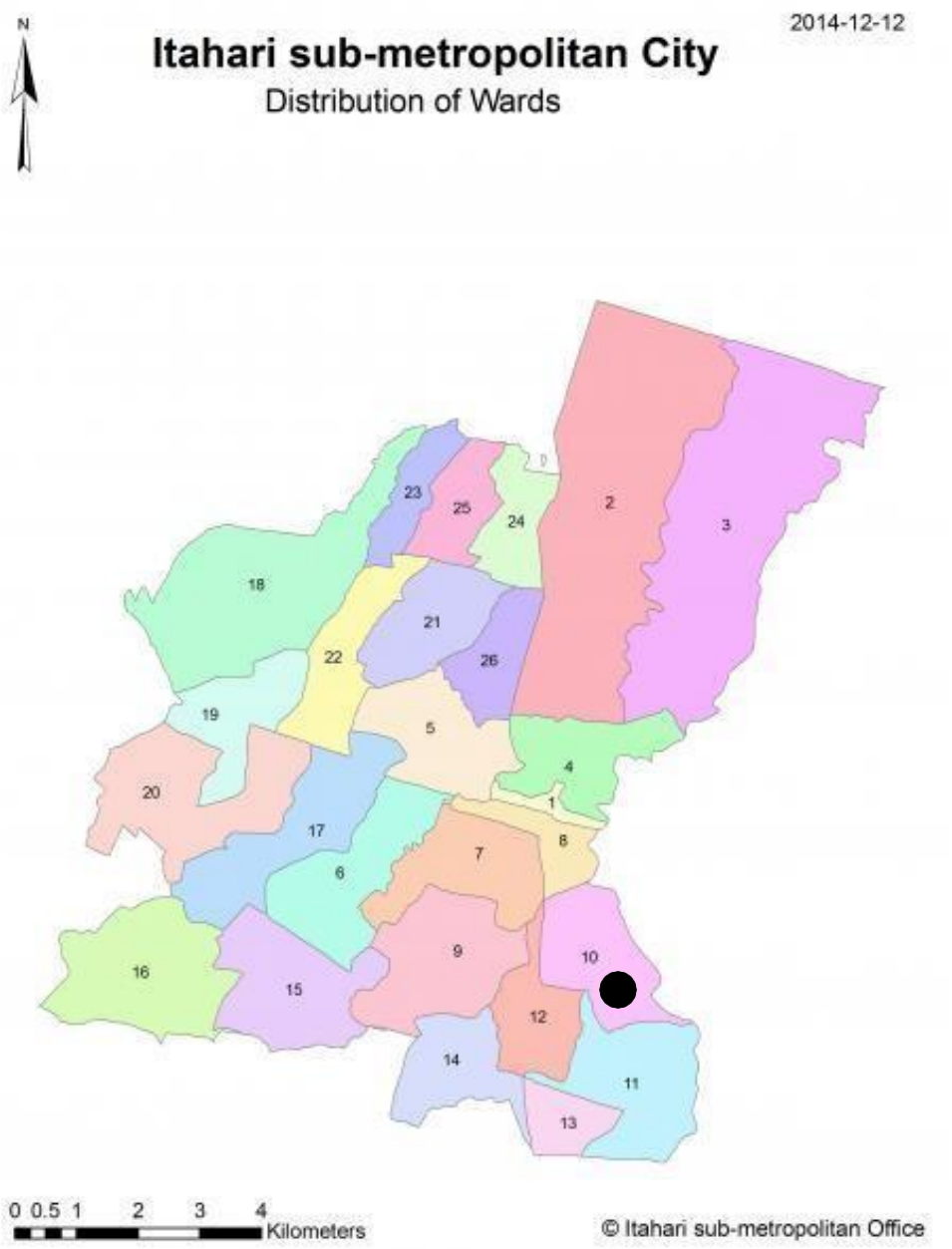
49) Do you remember the name of the medicine? Did You take your medicine yourself?

Food Frequency Questionnaire

Food Items	Everyday	Weekly	Fortnightly	Monthly	Rarely	Never
Cereals						
Pulses and Legumes						
GLVs						
Other vegetables						
Roots and Tubers						
Fruits						
Milk and milk products						
Egg						
Red meat						
Poultry						
Fish						
Oil						
Nuts and seed oils						
Sugar and Confectionary						
Caffeinated Beverages						
Carbonated Drinks						
Refined flour products						
packaged food						

Appendix C

Study Site: Ward no 10



Survey site is khanar, ward no. 10 of Itahari Sub-metropolitan City as shown in the map above

Source : (Sub-Metropolitan, 2025)

Appendix D

Photo Gallery

1. Weight Measurement

2. Waist Circumference Measurement

3. Interview with respondent

4. Interview with respondent

5. Hip Measurement

6. Height Measurement