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A Review of Nutritional Status of Workers in Textile Mills of India

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Abstract
The Indian textile industry, employing over 45 million workers, represents one of the country's largest labor-intensive sectors and a critical contributor to national economic growth. The nutritional status of its workforce remains a neglected determinant of both worker welfare and industrial productivity. This review critically examines existing evidence on the dietary patterns, nutrient intake and health outcomes of textile mill workers in India, highlighting widespread deficiencies in energy, protein and micronutrients such as iron, vitamin D and calcium. The coexistence of undernutrition and rising risks of obesity and non- communicable diseases underscores the "double burden of malnutrition" within this population. Gender disparities further exacerbate vulnerabilities, with female workers disproportionately affected by anemia, reproductive demands and wage inequities. Occupational hazards such as dust exposure, heat stress and irregular work shifts compound these nutritional risks, yet current research remains fragmented and largely region-specific. Policy responses, while extensive on paper through schemes like the Public Distribution System (PDS) and POSHAN Abhiyaan, seldom reach the factory floor, revealing a persistent policy–practice gap. Limited workplace- based interventions such as subsidized canteens, supplementation and public–private nutrition partnerships have shown promise but lack scalability and sustainability. This review underscores the urgent need for workplace-centered, gender-sensitive and empirically grounded nutrition strategies to improve health and productivity among textile workers. Strengthening research methodologies, integrating nutrition into occupational health frameworks and bridging gaps between national policies and workplace realities are essential to safeguard the well-being of this vulnerable workforce while supporting the long-term growth of India's textile sector.

Keywords: Nutritional status, textile mills, occupational health, malnutrition, gender disparities, workplace nutrition and policy gaps

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Introduction
Indian textile is the oldest and largest sector of the country with millions of people working and catering to the needs of both local and foreign markets. Having origins dating back over a century, textiles are not only a cultural image but also an economic support as they add about 2.3% of GDP, 13% of industrial output, as well as around 12% of export earnings. Directly, the industry provides employment to more than 45 million people and another 100 million people indirectly, making it the second-biggest employer since agriculture is the first in line of employers. [1]. Textile mills especially, consume a large part of the low-skill workforce many of whom are migrants who come to work in the mills because they are not doing well back home in economically deprived areas of India. This demographic mix poses special health and nutritional problems, with workers most likely to be part of households in chronic poverty, food insecurity and inadequate access to healthcare services. [2].

Nutritional status is a determining factor of health and productivity, particularly in labor intensive industries such as manufacturing of textile goods. Proper nutrition will equal physical strength, immunity to infections, cognitive ability and the ability to work over a long period of time [3]. Conversely, poor nutritional status contributes to fatigue, absenteeism, workplace injuries and long-term susceptibility to both communicable and non-communicable diseases [4].

In India, where dual burden of malnutrition, which refers to the presence of under nutrition along with increasing obesity has been documented, the industrial workers are a vulnerable population. An example of this weakness is seen in the textile industry which is dominated by both genders of low-income earners; anemia, protein-energy malnutrition and vitamin deficiency prevail among those in the industry[5].

The nutritional problems relating to the textile workers are complex. Working long hours, variable meal times and the absence of

healthier food in the work place may contribute to consumption of unhealthy food. Most of the workers use the inexpensive, nutrient sparse but calorie-rich foods sold on the streets or subsidized food that does not conform to the recommended dietary allowances [6]. Female workers, who constitute a substantial proportion of the workforce in spinning and garmenting units, often face additional nutritional stress due to gender-based wage disparities, household responsibilities and reproductive health demands [7]. Research shows that the prevalence of anemia among women has been at a disproportionately high rate between 40-70% by region [8].

Effects of bad nutrition go beyond the personal health outcomes. In the macro-context, worker malnutrition can be converted to less productivity, increased medical bills and economic cost to both the employer and country at large. A poorly-nourished workforce is more prone to fatigue and absenteeism thus breaking production schedules and affecting efficiency negatively overall [9]. On a collective health perspective, malnutrition among laborers leads to negative health outcomes in future generations because undernourished parents are more likely to end up passing on children who are stunted or underweight, hence further strengthening poverty and poor health outcomes in succeeding generations [10].

Globally, occupational nutrition has been recognized as a priority area within worker welfare and productivity research. The International Labor Organization (ILO) and World Health Organization (WHO) have consistently highlighted the need for workplace-based nutritional interventions, particularly in developing countries where workers face compounded challenges of poverty, food insecurity and occupational hazards [11]. Despite these international frameworks, India still lacks comprehensive workplace nutrition policies tailored for industrial workers, including those in textile mills. Current public health nutrition programs, such as the Integrated Child Development Services (ICDS) and the National Nutrition Mission (POSHAN Abhiyaan), largely target children and women in households but seldom extend coverage to the adult workforce in industrial environments [12].

