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Meat Safety in India: Hazards, Value Chain Vulnerabilities and Institutional Frameworks

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ABSTRACT

Meat and meat products constitute an increasingly important component of the Indian food system, driven by urbanization, changing dietary patterns, and rising demand for animal protein. India is one of the world's largest producers of livestock and poultry, with a highly diverse meat sector encompassing organized export-oriented plants as well as a vast informal domestic market. Despite its economic and nutritional significance, the meat sector in India faces persistent challenges related to food safety, particularly due to informal slaughter practices, fragmented supply chains, inadequate cold-chain infrastructure, and uneven regulatory enforcement. This review presents an India-specific assessment of meat safety, focusing exclusively on hazards associated with meat and meat products rather than the broader food sector. Biological and chemical hazards relevant to Indian meat systems are discussed in detail, along with contamination risks at pre-slaughter, slaughter, processing, distribution, and retail stages. The review critically examines meat safety management practices and evaluates the role of Indian regulatory and institutional frameworks, including veterinary services, meat inspection systems, and food safety authorities. Special attention is given to the dual structure of India's meat sector, where modern abattoirs coexist with traditional and informal markets. The review concludes by identifying priority areas for strengthening meat safety in India through risk-based inspection, institutional coordination, infrastructure development, and capacity building, with the objective of safeguarding public health and supporting sustainable growth of the meat sector.

INTRODUCTION

Meat and meat products play a significant and evolving role in India's food and nutrition landscape. Although India has a large vegetarian population, meat consumption has steadily increased over the past two decades due to urbanization, rising incomes, demographic shifts, and diversification of dietary preferences (Girish et al. 2024). Poultry meat dominates per capita consumption (Shubha et al. 2025), while small ruminant meat, pork, and buffalo meat contribute substantially to regional diets and export markets. India is also a major global exporter of buffalo meat, with export-oriented plants operating under stringent hygiene and certification requirements. From a food safety perspective, meat is among the most high-risk commodities in the Indian food system (Rathod et al. 2025). Meat is biologically active, highly perishable, and prone to contamination due to its origin from live animals and the extensive handling required during slaughter and processing. Meat safety in India is intricately linked to animal health, slaughter hygiene, veterinary public health, and post-slaughter handling practices.

The Indian meat sector is characterized by a pronounced duality. On one end, there are modern, mechanized abattoirs

and meat processing plants, particularly those catering to export markets, which operate under regulated environments with defined hygiene standards. On the other end, a large proportion of meat for domestic consumption is produced through informal or semi-formal slaughter facilities, municipal slaughterhouses, and wet markets (Mundhe et al. 2022). These systems often lack adequate infrastructure, standardized hygiene practices, and consistent regulatory oversight. Ensuring meat safety in India therefore presents complex challenges that extend beyond conventional food safety approaches. A generic food safety framework may not adequately address meat-specific risks such as zoonotic pathogen transmission, slaughterhouse contamination, or veterinary drug residues. This review adopts a meat-sector-focused perspective to examine hazards, value chain vulnerabilities, and institutional arrangements specific to meat safety in India.

Evolution of meat safety and meat inspection in India

Traditional meat consumption in India was historically localized, with slaughter and consumption occurring within short distances. Meat was typically sold fresh on the day of slaughter, minimizing storage but increasing exposure to environmental contamination. Scientific meat inspection and slaughterhouse regulation emerged during the colonial period, primarily to supply meat to urban centers and military establishments. Post-independence, meat inspection and slaughter regulation in India developed under state-level municipal laws and veterinary public health services. However, progress was uneven across states, and modernization of slaughter infrastructure lagged behind rapid urban expansion (Kumar et al. 2016). While export-oriented meat plants adopted modern hygiene practices and inspection systems, municipal slaughterhouses serving domestic markets often remained under-resourced.

The enactment of the Food Safety and Standards Act marked a significant institutional shift by consolidating food safety regulation under a single authority. However, meat safety continues to involve multiple institutions, including state animal husbandry departments, municipal bodies, veterinary services, and food safety authorities, leading to overlapping responsibilities. In recent years, there has been increasing recognition of the need for risk-based meat inspection, hygienic slaughter, and integration of veterinary public health into food safety governance (Girish et al. 2016). Nevertheless, implementation remains inconsistent, particularly in informal meat systems.

