Analysis of the circumstances of accidents and impact of transformations on the accidents in a beverage delivery company

Monique Lortie*

Keywords: Accidents Manual material handling Risk analysis Delivery industry Deviations Musculoskeletal mechanisms of injury

1. Introduction

Despite numerous interventions, material handling accidents remain a major occupational health problem. Despite technical advances in mechanization and automation, material handling activities are still present in many sectors and are still the dominant activity in some sectors, especially in the areas of distribution and delivery, which are important components of the food and especially the beverage industry. By de way, in 1997, the North American Free Trade Agreement (NAFTA) conducted a workshop in Mexico to examine specifically how safety could be improved in this sector. The president of a major British labor union has also cited this sector has being one of the most hazardous (http://www.tgwu.org.uk/Templates/News.asp?NodeID=94195).

In general, the back is recognized as the main affected area in material handling accidents. The question is addressed primarily through three main approaches, each producing an inter-related body of knowledge. The first, which uses primarily biomechanics, assesses stresses and strains related to handling activities to establish limits, especially in terms of weight, frequency, duration, height, and distance, and to identify risks (e.g., posture, asymmetry, and dynamics). The second, epidemiological, approach establishes links between presumed risk factors and musculoskeletal health. The third deals with accidents, to assess their seriousness and determine priorities or to identify the circumstances or causes of injury. Therefore, these approaches are intended primarily to identify the risks associated with material handling, with the understanding that there is overlap between sudden, trauma-type injuries and the development of chronic conditions. This dual perspective is implicit in the various theories proposed—Kumar (2001) has identified four—to explain the development of back problems.

Cumulative Load Theory suggests that there is a threshold at which a combination of load and repetition increases injury risk. Repetition and the temporal organization of activities interfere with the process of recovery of tissue, due to the latter’s viscoelastic properties, and increase spinal shrinkage. The redesign of a task in which the mass lifted is decreased but the frequency increased would indeed be counterproductive since the shorter the cycle time, the less energy is stored (Van Dieen et al., 1994; Au et al., 2001). Parkinson and Callaghan (2008) have shown, however, that rest does not significantly increase the resistance of the spine to cumulative compression. Nevertheless, fatigue associated with repetition or cumulative loading is considered a risk factor in itself because it causes muscular contraction (Chow et al., 2004), increases compressive force (Chen, 2000), and leads to lack of coordination. Overall, there is still no clear epidemiological demonstration, as shown by Bedak (2003) in a review of 48 studies in which only six were able to carry out the rather difficult task of documenting workload.
Overexertion Theory considers that the principal risk lies in effort that exceeds tissue capacity. This is probably the most documented and dominant theory, which translates into norms based on weight values that must not be exceeded in a given situation and on calculations of various tissue stresses (e.g., compression force, shearing, torque, moment of flexion). Besides weight, the main risk factor of interest—and taken into account in assessment procedures—is posture (Tak et al., 2007; Paquet et al., 2005). This is the theory that anchors—and feeds—the majority of accident studies since most national systems provide overexertion/overload as a cause or type of accident (Lortie and Rizzo, 1999).

Differential Fatigue Theory is centered on the concept of unbalance. The theory considers that asymmetric and unbalanced tasks, especially repetitive tasks, create differential muscle states of fatigue that increase the risk of injury. The fourth theory, Multivariate Interaction Theory, considers that injuries result from a combination of individual factors, both psychosocial and biomechanical.

Overall, these theories pay little attention to injuries from a traumatic event such as a fall, or a collision, because these injuries involve little understanding of injury mechanisms; nor do any of these theories incorporate clearly the concepts of deviation or dysfunction. Nevertheless, such events can cause strains exceeding tissue capacity. For example, it has been shown that loss of balance can be an important cause of back injury (Manning et al., 1984, 2000; Courtney et al., 2001; Davies et al., 2001). Suddenness (of exertion or movement)—caused, for example, by an unexpected load or a sudden release—has also drawn the attention of experimental studies (Andersen et al., 2001; Lavender et al., 1989; Commissaris and Touissant, 1997); such events may cause an overreaction, producing an intense muscular contraction and a loss of balance (Brown et al., 2003; Chow et al., 2003, 2005). Nevertheless, it is difficult, for obvious ethical reasons, to study the impact of deviations experimentally. In this respect, the main source of data is therefore accident descriptions, which often conserve a trace of these deviations and what caused them.