A review of the nutritional status of textile workers in India is, therefore, both timely and necessary. While scattered studies exist on dietary intake, anthropometric indicators and health outcomes among mill workers, a systematic consolidation and analysis of this evidence can provide insights into patterns, determinants and potential interventions. Such a review can also highlight research gaps, offering directions for future work in occupational nutrition, labor welfare and policy development.

This paper aims to synthesize available literature on the nutritional status of textile mill workers in India, examining dietary patterns, anthropometric and biochemical indicators, socio-economic and occupational determinants and health outcomes. It also reviews government policies and

interventions, compares Indian data with international experiences and outlines recommendations for improving worker nutrition. By doing so, the paper underscores the critical intersection between nutrition, worker welfare and national economic growth, making the case for urgent policy attention in this underexplored domain.

Textile Industry in India and Worker Demographics

The Indian textile industry holds a distinctive position in the global textile and apparel market, both for its historical legacy and its contemporary relevance. Historically, India has been a hub of cotton cultivation, handlooms and artisanal textile production, with evidence of weaving and dyeing practices dating back to the Indus Valley Civilization. In the colonial era, the advent of mechanized textile mills marked a shift toward industrial-scale production, particularly concentrated in cities such as Bombay (now Mumbai), Ahmedabad and Coimbatore [13]. Today, the Indian textile industry is among the world's largest, encompassing the entire value chain from fiber to finished garments. Traditional spinning technologies in India evolved from the Charkha to the electric spinning wheel, encompassing intermediate innovations such as the great wheel, treadle wheel and upright wheel

According to the Ministry of Textiles, the sector contributes around 13% to industrial output and employs over 45 million workers directly. While modern garmenting and apparel export units have expanded significantly, traditional textile mills remain vital in states like Maharashtra, Tamil Nadu, Gujarat and West Bengal. These mills employ large numbers of semi-skilled and unskilled workers, many of whom migrate from rural and economically underprivileged areas [14,15]. Employment opportunities in mills often appeal to marginalized communities because they provide a steady, though modest, source of income compared to subsistence farming.

2.1 Worker Demographics

The workforce composition of textile mills in India is marked by a unique interplay of gender, age, socio-economic background and migration status. Historically, mill employment was male- dominated, particularly in spinning and weaving. Over the past few decades, women have increasingly entered the workforce, especially in garment and ancillary units. In Tamil Nadu, for instance, women constitute nearly 60% of the spinning mill workforce, many of them in the younger age bracket of 18-30 years [16]. This

feminization of the workforce has brought attention to issues of wage inequality, occupational exploitation and nutritional vulnerability among female workers.

Table 1: Number of Textile workers by state.

State / UT	Total Handloom Workers	Women Workers (%)	Source
Assam	1,031,717	92%	[17]
Manipur	1,031,717	94%	[17]
Sikkim	Data not specified	97%	[18]
Goa	Data not specified	96%	[18]
Nagaland	Data not specified	85%	[18]
Mizoram	Data not specified	80%	[18]
Arunachal Pradesh	Data not specified	78%	[18]
Himachal Pradesh	Data not specified	73%	[18]
Meghalaya	Data not specified	71%	[18]
Uttarakhand	Data not specified	68%	[18]
North-East Region	Data not specified	~88%	[17]

Most of the textile laborers have lower-middle to middle-income status and typically belong to inferior castes and minority groups. They also have low educational levels and most workers barely reach high school or are illiterate [19]. The low level of education is a very important aspect, which influences the nutrition awareness and making decision about the food choices and opportunities to demand the better working conditions. Children born to mill workers are also exposed to breakdowns in education because of migration or economic need to earn an early income. Another characteristic of the textile work force is migration. Seasonal and rotational migration is also a tradition where the workers, who are natives of rural villages in Bihar, Uttar Pradesh, Odisha and Jharkhand, travel to urban textile centers such as Surat, Tiruppur and Ludhiana [20]. Migrant workers tend to be housed in crowded and even unhygienic conditions, close to the manufacturer with other migrant workers. This cohabitation also contributes to making them more susceptible to ill nutrition because they usually consume cheap, low quality food at factory canteens or street vendors instead of well-balanced and home-cooked meals.

2.2 Work Environment and Conditions

The textile mills have physically and mentally stressful work environment. The workers will work long hours performing the same jobs and are required to stand or sit in precarious postures, in dusty and damp conditions. Cotton dust in spinning and weaving factories is a factor that causes respiratory diseases such as byssinosis, whereas heat in dyeing and finishing factories is also an added physiological burden [21]. Combined with poor nutrition, these work related dangers jeopardize the health and output of the workers. Mills also have frequent overtime and shift work, resulting in poor eating schedules. Most workers do not eat three meals a day and sometimes depend on affordable but nutritionally poor snacks. Unlike massive garment operations in which subsidized meals are occasionally available, most conventional textile factories have no formal food programs and workers are forced to wander [22]. Poor sanitation of workplaces and insufficient rest breaks are other causes of nutritional and health threats.

