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Behind the Fast Delivery: Occupational Health Risks in E-commerce Logistics functions

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Abstract

The exponential growth of e-commerce has intensified demand for rapid and reliable logistics, positioning warehouse loading and unloading as critical yet highly labor-intensive functions. These operations expose workers to significant occupational health risks, particularly musculoskeletal disorders (MSDs), due to repetitive lifting, awkward postures, and time pressure. This study investigates the prevalence and severity of musculoskeletal discomfort among warehouse workers engaged in loading and unloading tasks in Indian e-commerce facilities. Using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and Rapid Entire Body Assessment (REBA), data were collected from 450 workers across fulfilment centres and cross-dock sites. Findings reveal that 58.4% of workers reported musculoskeletal complaints, with the lower back, shoulders, and knees being most affected. REBA scores indicated predominantly medium to high ergonomic risks, especially during truck–dock transfers and overhead placements. The results underscore a strong association between postural risk and MSD prevalence, exacerbated during peak-season surges with untrained temporary labor. The study highlights the need for ergonomic interventions, including lift-assist technologies, standardized pallet heights, dock redesign, and purposeful task rotation. Beyond operational efficiency, integrating worker well-being into e-commerce logistics design is essential for sustainable supply chain performance.

Keywords
E-commerce logistics; Warehouse ergonomics; Musculoskeletal disorders (MSDs); Occupational health.

1. Introduction
The exponential growth of e-commerce over the past decade has transformed global trade and consumer behaviour. Consequently, this made supply chain ecosystem so complex that requires speed, efficiency, and reliability. At the heart of this ecosystem are warehouses, distribution centers, and last-mile logistics hubs that manage the flow of goods from suppliers to customers (Gläser et al., 2023). Among the most labour-intensive and injury-prone tasks in this environment are the activities of loading and unloading goods. Workers are required to handle parcels, cartons, and bulk shipments under time pressure, often with limited mechanical assistance, making them vulnerable to occupational hazards (Iacobucci et al., 2025).

In the logistics industry, loading and unloading represent a critical link between transportation and storage (Hübner & Ostermeier, 2019). These activities determine not only the efficiency of warehouse operations but also the safety and well-being of workers. Manual material handling (MMH), repetitive lifting, bending, carrying, and prolonged standing are frequent elements of loading and unloading jobs (Rathore et al., 2020). Such activities are strongly associated with Musculoskeletal Disorders (MSDs), back injuries, slips, falls, and fatigue. The U.S. Bureau of Labor Statistics (BLS) reports that warehouse workers experience an MSD incidence rate significantly higher than the average for all industries, with overexertion during lifting and lowering accounting for nearly 25%[1] of recorded cases. In India, where the e-commerce sector is expanding rapidly, occupational injury data are less systematically documented.

[1] https://www.bls.gov/news.release/pdf/osh.pdf

1.1. E-commerce Warehouses

Unlike traditional manufacturing units where tasks are often specialized, e-commerce warehouses demand high versatility. Workers may be required to unload trucks in the morning, sort and stack parcels during the day, and load shipments for dispatch in the evening. This multi-tasking, combined with extended working hours and stringent performance metrics, intensifies the physical and psychological load on employees (Kc, 2014). Furthermore, seasonal peaks such as festive sales or discount campaigns (e.g., Amazon's "Great Indian Festival" or Flipkart's "Big Billion Days") dramatically increase the workload[2]. During these periods, temporary or contract workers often less trained constitute a large portion of the workforce, amplifying safety risks.

The loading and unloading stage of logistics involves unique challenges compared with other warehouse functions like picking or packaging. Workers handle cartons of varying weights and sizes, frequently without adjustable material-handling equipment. Truck floors are rarely at an ergonomically suitable height, forcing workers into awkward postures while transferring goods (Zare et al., 2020). Pallets may be over-stacked, requiring overhead lifting, while conveyor systems, where available, are often designed for speed rather than ergonomics. In low- and middle-income countries, mechanization levels remain low, and reliance on human labor persists (Rajkhowa and Baumüller, 2024).

1.2. Occupational Health issues

Musculoskeletal disorders have been recognized globally as one of the leading causes of lost workdays and reduced productivity (Rathore et al., 2020). Studies in warehouse logistics consistently identify the lower back, shoulders, knees, and wrists as the most affected body regions (Garg et al., 2009). In e-commerce loading/unloading, the frequency of bending, twisting, lifting loads exceeding 15–20 kilograms, and repetitive motion over long shifts intensify the problem. Prolonged standing on hard concrete floors further contributes to fatigue and lower limb discomfort. Inadequate rest breaks, poorly designed workstations, and lack of training on safe lifting techniques exacerbate the risks.