Indeed, mapping and documenting accidents are essential to acquiring an operational understanding of accidents in order to adopt preventive measures. As summarized by Jorgensen (2008), “The question is not why you are injured when you fall, but more why you are falling.” Two sources of data are particularly useful in this respect: data related to the activity at the time of the accident and data related to the course of the accident. The first allows establishing what the accident victim was doing, where he was, and what he was working with (Kjellen, 2000). However, extracting and organizing such data is only possible when the study targets a specific job, type of task, or sector. For example, the classifications developed in studies on hospital accidents—e.g., transfer type, transfer phase, equipment used, patient status (St-Vincent et al., 1999; Carrick et al., 2005)—are specific to that sector. The advantage of analyzing such data is that it can be used in ergonomics to focus observations and verbalization protocols on specific work elements. The second source of data, the course of accidents, is useful for better understanding injury risks and mechanisms. In this matter, the Merseyside Accident Information Model (MAIM), which identifies the events prior to the injury is, for now, the best suited system to provide evidence for musculoskeletal injury mechanisms (Davies et al., 2007). We think that a better mapping of both dimensions can increase our understanding of manual handling and bring about significant improvements.

Thus, our first aim was to analyze the narratives in accident files to document the circumstances of accidents in a beverage delivery company, in particular, in regard with the activities performed at the time of the accident and the deviations reported.

The study was conducted in a company that initially asked to implement a training program to reduce accidents rates, which were on the rise. The accident study was proposed to clarify the nature of the problems and to explore possible transformation avenues (e.g., equipment, work organization). However, it was soon apparent that the increase in accidents was rather sudden and that the profile of accidents had changed. A series of modifications had indeed been introduced. A second objective was therefore to understand and document the effect of these decisions on accidents. Such studies do not allow turning back the clock but may help situate health and safety issues at the heart of decision making and to increase awareness about them in the future.

2. Material and method

2.1. Accident files

The study was drawn from 546 accident files (exclusive of driving accidents) covering a 7-year period, of which 428 involved absences. Data was scattered throughout various separately kept files: internal and external accident report forms (required by the Occupational Health and Safety Board) including accident descriptions, absence records, and medical follow-up; professional work histories; and delivery worker lists. Some of the data was available on computer, in particular, absences and medical data. Matching the data was difficult, however, so a separate database was created (using Microsoft Access). The accident descriptions were more extensive than usual; after each reported accident the injured workers were asked what they were doing at the time of the accident and what exactly happened.

Absences were of two types: regular (26%) and light-duty assignments (74%). The latter referred to workers unable to return to their regular duties. Since, in most cases, light duties were unavailable, the injured worker, though not officially absent, did not work. The two types of absences are grouped in the tables below. Accident victims were considered absent until they returned to their regular jobs or were officially transferred to another job.

2.2. Delivery workers

Delivery jobs were primarily occupied by male workers with an average age of 41.8 (±5.5) years at the time of their accident. During the study, there were four employment statuses: regular permanent, transitional (regular non-permanent workers), temporary, and student. Apart from students hired during the summer months, the delivery worker population was stable. The company maintained a list of more than 200 deliverers of which around 100 had regular permanent status.

2.3. General organization and work activity

Delivery jobs were divided into five areas, each having its own characteristics (e.g., driving distance, customer habits and demands, layouts, average number of customers). There were three types of routes, differing greatly in terms of handling work (manual, pallet/lift, draft). Delivery workers generally worked in stable pairs, while only permanent workers were assigned to the same route in a given area.