2.3 Economic Profile of Workers

Textile mill workers are among the lowest-paid segments in India's industrial workforce. Wages vary depending on location, type of mill and skill level, but in many cases, earnings barely meet subsistence requirements. According to the Periodic Labor Force Survey (PLFS), the average daily wage of textile workers is insufficient to ensure a balanced diet for a household, particularly in urban areas where living costs are high [23]. Wage disparities also exist between men and women, with female workers often earning 20-30% less than their male counterparts for similar tasks [24]. This wage inequality directly affects women's ability to access nutritious food and healthcare, thereby worsening their nutritional status.

Employment contracts in textile mills are often informal, with workers lacking social security benefits, health insurance, or pension coverage. The absence of organized labor protections in some regions further reduces workers' bargaining power to demand better working conditions, including access to nutritious food at workplaces. Although trade unions historically played a strong role in protecting mill workers' welfare, especially in Maharashtra and West Bengal, the decline of union power in recent decades has left many workers unprotected [25].

2.4 Intersection with Nutrition

The demographic and socio-economic characteristics of textile mill workers create an environment where nutritional vulnerability is almost inevitable. Migrant status, low wages, irregular work hours and gender-based disparities converge to reduce access to adequate and balanced diets. Also, the physically taxing nature of textile work increases energy and nutrient requirements, which are seldom met under current dietary practices. Understanding the demographic and occupational context of textile workers is thus essential to framing their nutritional challenges within broader labor welfare and public health discussions.

Concept of Nutritional Status and Its Occupational Relevance

Nutritional status is often defined as the health condition of an individual shaped by nutrient intake, absorption and utilization [26]. While this definition is widely accepted, its measurement in occupational groups such as textile workers is fraught with limitations. Most available studies rely on simplistic indicators such as BMI or hemoglobin levels, which fail to capture the multidimensional nature of nutrition. For example, BMI may under represent muscle depletion in workers performing heavy labor, while hemoglobin alone does not distinguish between nutritional anemia and anemia due to chronic infections. This methodological over-reliance on single metrics weakens the evidence base for policy design. A more integrated assessment that combines dietary, anthropometric and biochemical measures is rarely applied in textile settings, resulting in fragmented knowledge [27].

Table 2. Diet and nutritional status of textile mill workers[28].

Variables	Current Employees	Past Employees	Never Been Employed	P value
Stayed hungry due to lack of food				
Yes	62 (57.9%)	58 (54.2%)	64 (59.8%)	0.7
Consumption of fruit in the past one week				
Yes	75 (70.1%)	86 (80.4%)	101 (94.4%)	<0.001
Consumption of vegetable more than once a day in the past one week				
Yes	78 (72.9%)	88 (82.2%)	93 (86.9%)	0.036
Consumption of soft drink in the past one week				
Yes	57 (53.3%)	42 (39.3%)	45 (42.1%)	0.093
Consumption of fast food in the past one week				
Yes	42 (39.3%)	21 (19.6%)	29 (27.1%)	0.006
Nutritional education at school or workplace				
Yes	51 (47.7%)	68 (63.6%)	87 (81.3%)	<0.001
No	49 (45.8%)	34 (31.8%)	12 (11.2%)	

Unsure	7 (6.5%)	5 (4.7%)	8 (7.5%)	
Nutritional education at home				
Yes	68 (63.4%)	72 (67.3%)	84 (78.5%)	0.057
No	35 (32.7%)	33 (30.8%)	18 (16.8%)	
Unsure	4 (3.7%)	2 (1.9%)	5 (4.7%)	

χ^2 test, significance level p value <0.05.

3.1 Nutrition and Work Capacity

The relationship between nutrition and physical work capacity is well established, yet most studies on textile workers focus narrowly on calorie and protein deficits [29,30]. While caloric deficiency has been shown to reduce productivity, few studies quantify the direct economic loss in terms of output or absenteeism, limiting the persuasiveness of policy advocacy. Micronutrient deficiencies such as iron, thiamine and vitamin D are often acknowledged but not systematically measured in occupational cohorts [31,32]. This lack of comprehensive data obscures the extent to which specific deficiencies impair cognitive ability, injury risk, or long-term employability. Without such evidence, interventions remain reactive rather than preventive.

3.2 The Double Burden of Malnutrition

The "double burden" framework highlights the coexistence of undernutrition and overweight/obesity, but its application to India's textile workforce has been inconsistent. Rural mill workers are reported to be chronically undernourished, whereas urban workers show rising overweight and diabetes risk [33]. These conclusions often come from isolated studies without standardized methods, making it difficult to determine whether the patterns reflect true epidemiological trends or sampling biases. Also, structural drivers such as wage levels, access to subsidized food and regional food environments are rarely analyzed in depth. As a result, policy responses risk being generalized and ineffective. For example, interventions targeting only anemia may overlook the simultaneous rise in hypertension and obesity in urban mills [34,35]. A

critical research gap is the absence of longitudinal tracking to show how workers transition between undernutrition and overnutrition over the course of employment.