Meat-borne hazards in the Indian context

Biological hazards associated with meat in India

Biological hazards constitute the most significant meat safety concern in India. Livestock and poultry in India may harbor a range of zoonotic pathogens without showing clinical signs. During slaughter and processing, these pathogens can contaminate meat through direct contact, cross-contamination, or unhygienic handling. Bacterial pathogens are the predominant cause of meat-borne illnesses in India (Sen et al. 2021). Poor evisceration practices, lack of separation between clean and dirty zones, reuse of contaminated water, and inadequate sanitation of knives and surfaces contribute to widespread contamination. In informal slaughter settings, carcasses are often dressed on floors or open surfaces, further increasing microbial risks.

Certain pathogens of public health importance are particularly relevant in Indian meat systems due to climatic conditions, which favor microbial survival and growth. High ambient temperatures and humidity exacerbate spoilage and pathogen proliferation when refrigeration is absent or inadequate. Parasitic hazards also persist in India, especially in pork and small ruminant meat, where traditional rearing systems and backyard production are common. Consumption of undercooked or improperly processed meat increases the risk of parasitic infections. Viral contamination of meat is generally indirect but may occur through infected handlers or contaminated water used during processing, particularly in ready-to-eat or minimally processed meat products (Barbuddhe et al. 2020).

Chemical hazards in Indian meat systems

Chemical hazards in Indian meat arise from veterinary practices, environmental exposure, and adulteration. Veterinary drugs are widely used in livestock and poultry production, and improper observance of withdrawal periods can result in residues in edible tissues. Inadequate awareness among smallholders and limited residue monitoring in domestic markets increase this risk (Thomas et al. 2020). Environmental contaminants such as heavy metals may enter the meat chain through contaminated feed, water, or grazing areas, particularly in peri-urban livestock production systems. Industrial effluents, mining activities, and improper waste disposal contribute to environmental contamination in certain regions (Karkaz et al. 2026; Karabasanavar et al. 2020). Adulteration of meat products remains a concern in informal markets, where unauthorized additives may be used to enhance appearance, mask spoilage, or extend shelf life. Such practices pose direct health risks and undermine consumer confidence (Girish et al. 2017).

Emerging and re-emerging Risks

The intensification of poultry and livestock production in India has altered the epidemiology of meat-borne hazards. High-density production systems facilitate pathogen transmission while extensive use of antimicrobials contributes to the emergence of resistant strains. Climate variability, including rising temperatures and extreme weather events,

may further influence the survival and spread of meat-borne pathogens. Increased movement of animals and meat across regions also raises concerns about transboundary disease transmission (Jayathilakan et al. 2018).

Meat safety along the Indian meat value chain

Pre-slaughter factors

Meat safety in India begins at the farm level, where animal health management, feed quality, and biosecurity practices vary widely. Smallholder and backyard systems dominate livestock production, often with limited access to veterinary services. Animals may be transported to slaughterhouses without prior health screening, increasing the likelihood of diseased or stressed animals entering the meat chain. Animal transport conditions in India often involve overcrowding, long travel distances, and inadequate vehicle sanitation. These factors increase stress and pathogen shedding, thereby elevating contamination risks during slaughter (Naveena et al. 2018; Abbas et al. 2025).

Slaughter practices and infrastructure

Slaughter represents the most critical stage for meat safety control. In India, slaughter infrastructure ranges from modern mechanized abattoirs to rudimentary facilities lacking basic hygiene amenities. Municipal slaughterhouses often operate with outdated infrastructure, insufficient potable water, poor waste disposal systems, and inadequate segregation of clean and dirty operations. Informal slaughter, conducted outside designated facilities, remains widespread in many regions. Such practices bypass ante-mortem and post-mortem inspection, eliminate traceability, and significantly increase public health risks. Slaughtering on open ground or within residential areas also raises environmental and social concerns (Naveena et al. 2018; Girish et al. 2017).