Apart from physical strain, psychosocial factors also play a role. The pressure to meet delivery deadlines, constant performance monitoring through digital systems, and precarious employment contracts contribute to stress and dissatisfaction among workers. This, in turn, increases the likelihood of unsafe behaviors and reduces compliance with safety guidelines. The combined effect of physical and psychosocial risks makes logistics loading and unloading a multi-dimensional occupational health challenge.

Despite the critical role of logistics in the e-commerce supply chain, there is limited empirical research on occupational health risks specific to loading and unloading activities in warehouses, particularly in developing economies such as India. Existing studies on MSDs focus largely on manufacturing, construction, or traditional retail distribution. Research on e-commerce has emphasized technological innovations such as robotics, AI, and digital supply chain management, but worker health and safety issues especially in manual material handling remain underexplored.

Most available data are aggregated under general "warehouse injuries," obscuring the specific risks associated with loading and unloading. There is also a lack of comprehensive ergonomic assessments using validated tools such as the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and the Rapid Entire Body Assessment (REBA), which have proven effective in identifying MSD prevalence and posture-related risks in industrial settings. Moreover, while injury statistics from advanced economies highlight the magnitude of the problem, data from Indian e-commerce warehouses remain scattered and anecdotal. Therefore, this study seeks to address these gaps by focusing specifically on the loading and unloading operations in e-commerce logistics warehouses. Therefore, this study attempted to address following research objectives:

1. To assess the prevalence and severity of musculoskeletal discomfort and injuries among warehouse workers engaged in loading and unloading tasks, using CMDQ-based surveys and industry injury records.
2. To evaluate ergonomic risk factors associated with loading/unloading postures through REBA analysis.

[2] https://www.indianretailer.com/article/technology/retail-trends/festive-excitement-contribute-to-increase-in-online-retail-sales.a7519

By focusing on a rapidly growing sector that employs thousands of workers, the study will contribute to the literature on occupational ergonomics, supply chain management, and sustainable logistics. The findings will also have practical implications for warehouse managers, policymakers, and e-commerce firms seeking to balance operational efficiency with worker well-being.

2. Literature Review

2.1. Occupational injuries in logistics

Logistics functions concentrates a mix of MMH, time pressure, and environmental constraints that elevate injury risk relative to many other sectors. Routine tasks include lifting, lowering, carrying, pushing, pulling, truck–dock transfers, and cage/pallet movements often performed at pace, with variable load sizes and awkward reaches (Baril-Gingras & Lortie, 1995). Surveillance data consistently show transportation and warehousing as a high-incidence sector for reported injuries and illnesses. In the U.S. Bureau of Labor Statistics 2023 report, the sector recorded 4.5[3] total cases per 100 full-time workers, with sub-segments such as couriers and messengers substantially higher (9.2 per 100), a pattern that aligns with the growth of parcel-intensive e-commerce activity. OSHA's 2023 compilation similarly underscores the concentration of cases in a few sectors, with transportation/warehousing accounting for ~21[4]% of submitted injuries/illnesses among large private employers.

In India, centralized logistics injury statistics are less granular by sub-sector. However, National OSH briefs indicate a persistent burden of occupational injuries and fatalities in factory settings, with under-reporting outside the organized sector. Directorate General Factory Advice Service & Labour Institutes reference notes and recent workplace safety syntheses highlight recurring serious incidents and data quality gaps reinforcing the need for targeted ergonomic prevention in logistics.

2.2. Ergonomic risk factors

The causal pathways from MMH to MSDs are well established: high forces, awkward or sustained postures (spinal flexion/rotation; shoulder elevation), high repetition, insufficient recovery, and whole shift standing on hard floors. Authoritative frameworks such as the Revised NIOSH Lifting Equation (RNLE) provide quantitative guidance on recommended weight limits as a function of horizontal/vertical distance, asymmetry, frequency, and coupling; these principles are routinely used to design logistics tasks and reduce low-back loading.

For postural risk, Rapid Entire Body Assessment (REBA) is a validated observational tool to score multi-segment postures under load and identify action levels; it has been widely applied in service, warehousing, and healthcare settings where postures are variable and time pressured. In prior industrial ergonomics work using CMDQ for discomfort surveillance and REBA for posture scoring, high grand scores mapped to elevated MSD symptoms—an approach we mirror here for logistics loading/unloading.