3.3 Occupational Hazards and Nutritional Requirements

Occupational exposure in textile mills such as cotton dust, high heat and irregular shifts clearly amplifies nutritional needs [36,37]. Most literature discusses this link theoretically rather than with empirical evidence. For instance, while antioxidant intake is recommended to counter oxidative stress from dust exposure, no studies directly assess antioxidant status among textile workers. Similarly, the relationship between dehydration in hot environments and mineral deficiencies is acknowledged, but intervention trials in Indian mills are almost nonexistent [38,39]. Current research also overlooks the cumulative effects of irregular shift work on circadian rhythm and metabolism, despite international evidence that shift workers are more prone to obesity and diabetes. This highlights a pressing need for occupational-nutrition research that goes beyond descriptive dietary surveys.

3.4 Gender Dimensions of Nutritional Relevance

Gender disparities are well documented, with women facing higher risks of anemia and maternal undernutrition [40,41]. Yet the literature often treats this as a biological inevitability rather than the outcome of structural inequities such as wage discrimination, food allocation norms and lack of workplace maternity support. While women's anemia has received extensive attention, men's nutritional vulnerabilities such as musculoskeletal injuries linked to inadequate calcium and protein intake are underexplored. The intergenerational implications of poor maternal nutrition, though frequently cited, remain inadequately researched in textile-specific contexts. Longitudinal studies tracking the health of children born to textile workers are virtually absent, limiting our understanding of how occupational malnutrition perpetuates cycles of poverty.

3.5 Nutrition as a Component of Occupational Health

Despite clear international recognition of workplace nutrition as a determinant of health [42,43], Indian occupational health frameworks largely ignore it. The dominance of safety-focused measures such as dust control and accident prevention sidelines nutrition into a peripheral concern. Where nutrition is mentioned, it is framed as an individual responsibility rather than a structural issue shaped by wages, workplace canteens and policy enforcement. This reflects a deeper policy–practice gap: although the ILO and WHO recommend workplace-based interventions such as fortified meals and nutritional screening, Indian textile factories have yet to adopt them at scale. The absence of integration not only undermines worker welfare but also weakens the economic case for improved productivity.

3.6 Summary

While the concept of nutritional status is well-defined, its application to textile workers remains methodologically narrow and policy-wise underutilized. Evidence is fragmented, with overemphasis on anemia among women, lack of standardized assessment methods and little empirical research linking occupational hazards to nutrition outcomes. To move beyond

descriptive findings, future work must adopt interdisciplinary, longitudinal and gender-sensitive approaches that capture the complex interactions between diet, work environment and socio- economic inequities. Only then can nutrition be meaningfully embedded within occupational health frameworks in India's textile sector.

Dietary Patterns, Nutrient Intake and Deficiencies

The dietary patterns of Indian textile workers reflect the intersection of socio-economic status, regional food cultures and occupational demands. While existing studies consistently document inadequate diets among workers, the evidence also reveals significant methodological and contextual limitations that make it difficult to establish a fully representative picture. Despite long hours of physically demanding labor, the diets of these workers are often inadequate in both quality and quantity, leading to a range of nutritional deficiencies. Much of the available data is derived from small-scale or localized studies, which may not fully capture regional diversity in dietary practices.

4.1 General Dietary Habits

Most textile workers belong to low-income groups where food choices are constrained by affordability rather than nutritional value. Diets are cereal-based, relying heavily on rice in the South and wheat in the North, supplemented with minimal pulses and vegetables [44]. Access to animal proteins, fruits and dairy is limited, resulting in monotonous meals that meet energy needs only partially [45]. While such patterns are well documented, the reliance on self-reported dietary recalls in many studies introduces recall bias, potentially underestimating the extent of consumption of low-quality street foods. Canteen meals, when available, often provide low-cost, carbohydrate-rich options with little diversity, but very few evaluations exist on whether these meals meet recommended dietary allowances.

4.2 Macronutrient Intake

Workers engaged in moderate to heavy labor require 2,300–3,400 kcal/day, but surveys report intakes 15–25% below this range [43]. Protein intake is typically 35–45 g/day, well under the recommended 60–70 g for adult men and 50–60 g for women [47]. Rising costs of pulses and negligible consumption of animal proteins exacerbate protein-energy malnutrition [48]. Yet, these findings must be interpreted cautiously, as regional differences in affordability and food availability may distort national-level generalizations. Carbohydrates, largely from polished rice and refined wheat flour, dominate diets, while fat intake is low and often derived from reused cooking oils in canteens or street foods [49]. This imbalance contributes to both undernutrition and the emerging risk of overweight and metabolic disorders among a subset of workers, underscoring the "double burden of malnutrition." Current data do not adequately disentangle whether these risks are concentrated in specific sub-groups (e.g., urban vs. rural workers), leaving a gap in targeted policy guidance.