The work activity consists essentially in unloading piles of cases (or barrels) from racks located on each side of a truck, usually at two heights. Delivery workers must climb to reach the highest and furthest cases as well as those located above the wheels. A step platform may be used. The cases may be placed on a hand truck, a roller conveyor, the step platform, or the ground, or handed to another delivery worker. Trucks may be of various sizes. Cases may be carried by hand or using a two-wheel hand truck, or slid onto a roller conveyor. Placement of the cases depends on each customer’s situation (refrigerator, warehouse, shelves, etc.).
2.4. Transformation history

Transformations described here were introduced gradually. There are no days = D. The information was collected progressively through questions emerging from data classification, preliminary analysis, and field observations.

The largest and most decisive transformations were organizational. The workweek was compressed from 5 days to 4, and the maximum daily quota of cases was eliminated. These transformations, in particular, the 4-day schedule, were supported by delivery workers and their union, who saw benefits in terms of organizing their activities.

In the past, two criteria determined daily quotas: maximum number of cases to deliver (lower in winter), and delivery time (driving time + setup time at customer site + delivery time based on time unit per case). Generally, the first quota attained was the number of cases. These transformations had three important advantages: (1) increasing the flexibility of the system by distributing the workload over a longer period in a context in which size and number of orders can vary depending on many factors; (2) reducing the number of trucks and optimizing larger routes (the delivery territory is vast); (3) simplifying route management, since computing and updating delivery times for each customer were no longer required (time-moving studies applied to the most plausible delivery method according to customer layout).

The corollary of this transformation was that larger trucks were acquired, which increased the height of loads and caused more parking and traffic problems. In contrast, some trucks were equipped with rear lift systems (Moffett), which allowed entire pallets to be unloaded and significantly reduced manual handling. Some trucks were fitted with pod systems enabling direct access to the upper floors of companies equipped with the appropriate loading bays.

Another important transformation – not welcome – was the introduction of the status of transitional delivery worker. These employees, in exchange for guaranteed regular work, have no fixed route and lower wages. This increased the flexibility of the system by ensuring a more or less regular workforce.

Other minor transformations were effected but were difficult to situate precisely in time. For example, some procedures, such as the systematic quality control of pallets and the re-driving of protruding nails in pallets were abolished. Other transformations were effected externally. For example, the thickness of cardboard boxes supplied by an outside company was reduced, making them more fragile. The pallet supplier began to use less cured wood, which reduced the pallets’ resistance to warping.

2.5. Classification of the descriptive material

The descriptive material was classified according to three main groups of variables: the activity taking place at the time of the accident, the deviations leading to the accident, and the accident itself. These are presented in Table 1. The classification grid is based on the descriptive material of the accident combined with our knowledge of the activities. Variables and classes were established following a free reading of all accident reports and then adjusted following a preliminary data entrance. Variables used for the activities were specific to the context of the company. Deviation variables could be considered generic, but categories were specific to this context. Classification was also carried out to establish links with field observations.

The first level of classification, where relevant, was binary (yes, no; present, absent), which allowed proceeding from more general to more specific; the systematic use of “Unclear, unspecified, or other” classes allowed to work from a stable denominator.

2.5.1. Activity

Four types of data were identified: main activity/operation, location of the activity taking place at the time of the accident, equipment involved, and foot support base. Material handling included the use of a two-wheel hand truck to transport the cases; however, the handling of this piece of equipment per se (removal and replacement on truck) was classified under installation operations.

2.5.2. Deviations

Jacinto and Aspinwall (2004) define deviations as the “last event deviating from the normal situation and leading to the accident... immediate cause of the accident or the event that triggers it.” In this study, the concept of deviation was expanded to include difficult or unusual states or conditions without reference to temporal connections. Three categories of deviations were defined: (1) a particular, unusual, or difficult condition recognized and known as such by the delivery workers at the time of their accident (e.g., lack of space, slippery floor surface, working with a new co-worker) and specifically reported by them (i.e., not inferred from their description); (2) an unexpected (e.g., broken handle) or unseen (e.g., ice under snow or black ice) event generally related to the environment and external to the delivery worker; (3) a dysfunction in the activity itself prior to the accident and injury, such as loss of balance or overexertion, reported explicitly or tacitly and usually including information about injury mechanisms and material handling difficulties. A description could have reported several deviations, or none at all.