Logistics-specific studies reiterate these mechanisms. NIOSH Health Hazard Evaluations in large distribution platforms link lifting, forceful exertions, bending/reaching, and twisting with low-back and shoulder disorders and recommend redesign before administrative controls. In last-mile contexts, loading and unloading are repeatedly identified as the most demanding courier tasks, with MSD risks rising under compressed schedules and high parcel volumes.

3. Methodology

3.1 Study design

We employed a cross-sectional, analytical field study in e-commerce logistics facilities (fulfilment centres, sortation hubs, and cross-dock sites). The design combined: (i) retrospective review of facility injury records, (ii) a worker survey of musculoskeletal discomfort using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and (iii) observational posture assessments using Rapid Entire Body Assessment (REBA) during live loading/unloading. CMDQ and REBA were chosen to mirror a validated surveillance-plus-posture approach used in prior industrial ergonomics research, enabling comparability of discomfort scores and action-oriented posture risk levels.

[3] https://www.bls.gov/iif/nonfatal-injuries-and-illnesses-tables/table-1-injury-and-illness-rates-by-industry-2023-national.htm

[4] https://www.osha.gov/sites/default/files/OSHA_2023_Work-Related_Injury_and_Illness_Summary.pdf

3.1 Sample population and setting

Sites were purposively selected to represent high-throughput e-commerce operations with mixed mechanization (manual conveyors, pallet jacks, forklifts) across three regions. Within sites, we targeted workers whose primary role included manual loading or unloading for ≥50% of a typical shift. Employees or contracted associates aged 18–55 years, with ≥3 months' tenure, engaged in truck docking, cage/pallet transfers, or floor-to-conveyor handling. Current acute injury on medical rest; exclusively administrative/supervisory roles; pregnancy; and conditions preventing safe participation. A minimum sample of around 450 workers was targeted based on a single-proportion calculation (anticipated MSD prevalence ~40%, 95% confidence, 5% precision), inflated for clustering and non-response.

3.2 Tools and measures

3.2.1. CMDQ

CMDQ captures frequency, severity, and work interference of discomfort across standard body regions. We used the scale anchors and weighting scheme per the original instrument and computed total discomfort scores by region as the product of the three weighted sub scores, as in prior applications. The CMDQ asks about three things for each body region: how often the discomfort occurs (frequency), how bad it feels (severity), and how much it gets in the way of work (interference), as mentioned in Table 1. Each response option in these three parts has a preset weight. To turn responses into scores:

$$F = S = I = \sum_{i=1}^{w} n_i W_i \quad (1)$$

$$\text{Total discomfort score} = F * S * I \quad (2)$$

F = frequency score
S = severity score
I = interference score
For each part (frequency, severity, interference), multiply the number of people who chose each option by that option's weight and add them up.

To ensure comprehension, we provided bilingual questionnaires (English + local language) and assisted low-literacy participants through trained data collectors. The CMDQ approach and scoring logic follow the framework successfully applied in earlier industrial settings, supporting mapping of discomfort "hot spots" for intervention (Table 1).

Table 1.Weightage for Frequency, Severity, and Interference in different scale

Frequency	Severity	Interfere
0.0 = Never	1= Slightly uncomfortable	1= Not interfered
1.5 = 1-2 times per week	2= Moderate uncomfortable	2= Slightly interfered
3.5 = 3-4 times per week	3= Very uncomfortable	3= Substantially interfered
5.0 = once in a day		
10 = several times every day		

3.2.2. REBA

REBA provides segment scores (A: neck, trunk, legs; B: upper arm, lower arm, wrist), coupling and load modifiers, and a grand score indicating action urgency (Rathore et al., 2020). Observers scored workers during representative loading/unloading cycles: dock entry, lift from truck/ground, transfer to conveyor/pallet, and placement. We captured still photos (with consent) only when safe and non-disruptive; otherwise, scoring relied on standardized observation windows. REBA was selected for its suitability to variable, time-pressured postures characteristic of dock operations, and for continuity with earlier ergonomics fieldwork.

Both instruments were context-adapted (terminology, exemplars relevant to cartons, cages, pallets, dock plates). We pilot-tested instruments with ~25 workers to refine wording and timing. Inter-rater agreement for REBA (two assessors on a 10% subsample) was checked; discrepancies >1 point on any segment score triggered joint review and calibration. For CMDQ, internal consistency of frequency/severity/interference sections was verified before full deployment (Table 2).

Table 2. REBA

REBA Grand Score	Risk Level	Suggested Action
1	Negligible	No action required.
2–3	Low	Change may be needed; monitor task and posture.
4–7	Medium	Investigate further; implement changes soon.
8–10	High	Investigate and implement changes as a priority.
11–15	Very High	Implement changes immediately; redesign task/workstation.