4.3 Micronutrient Deficiencies

Nutrient inadequacies are widespread, although the evidence base is uneven across nutrients:

- Iron: Iron-deficiency anemia remains the most common condition, affecting 60–70% of female textile workers and 25–35% of males [50]. While the prevalence is consistently high, variations in diagnostic thresholds across studies limit comparability.
- Vitamin D: Long working hours indoors contribute to high prevalence of vitamin D deficiency, with musculoskeletal complaints common among affected workers [51]. Few studies directly link workplace exposure patterns to biochemical outcomes, leaving causality underexplored.
- Vitamin B12 and Folate: Vegetarian diets and low intake of leafy vegetables contribute to megaloblastic anemia [52]. The lack of dietary diversity is well established, but few studies measure biomarkers systematically.
- Calcium: Poor dairy consumption limits calcium intake, raising long-term risks of osteoporosis, particularly in women [53]. Yet, evidence on fracture or bone-density outcomes among workers remains limited.
- Other Micronutrients: Deficiencies of vitamin A and iodine occur sporadically, though iodized salt coverage has improved in recent decades [54]. This suggests progress in some areas, though isolated studies make it difficult to gauge whether improvements extend to textile worker populations specifically.

4.4 Summary

Overall, the diets of Indian textile workers remain heavily cereal-based and nutrient-poor, leading to inadequate energy, protein and micronutrient intake. The coexistence of undernutrition and emerging overnutrition reflects the broader "nutrition transition" in

India. Yet, the fragmented and regionally constrained nature of existing evidence limits generalizability. While anthropometric and biochemical studies highlight iron deficiency anemia, vitamin D insufficiency and protein-energy malnutrition as critical challenges, the absence of large-scale, nationally representative data makes it difficult to assess the full scope of nutritional vulnerability in this population.

Most dietary intake studies among textile workers are based on small, cross-sectional surveys, often limited to single factory sites. This raises concerns about representativeness, especially given the regional variation in diets across India. Many studies rely on self-reported dietary recalls, which are prone to recall bias and may underestimate street food consumption. Addressing these gaps is essential for safeguarding both the health of workers and the productivity of the textile sector.

Health Consequences of Poor Nutrition in Textile Workers

The dietary deficiencies encountered in Indian textile workers manifest in a broad spectrum of health issues, both acute and chronic. While the literature consistently links poor diets to morbidity and diminished productivity, most studies are region-specific, limiting the generalizability of conclusions to the entire workforce. Coupled with the straining physical requirements and long working hours, the unfavorable and often hazardous conditions of textile plants exacerbate nutritional risks. In this context, poor diets not only increase morbidity but also perpetuate the cycle of poverty and ill-health. The evidence base tends to highlight certain

conditions such as anemia while underreporting others, pointing to gaps in occupational nutrition research.

5.1 Undernutrition and Energy Deficits

The most acute effect of insufficient dietary intake is undernutrition, commonly observed as low BMI, muscle wasting and persistent fatigue. Surveys in various textile centers in India report significant percentages of the workforce as underweight, with BMI values systematically below adult norms [55]. While such findings underscore vulnerability, they often come from small- scale studies and may not account for seasonal fluctuations in food availability or wage patterns. Undernutrition decreases physical endurance, impairs the ability to sustain long working hours and contributes to absenteeism due to illness. Chronic energy deprivation also undermines immune responses, predisposing workers to communicable diseases like tuberculosis, which remain common in crowded industrial housing [56]. Yet, longitudinal data linking nutrition to disease incidence among workers are scarce, limiting the strength of causal inferences.

5.2 Iron-Deficiency Anemia

Iron-deficiency anemia is consistently reported as the most prevalent nutritional disorder among textile workers, especially women in spinning and garment factories. Poor dietary diversity, low intake of heme iron sources and the inhibitory effects of tea and phytates on iron absorption all contribute to persistently low hemoglobin levels [57]. Workers report dizziness, weakness, reduced concentration and lower work output, which are well-documented consequences of anemia. For women, menstrual blood loss and reproductive demands intensify the problem. Differences in diagnostic thresholds across studies make prevalence estimates difficult to compare. The chronic fatigue associated with anemia creates a vicious cycle: low productivity reduces income, which in turn limits food purchasing power [58]. While this feedback loop is widely recognized, few intervention studies quantify the productivity gains achievable through improved iron intake.

5.3 Micronutrient Deficiencies Beyond Iron

Beyond iron, deficiencies in vitamin B12, folate, calcium and vitamin D are common. Low consumption of animal products contributes to macrocytic anemia and neuropathies linked to vitamin B12 deficiency [59]. Similarly, inadequate calcium and vitamin D intake exacerbate musculoskeletal problems, already aggravated by repetitive mechanical work [60]. Female workers are particularly vulnerable to osteopenia and early osteoporosis, given lower dairy intake and higher physiological requirements. Evidence remains fragmented: while biochemical studies highlight deficiencies, few link them directly to clinical outcomes such as fractures or long-term disability, leaving gaps in assessing the full burden of micronutrient inadequacies.