2.5.3. Accident and injury

Variables are the same as those used in most studies, i.e., type of accident, type of injury, and body area injured.

2.6. Data analyses

Analyses were primarily descriptive and consisted of cross-tabulations. Data was compiled into accidents with or without absences; total days of absence; and average length of absence. However, the format that appeared most enlightening and inclusive was to present the results as a distribution, i.e., in terms of percentages relative to total accidents (with or without absences) and total days of absence. Analyses distinguishing with or without absences showed no notable differences, modifying the interpretation.

Accident data was also stratified according to employment status, delivery area, and route type. As expected, delivery area and route type influenced accident occurrence and profile, but these results have relevance only for the company and are not included in this paper. Also not included are analyses with regard to employment status and age, which in this case, did not reveal any clear differences. These types of results are complex to interpret because of the interaction between employment status and road or sector allocation, as are the results of analyses by month, day, or hour.

2.7. Impact of transformations

Data was organized into three groups: the 3 years preceding the transformations, the 3 years following the transformations, and the fourth year post-transformation. The latter aimed to assess whether the situation had stabilized, had improved, or was still developing.

3. Results

Section 3.1 presents an overview of the accident circumstances; Section 3.2 describes the impact of transformations on accidents.
3.1 Accident circumstances

The main results are summarized in Table 2. A higher proportion of absences for certain accidents indicates that the resulting injuries were more severe than for other accidents. Where relevant, the average length of absence is given. The first column refers to all accidents, while the second presents the intra-category distribution. The category "other" actually refers to three categories: unclear, unspecified, or other.

3.1.1. Activity at time of accident

Two out of three accidents were directly related to handling activities. However, accidents occurring while the delivery worker was moving about (without a load) or installing/handling equipment (N: 28%; Abs: 24%) were far from negligible. Analysis of handling activities shows that two out of three accidents occurred during the transfer of boxes—mostly at the beginning of the transfer, during the grasping phase (N: 39%; Abs: 53%)—and that one out of three occurred during transport. Surprisingly, more than half of the handling accidents occurred neither in the grasping nor deposit phases, but between the two or just prior to or following the handling activity.

Accidents occurred slightly more often on the customers’ premises than at the truck itself (N: 44% vs. 40%), but the injuries involving the truck were more serious (Abs: 37% vs. 44%). In nearly a third of the cases, the delivery worker was on a small support surface such as a step or staircase.

3.1.2. Deviations

3.1.2.1. Unusual or difficult context/situation. Workers described the context as being difficult/unusual one out of two times (N: 49%; Abs: 54%), the most prevalent situation being a space or layout presenting a difficulty (far, high, low, lack of space, etc.). The most serious injuries occurred when the load was reported as being too high (average absence: 144 days).

3.1.2.2. Unexpected event. Such events were described in more than one out of three accidents (39%). Three types of events were generally reported: (1) something falls or moves; (2) a material element is defective or breaks (e.g., nail protruding from a pallet, box bottom falling out); (3) a risk related to unseen underfoot hazards (e.g., a hole). The most serious injuries were associated with breakages/defects (avg. Abs: 79 days).

3.1.2.3. Dysfunction in the activity. Workers reported an element of dysfunction in three out of four accidents, the most frequent being a loss of balance (N: 44%; Abs: 48%) caused by slipping or a trunk imbalance during handling. A variety of other dysfunctions were reported—forcing, suddenness, control difficulty, unexpected workflow—each representing 11–18% of these accidents. Forcing was generally caused by an element that was stuck.

3.1.3. Type of accident and injury

Although the area of the body most frequently injured was the back (36%), injuries to the upper limbs were more severe and caused almost half of the absences (45%). Injuries to other areas were far from negligible, especially to the lower limbs.

Nearly three out of four injuries were musculoskeletal, about half being strains. (N: 53%; Abs: 50%). In contrast, "-itis" type injuries caused the longest return-to-work times (strain: 43 days; "-itis": 110 days). The mechanism of injury most frequently described was suddenness (effort or sudden movement: 33%), while
injuries associated with overexertion were significantly less frequent (18%). Ten percent attributed their injuries to cumulative exposure or to a previous injury rather than to a specific event.