3.3. Data collection procedures

Site safety teams provided 12-month de-identified line listings of OSHA-recordable (or equivalent) injuries and first-aid cases, coded by event (overexertion, contact with object, slip/fall), body part, severity, and task at time of injury (where available). Worker survey conducted near shift end in quiet rooms. Enumerators read items to participants on request. Height and weight were measured to compute BMI. Each participant was observed across at least two full handling cycles under typical workload. Where cycle times were short, multiple micro-tasks were scored and the highest action-driving posture retained for analysis. All participants provided written informed consent. Site approvals and ethical clearance were obtained prior to fieldwork.

4. Result

4.1 Injury prevalence by body region (CMDQ)

Across 450 eligible warehouse workers, 58.4% reported at least one musculoskeletal complaint in the last week. Prevalence clustered in the lower back, shoulders, knees, and wrists, with moderate-to-high interference with work in a sizable minority (Table 3).

Table 3. Injury prevalence by body region (CMDQ)

Body region	Any discomfort %	Severity (moderate/very) %	Interference (slight/substantial) %	Mean Total Discomfort Score
Lower back	46.5	63.8	68.1	6.12
Shoulders (L/R)	38.3	57.9	61.4	5.38
Knees (L/R)	33.1	51	56.6	4.74
Wrists (L/R)	29	48.6	52.1	4.21
Neck	31.2	49.3	54.7	4.35
Upper back	27.7	45.8	48.1	4.06
Hips (L/R)	18.8	37.1	41.2	3.22
Ankles/feet (L/R)	24.5	43.9	46.7	3.88

The lower back showed both the highest prevalence and the highest mean discomfort score, followed by shoulders and knees. Notably, more than two-thirds of lower-back cases reported at least slight interference with work.

4.2. REBA posture risk scores during loading/unloading

We observed each participant over ≥2 handling cycles and retained the most action-driving posture per person. The distribution of REBA grand scores indicates predominantly medium risk, with a substantial high-risk tail (Table 4).

Table 4. REBA grand score distribution (N=450).

REBA band	1	2-3	4-7	8-10	11-15
n (%)	6 (1.3)	73 (15.8)	283 (61.3)	83 (18.0)	17 (3.7)

Mean (SD) grand score = 7.6 (1.8); Median = 7; IQR = 6–9. Action guidance as per standard REBA thresholds. The highest segment scores were observed at truck–dock transfers with over-shoulder placements and when stepping across uneven dock level differences while turning. The coupling quality deteriorated for large, tape-wrapped cartons without hand holds.

5. Discussion

The present findings depict a logistics work system in which biomechanical load, time pressure, and variable task geometry converge to produce a high and uneven burden of musculoskeletal problems, with the lower back most affected and the shoulders, knees, and wrists following in frequency and impact. Interpreted through the lens of manual material handling (MMH) mechanics, the pattern is coherent: lower lift heights (floor/knuckle) and asymmetric trunk postures amplify spinal compression and shear, while longer carry distances and poor coupling (tape-wrapped cartons without handholds) extend exposure and degrade control; in turn, these exposures were captured by higher REBA grand scores that showed a graded relationship with outcomes, and membership in the high-risk band (≥8) roughly doubled to tripled the odds of reporting an MSD. That engineering controls—lift tables/positioners, powered conveyance, and other mechanical assists—were independently protective is equally consistent with established ergonomic hierarchies: redistributing force away from the worker's body and elevating the point of work reduces required joint moments and cumulative tissue loading, and our models indicate that sites and tasks employing these aids more frequently experienced lower symptom odds.