5.4 Occupational Vulnerabilities Exacerbated by Malnutrition

Poor nutrition intensifies occupational health risks already embedded in textile environments. Cotton dust exposure increases risks of byssinosis and chronic respiratory problems, which are more severe in workers with compromised immunity or limited antioxidant reserves [61]. Energy

deficits also reduce muscle strength, heightening susceptibility to repetitive strain injuries and back pain when handling heavy loads. Yet, most occupational health studies treat nutrition as peripheral, meaning the interaction between workplace hazards and malnutrition remains underexplored. This gap undermines a full understanding of how nutrition determines resilience to industrial

exposures.

5.5 Non-Communicable Diseases and the Nutrition Transition

Although undernutrition remains the dominant issue, urban-based textile workers face a growing "double burden" of malnutrition. Diets high in refined carbohydrates and low in micronutrients are linked to rising obesity, type 2 diabetes and hypertension, even in low-income occupational groups [62]. These NCDs, coupled with strenuous working conditions, elevate risks of long-term morbidity and premature mortality. The coexistence of underweight and overweight individuals within the same workforce illustrates India's nutrition transition. The lack of disaggregated data by workplace setting (urban vs. rural mills) or gender makes it difficult to identify which groups are most at risk of diet-related NCDs.

5.6 Gendered Health Impacts

The health consequences of poor nutrition are unevenly distributed across genders. Women workers who form a large share of the workforce in states like Tamil Nadu, Gujarat andKarnataka face heightened risks due to menstruation, pregnancy, lactation and entrenched inequalities in household food allocation [63]. Adolescent girls often enter employment already malnourished, compounding reproductive health risks and perpetuating intergenerational cycles of undernutrition. While male workers may present more often with musculoskeletal injuries and lifestyle-related NCDs, the literature disproportionately emphasizes women's vulnerabilities. This imbalance reflects the gendered lens of existing research but also highlights gaps in understanding men's nutrition-related health risks.

5.7 Economic and Productivity Consequences

From an economic perspective, malnutrition reduces efficiency, increases absenteeism and lowers output. Employers face productivity losses, while workers experience the dual burden of ill-health and reduced earnings [64]. The World Bank has long highlighted hidden hunger as a drag on economic growth and these dynamics are especially visible in the textile industry where production speed and quality are nutrition-dependent. Most studies stop short of quantifying productivity losses in economic terms, leaving only broad assertions rather than measurable impacts. Existing literature often isolates anemia or micronutrient deficiencies without examining how combined deficiencies interact to amplify productivity costs. While workplace nutrition programs are frequently recommended as solutions, their long-term sustainability and scalability remain poorly evaluated.

Although anemia prevalence is consistently highlighted, few studies measure hemoglobin using standardized methods; some rely on proxy indicators, potentially inflating prevalence estimates. Evidence on non-communicable diseases is contradictory: while urban surveys point to rising obesity, other studies in rural-based mills still report high underweight prevalence, suggesting a dual reality that cross-sectional data cannot fully capture.

Policies, Programs and Workplace Interventions

Not only are the food habits of the textile workforce influenced by individual choices and socioeconomic conditions, but the broader policy framework and employer practices also play a decisive role in shaping nutritional status. Several national nutrition and labor welfare schemes have been launched in India, which overlap though often imperfectly with the needs of industrial laborers. The literature consistently shows that health promotion interventions are rarely adapted to occupational settings. This is particularly concerning in the case of textile workers, who experience high rates of nutritional deficiencies aggravated by long working hours, repetitive tasks and low wages. Thus, while the policy landscape appears comprehensive on paper, its limited alignment with workplace realities highlights a persistent policy–practice gap.

6.1 National Nutrition Policies and Their Relevance

India's National Nutrition Policy (1993) and the subsequent National Nutrition Mission (Poshan Abhiyaan, 2018) were designed to reduce malnutrition across vulnerable populations. These frameworks prioritize women of reproductive age, children and adolescents demographics that overlap significantly with the textile workforce, where young women form a substantial proportion [65]. Yet, their delivery mechanisms rely heavily on community-based platforms such as Anganwadis. Rigid factory schedules prevent industrial workers from accessing these services, leaving formal sector employees in textile hubs underrepresented. This mismatch between program design and worker realities raises questions about whether national policies adequately recognize the needs of adult industrial populations.