3.2. Impact of transformations on the rate of accidents and absences

3.2.1. Changes in the rate of accidents and absences

As shown in Table 3, the number of accidents and their severity increased dramatically following the introduction of the various transformations. In total, over a period of 3 years, the number of accidents doubled, as did the average length of absences, which resulted in a fivefold increase in the number of absentee days. This situation had still not stabilized in the fourth year post-transformation.

3.2.2. Changes in circumstances of accidents: Activity and deviations

3.2.2.1. Activity at the time of the accident. Some differences were noted in terms of the distribution of activities at the time of the accident, but such differences were not particularly marked (see Table 2).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Main activity</th>
<th>Number (%) (total: 422 cases)</th>
<th>Absentee days (%) (total: 19,762)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual handling</td>
<td>Transfer</td>
<td>65</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Transfer phase</td>
<td>Grasping</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Between</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deposit</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Truck</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Between both</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Full surface</td>
<td>Yes</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>32</td>
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<td></td>
<td>Unspecified</td>
<td>9</td>
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<tr>
<td>Deviation reported</td>
<td>Particular conditions</td>
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<td>Spatial context</td>
<td>87</td>
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<tr>
<td></td>
<td>Unexpected events</td>
<td>39</td>
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</tr>
<tr>
<td></td>
<td>Dysfunction</td>
<td>77</td>
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</tr>
<tr>
<td></td>
<td>Loss of balance</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forcing</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suddenness</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected workflow</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control difficulty</td>
<td>11</td>
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<tr>
<td>Injury</td>
<td>Musculoskeletal injury</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Type of injury</td>
<td>Strain</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>“-itis”</td>
<td>14</td>
<td></td>
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<tr>
<td></td>
<td>Other</td>
<td>33</td>
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<tr>
<td>Body part</td>
<td>Back</td>
<td>37</td>
<td></td>
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<tr>
<td></td>
<td>Upper limbs</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>29</td>
<td></td>
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<tr>
<td>Type of accident</td>
<td>Over exertion</td>
<td>18</td>
<td></td>
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<tr>
<td></td>
<td>Suddenness, false movement</td>
<td>33</td>
<td></td>
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<tr>
<td></td>
<td>Cumulative</td>
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<tr>
<td></td>
<td>Impact</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>12</td>
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</tr>
<tr>
<td></td>
<td>Other</td>
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Table 3

<table>
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<th>Accident</th>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td></td>
<td>3 years</td>
<td>3 years</td>
</tr>
<tr>
<td>Number</td>
<td>99</td>
<td>213</td>
</tr>
<tr>
<td>Days of absence</td>
<td>2168</td>
<td>10,895</td>
</tr>
<tr>
<td>Absence: average duration</td>
<td>22</td>
<td>51</td>
</tr>
</tbody>
</table>

Table 4). The truck gradually became the most frequent place of accidents, as opposed to customer site. The proportion of accidents linked to handling activities remained stable, but the contribution of these accidents to absences increased significantly (Abs: 54% vs. 65% vs. 79%). Conversely, the proportion of accidents associated with moving about (N: 22% vs. 18% vs. 11%; Abs: 38% vs. 17% vs. 7%) and placing cases (at customer site) strongly decreased (N: 21% vs. 16% vs. 9%; Abs: 14% vs. 25% vs. 4%). The impact of the restricted underfoot surfaces remained stable.
3.2.2. Deviations. With a few exceptions, differences in deviations were also not especially marked. Difficult or particular circumstances were more often reported, especially in terms of space, but not unexpected events. However, the distribution of unexpected events evolved: situations involving unsteadiness decreased significantly, while those involving defects increased. The profile related to activity dysfunctions, except for problems of control, which increased sharply in the fourth year, remained stable.

3.2.3. Changes in the type of accidents and injuries

The proportion of MS injuries remained quite constant (around three out of four). However, three important changes in the pattern of injuries occurred.

3.2.3.1. Body area injured. Upper limb areas, in particular the shoulder, replaced the back as the most injured body area. In the past, absences due to back injuries were twice as frequent compared to absences due to upper limb injury. Following the transformations, the opposite was nearly true.