Meat processing and value addition

Processing of meat in India includes cutting, mincing, curing, cooking, drying, and fermentation (Shubha et al. 2025). While industrial processors catering to export markets adhere to defined hygiene standards, small-scale processors and street-level vendors often operate with minimal controls. Processed meat products intended for domestic markets may be exposed to repeated handling, inadequate cooking, or post-processing contamination. Ready-to-eat meat items sold through informal channels are particularly vulnerable to microbial hazards.

Distribution, retail, and wet markets

Cold-chain infrastructure in India remains unevenly distributed. While refrigerated transport and storage are common in organized sectors, large volumes of meat are distributed and sold without refrigeration (Jaiswal et al. 2026). Wet markets dominate retail meat sales, where meat is displayed at ambient temperatures and exposed to environmental contaminants. Retail practices such as cutting meat on wooden blocks, use of unclean water, and lack of personal hygiene among handlers further increase contamination risks. Consumer demand for freshly slaughtered meat often discourages refrigeration, perpetuating unsafe practices.

Meat safety management systems in India

Meat safety management in India varies significantly between organized and informal sectors. Export-oriented plants implement structured hygiene and process control systems, including documented sanitation procedures, temperature monitoring, and traceability mechanisms. In contrast, domestic meat systems largely rely on visual inspection and traditional practices. Implementation of hazard-based approaches remains limited, particularly in municipal slaughterhouses and informal processing units. Training of meat handlers, butchers, and slaughterhouse workers is a critical gap. Limited awareness of hygiene principles, personal protective measures, and sanitation protocols undermines meat safety outcomes. Strengthening capacity through targeted training programs is essential (Naveena et al. 2018).

Institutional and regulatory framework for meat safety in India

Meat safety governance in India involves multiple institutions. The Food Safety and Standards Authority of India serve as the apex body responsible for food safety regulation, including meat and meat products. State food safety departments implement regulations at the ground level. Veterinary public health functions, including ante-mortem and post-mortem inspection, are primarily handled by state animal husbandry departments and municipal veterinary services (Beniwal et al. 2014). Local bodies regulate slaughterhouse licensing and market operations. This multi-institutional arrangement often results in fragmented responsibilities and coordination challenges. Overlapping mandates and limited resource allocation hinder effective enforcement, particularly in informal sectors. Efforts to modernize slaughterhouses and strengthen meat inspection have been initiated in several states, but progress remains uneven. Greater integration of veterinary services with food safety authorities is needed to adopt a holistic approach to meat safety (Jaiswal et al. 2026).

Challenges unique to the Indian meat sector

India's meat sector faces several structural challenges, including dominance of informal markets, cultural preferences for fresh meat, limited cold-chain infrastructure,

and socio-economic dependence of large populations on meat trade for livelihoods. Regulatory enforcement must balance public health objectives with livelihood considerations. Heavy-handed regulation without supportive measures risks pushing meat activities further into informality (Thomas et al. 2026).

Future priorities for strengthening meat safety in India

Improving meat safety in India requires a shift toward risk-based inspection, modernization of slaughter infrastructure, and strengthening of institutional coordination. Capacity building for veterinary inspectors, meat handlers, and small-scale processors is essential. Technological interventions such as rapid diagnostic tools, digital monitoring of slaughter and transport, and low-cost refrigeration solutions can enhance safety when adapted to local conditions (Thomas et al. 2026; Devatkal et al. 2026; Jaelan et al. 2025). Consumer awareness campaigns promoting safe handling and cooking practices are equally important (Sharma et al. 2025).

CONCLUSION

Meat safety in India represents a critical public health, economic, and governance challenge. The coexistence of modern export-oriented facilities and extensive informal meat systems creates uneven safety outcomes across the country. Biological and chemical hazards associated with meat are amplified by inadequate infrastructure, fragmented regulation, and limited awareness. Addressing these challenges requires India-specific, meat-focused strategies that integrate animal health, hygienic slaughter, processing controls, and institutional coordination. Strengthening meat safety systems will not only protect consumers but also support sustainable development of India's meat sector, enhance domestic and international market confidence, and contribute to national food security goals.

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