6.2 Food Subsidy Programs and Worker Access

The Public Distribution System (PDS) remains India's largest food-security scheme, providing subsidized cereals to low-income households. Textile workers are technically eligible, but irregular documentation among migrant laborers and distribution timings hinder access [66]. State-level expansions, such as fortified rice and pulses in Tamil Nadu and Karnataka, show promise, yet uptake

among workers remains inconsistent. This reveals a structural weakness: PDS is household-based rather than workplace-linked. Without mechanisms to deliver rations directly to worksites, migrant and shift workers are systematically disadvantaged.

6.3 Workplace Canteens and the Role of Employers

Under the Factories Act (1948), factories employing more than 250 workers must provide canteens. In practice, implementation is highly uneven. Studies indicate that canteen meals in textile units often consist of calorie-dense, nutrient-poor staples, with little inclusion of vegetables, pulses, or animal protein [11]. While a handful of progressive mills piloted subsidized nutritious meals and reported productivity gains, such initiatives are exceptions rather than the norm. The fragmented and largely informal nature of India's textile sector dominated by small and medium enterprises renders scaling of such models difficult. Weak enforcement of existing legal provisions further undermines their impact, illustrating the gap between legislative intent and worker experience.

6.4 Supplementation and Fortification Programs

Micronutrient supplementation and food fortification strategies have demonstrated effectiveness in controlled settings, but their reach into industrial workplaces remains limited. The National Iron Plus Initiative (NIPI) distributes iron and folic acid tablets to adolescents and women, yet workplace delivery mechanisms are largely absent [67]. Similarly, fortification initiatives such as iron-fortified wheat flour and double-fortified salt have shown promise in addressing anemia and iodine deficiency [68]. Still, integration of fortified staples into factory canteens is rare, suggesting that interventions remain policy-oriented rather than worker-centered. Without formal channels of distribution at worksites, the scalability and consistency of such programs remain questionable.

6.5 Health and Nutrition Education

Behavioral interventions offer long-term potential, yet evidence remains sporadic. Workplace- based nutrition education campaigns have shown measurable improvements in dietary choices and hygiene practices. For instance, a pilot program in Gujarat garment factories led to increased fruit and vegetable consumption [69]. Peer-led models, where trained workers act as nutrition ambassadors, also show promise in overcoming cultural barriers. The lack of institutionalization across the sector means these benefits are localized and temporary. Most importantly, education without structural dietary access risks being ineffective in the face of low wages and limited food availability.

6.6 Women-Centered Interventions

Given that women constitute a majority in spinning and garmenting units, gender-sensitive programs are essential. The Maternity Benefit (Amendment) Act, 2017 legally mandates crèche facilities and extended maternity leave, but enforcement in textile factories remains inconsistent [70]. Similarly, hot cooked meal provision under schemes such as the Pradhan Mantri Matru Vandana Yojana (PMMVY) has potential, yet employer accountability is weak and workplace- linked delivery is rare. These gaps highlight a recurring issue: while policies exist, they are poorly adapted to the industrial context, leaving women the most nutritionally vulnerable group without consistent support.

6.7 Public–Private Partnerships (PPPs) in Nutrition Delivery

Collaborations between government, NGOs and private sector actors have piloted innovative workplace-based nutrition models. For example, fortified snacks and milk distribution programs implemented by the Global Alliance for Improved Nutrition (GAIN) in South Indian textile units reduced anemia prevalence [71]. While these outcomes are promising, their long-term sustainability depends on continued government incentives and CSR funding. Reliance on external funding highlights the fragility of PPP-based models, which risk collapse once donor or corporate interest declines.

6.8 Gaps and Future Directions

Despite the existence of multiple overlapping schemes, translation of policies into meaningful workplace outcomes remains inadequate. Several systemic challenges persist:

- Exclusion of migrant workers due to non-portable entitlements.
- Weak enforcement of canteen and health provisions, particularly in small factories.
- Limited gender focus, despite the dominance of women in the sector.
- Fragmented monitoring, with no unified framework for tracking worker nutrition outcomes.

Ultimately, most national nutrition programs were not designed with industrial workers in mind, leading to structural exclusion. The Factories Act's canteen provision is poorly enforced and pilot programs while beneficial remain localized and difficult to scale without systemic incentives. This dependence on CSR-driven initiatives raises serious concerns about sustainability. To bridge the persistent policy-practice gap, future strategies must align labor welfare, nutrition policy and industrial regulation in a coordinated framework.

Conclusion and Future Perspectives

The nutritional challenges faced by textile workers in India reflect a complex interplay of socioeconomic, occupational and policy-level determinants. This review has shown that while malnutrition is often studied in rural and child populations, industrial workers particularly those in the textile sector remain neglected in both research and policy attention despite being highly vulnerable. Poor dietary diversity, irregular access to public welfare schemes, occupational fatigue and gender inequities compound nutritional deficits, resulting in reduced productivity and heightened chronic disease risks. At the same time, the fragmented and regionally constrained evidence base limits the precision of these conclusions, underscoring the need for cautious interpretation.