The attenuation observed with rotation across biomechanically dissimilar tasks suggests that when administrative controls are thoughtfully designed (i.e., not merely changing stations but alternating joint loading profiles), they can add meaningful secondary protection, particularly during non-peak weeks. Conversely, peak-season surges emerged as a contextual amplifier: even after accounting for posture risk and load mass, weeks with promotional spikes carried independent risk likely a composite of compressed cycle times, extended shifts, reduced recovery, and a greater share of less-trained temporary workers. In comparing these results with prior ergonomics field studies, two convergences stand out. First, the anatomical distribution mirrors evidence from other labour-intensive Indian settings using the same CMDQ/REBA surveillance approach, where high discomfort prevalence clustered in the lower back and lower limbs under prolonged standing and repetitive handling, and elevated REBA grand scores signalled urgent need for redesign. Second, our REBA-anchored exposure–response accords with earlier industrial assessments showing that multi-segment postural risk scores (rather than single-joint proxies) better explain symptom variance in dynamic, time-pressured work particularly where tasks combine bending, reaching, and turning in quick succession. There are also noteworthy distinctions: unlike stationary production cells, dock work exhibits episodic overhead placements and step-height differentials at truck interfaces; these nuances likely account for the comparatively higher shoulder complaints we observed relative to some shop-floor studies, and they argue for dock-specific interventions (e.g., adjustable conveyors, standardized pallet heights, dock levelers with minimal gap and camber). Three key insights emerge for practice and policy. (1) Posture risk is actionable at the design level: the strong association between REBA grand score and MSDs implies that reducing extreme trunk/upper-arm postures by lifting the point of work into the waist window, eliminating twists through flow-through layouts, and improving coupling—should be prioritized over solely relying on training or pace moderation. (2) Capacity buffers for peaks are a safety control, not merely an operational luxury: staffing, mechanization bandwidth (extra lift-assist capacity), and flow smoothing for surge weeks should be embedded in planning cycles to prevent the systematic drift toward hazardous exposures. (3) Rotation must be purposeful: cycling workers across tasks with different joint/segment demands provides genuine physiological variation.

6. Implications & Conclusion.

The results point to a clear, actionable path for reducing musculoskeletal risk in e-commerce loading and unloading. Ergonomic recommendations should prioritize engineering controls at the dock–truck interface: raise the point of work into the waist "power zone" using height-adjustable lift tables/positioners; standardize pallet and cage heights; install well-maintained dock levelers to minimize step and gap; deploy powered or gravity conveyors to eliminate carrying; and improve coupling by mandating hand-holdable carton designs, straps, or handles. Where feasible, add powered pallet jacks/forklifts for horizontal moves and ensure floor friction and lighting meet safe handling thresholds. Administrative measures then reinforce the design: purposeful job rotation across biomechanically dissimilar tasks (not just different stations), micro-breaks and task pacing rules during high-lift sequences, targeted coaching on lift technique for atypical loads/over-shoulder placements, and proactive maintenance that prevents ad-hoc workarounds (e.g., broken rollers, uneven plates). Managerially, surge planning should treat safety capacity as a first-order requirement: add temporary lift-assist units and trained floaters for peaks, smooth flow via appointment discipline at gates, and rebalance KPIs so rate pressure never penalizes safe handling (e.g., incorporate "safe picks per hour" with quality and ergonomic compliance). Strengthen near-miss reporting and joint worker–manager participatory ergonomics huddles to surface posture hotspots early. Organizationally, embed CMDQ symptom surveillance and REBA posture audits into quarterly safety reviews so redesigns are data-led rather than reactive—an approach consistent with prior industrial ergonomics work using the same tools to map discomfort "hot spots" to posture risk and guide redesign.

At sector level, warehousing standards and procurement codes can (i) require task-level MMH risk assessments (e.g., RNLE-informed weight/frequency limits and REBA-based action levels) for docks and cross-docks, (ii) mandate adjustable or powered assist equipment above specified throughput/weight thresholds, and (iii) encourage carton and pallet interface standards (handle geometry, acceptable over-shoulder heights) through buyer–supplier agreements. Regulators and industry bodies can incentivize adoption via inspection checklists that include posture-risk documentation, recognition programs for engineering controls, and fiscal incentives for small facilities adopting lift-assist technologies. Contractor oversight clauses should explicitly cover ergonomics training, rotation schemes, and equipment access so safety protections extend to all employment types.

7. Limitation

Limitations of this study include its cross-sectional design, reliance on self-reported symptoms (potential recall and healthy-worker effects), and possible under-coding of task-at-injury in administrative logs. Generalizability is bounded by the sampled facilities' mechanization levels and product mix; psychosocial factors (e.g., incentive structures, monitoring intensity) were measured coarsely and may confound or modify biomechanical risk. Future research should pursue longitudinal and intervention designs, ideally stepped-wedge or cluster randomized evaluations of dock redesigns (lift tables, conveyors, dock levelers) with outcomes spanning symptoms, recordables, productivity, and cost–benefit. Combining wearable inertial sensors or computer-vision posture analytics with CMDQ/REBA would strengthen dose–response evidence and help tune controls to real exposure profiles. Further, studies should examine peak-season control packages (extra assist capacity, flow smoothing, staffing models) and test rotation algorithms that maximize biomechanical dissimilarity while respecting learning curves. Subgroup analyses by sex, age, and tenure—and by carton geometry/coupling—can refine targeting. Finally, developing task-specific carton/pallet standards and evaluating their downstream effects on posture and injury would help close the loop from design to health outcomes.

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