7.1 Synthesis of Key Findings

Across multiple sections of this review, several recurring themes have emerged (Figure 1):

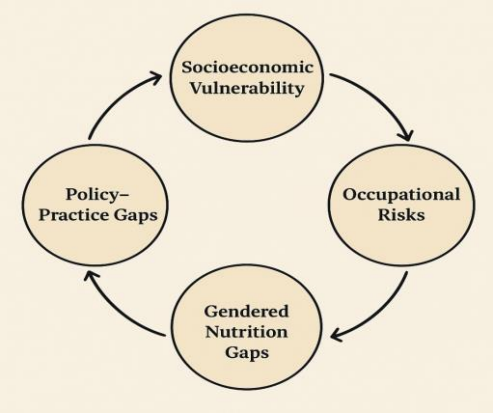

Figure 1. Interconnected cycle illustrating the links between socioeconomic vulnerability, occupational risks, gendered nutrition gaps and policy-practice gaps.

1.Socioeconomic Vulnerability – Low wages and migrant status limit access to nutritious food, perpetuating cycles of energy deficiency and micronutrient malnutrition [72]. Yet, the degree to which these vulnerabilities vary across regions or factory types remains underexplored.
2.Occupational Risks – Extended working hours, high physical workloads and exposure to heat or chemicals elevate caloric and micronutrient requirements [73]. Very few studies directly quantify the nutritional implications of occupational exposures.
3.Gendered Nutrition Gaps – Female workers, who make up the majority in spinning and garment industries, remain particularly vulnerable due to anemia, reproductive health needs and lack of workplace support [74]. Still, the literature tends to overemphasize women's vulnerabilities while underexploring men's long-term risks.
4.Policy–Practice Gaps – National nutrition programs and labor legislations exist, but they are poorly aligned with workplace realities. PDS, ICDS and supplementation schemes seldom reach factory floors in meaningful ways [75]. Enforcement failures and structural exclusions, especially of migrant workers, remain significant barriers.
The cumulative outcome is a workforce that is both economically and nutritionally fragile, undermining not only individual well-being but also industrial productivity and labor sustainability.

7.2 Emerging Opportunities

Despite these challenges, there are several promising opportunities for intervention:

• Workplace Nutrition Integration: The workplace is a natural delivery platform for fortified foods, supplements and health education. Embedding nutrition into occupational health frameworks could achieve higher compliance than community-only programs [76]. Yet, the challenge remains in scaling such initiatives beyond pilot projects.
• Public–Private Partnerships: Initiatives such as fortified meal programs in South Indian textile units illustrate how government, NGOs and factory management can collaborate to improve hemoglobin levels and productivity [77]. Sustainability beyond CSR or donor funding is uncertain.
• Digital and Technology-Enabled Monitoring: Linking Aadhaar-based PDS entitlements to workers' employment records could enhance portability for migrants, but privacy concerns and uneven digital infrastructure may limit feasibility.
• Gender-Specific Programs: Workplace anemia screening, subsidized sanitary provisions and maternity-linked nutrition support are urgently needed. Yet, success depends on stronger enforcement mechanisms to ensure employer accountability.

7.3 Research and Policy Priorities

Several areas warrant systematic attention:

1.Data Gaps – Few large-scale surveys focus specifically on industrial workers' nutrition. Dedicated NFHS or NSS modules could bridge this gap, though funding and political will remain obstacles.
2.Evaluation of Interventions – Pilot programs exist, but long-term evaluations of sustainability and scalability are lacking. Evidence remains largely anecdotal rather than systematically measured.
3.Cross-Sectoral Convergence – Nutrition policy must converge with labor, migration and industrial regulation to reflect workforce realities. Current siloed approaches dilute impact.
4.Global Learning – Experiences from countries like Bangladesh, where garment sector nutrition initiatives are more advanced, could inform India's strategy [78], contextual differences in regulation and labor structures mean such lessons cannot be transplanted without adaptation.

7.4 Conclusion

Nutrition is both a human right and a determinant of productivity. For India's textile sector employing millions of women the stakes are especially high. Addressing nutritional challenges is not merely a welfare measure but also a strategic investment in industrial growth, worker well- being and social equity. Future progress will depend on bridging gaps between national policies and workplace realities, strengthening workplace-based delivery systems and institutionalizing gender-sensitive interventions.

If effectively implemented, nutrition-sensitive industrial policies could transform textile workers from a nutritionally vulnerable group into a healthier, more resilient and productive labor force, thereby contributing not only to economic gains but also to broader public health and social development goals.

At the same time, the strength of conclusions drawn from this review is limited by the uneven quality of available evidence. Few nationally representative surveys exist and much of the literature remains fragmented across small, region-specific studies with methodological gaps. Future research must therefore expand coverage while addressing biases such as the overemphasis on women's reproductive health at the expense of men's chronic disease risks. Only with more rigorous, inclusive and workplace-centered evidence can policies be designed that truly align with the realities of this critical workforce.

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