3.2.3.2. Type of injury. Before the transformations, “-itis” type diagnoses were infrequent; they were associated with 7% of absentee days. After, they accounted for a third of absentee days (avg. Abs: 91 days). Thus, the seriousness of reported injuries, as opposed to their proportion of the total number of accidents, increased markedly.

3.2.3.3. Type of accident. Impact was less marked. There were slightly fewer impact-type accidents, and more workers linked their injuries to a cumulative effect (e.g., a difficult day) or to a previous injury condition than to a specific event. This difference was still evident at the fourth year, where it explains nearly one in five
absences (N: 4% vs. 16%; Abs: 3% vs. 22%). In contrast, the seriousness of suddenness-type accidents decreased from 44% to 27%.

4. Discussion

In the first part of the discussion, results will be reviewed with regard to current theories on musculoskeletal injuries and risk factors. The impact of transformations and management decisions on accidents will be discussed in the second part. We will terminate with the limits of the study. As explained in the Method section, accident analyses raised issues that were conveyed to various people during the study. Elements relevant to the interpretation have been integrated into the discussion.

4.1. Accident profiles vs. theories of injury

The results show that increased workload due to longer shifts as well as the deregulation of quotas for number of cases to be delivered had a general impact on the rate of accidents (Cumulative Load Theory). The workers themselves associated their injuries more often to an accumulation of strains than to a specific event. Delivery work can be considered, in part, repetitive, i.e., the unloading and placing of cases, interspersed with transport operations, communications with customers, and driving. The more quotas increase, the more the repetitive dimension becomes significant, particularly for the upper limbs, and the more it approaches highly repetitive work as defined by Silverstein et al. (1987), i.e. a cycle of 30 s or less, or the same activity representing more than 50% of working time. Usually, it is difficult to demonstrate the impact of repetition through accident studies. In this study, we were able to do so because we had access to accident records prior to and following significant transformations that increased daily workload and repetition by introducing a 4-day week and eliminating the maximum daily quota. Mostly, however, this increase seemed to have had an impact on the severity of injuries. Fatigue, therefore, increased the risk of injury at two levels. The general increase in accidents not restricted to specific circumstances suggests that the effect was systemic.

Injured workers only occasionally referred to situations involving overexertion, which were not usually associated with the load itself, but rather, to a particular event such as a case being stuck. Tissue overstrain appears to be linked more often to a deviation of work practice, a sudden action related to effort or movement than it is to an overexertion or overload per se. In fact, Overexertion Theory, based largely on accident statistics, may partly reflect a classification bias regarding national statistics. Indeed, most classification systems start with the injury and work back to the activity. Once a handling activity is mentioned, encoders may be quick to use the designated code “overexertion” because it is the only category proposed, even if the injured worker did not describe the injury as such. This leads to confusion between a worker who specifically indicates overexertion and an event that actually causes tissue overstrain.

Results related to suddenness also bring about other perspectives. Until now, suddenness has been explored mostly in relation with load weight (unexpected, overestimated, or unbalanced) and sudden release. This is typically encountered in the transport industry, where load formats and weights vary greatly (Lortie et al., 1996). This is not the case in delivery settings, where sudden effort or movement occurs because a material element breaks or becomes stuck. Another major source of suddenness is the recoil effect of an exertion suddenly being stopped. This could be due to a protruding nail or a warped pallet preventing a case from sliding. Thus, a wide array of events can cause a sudden reaction. Unfortunately, these events, which probably only occur occasionally during a workday, are easily overlooked in normal work situation analyses. Such events are absent from rating systems, which are mainly developed for simple and repetitive situations. Differentiating between risk and risk factor may be a first step in accounting for these deviations. A risk factor, which is an epidemiological concept, is a mathematical relationship between the factor and the injury. A risk, as safety concept, is assessed in itself in terms of frequency, potential severity (or consequence) and number of people exposed.

Regarding the Differential Fatigue Theory, delivery tasks may be considered as asymmetric repetitive loading tasks because cases are generally manipulated with one hand. Delivery workers also consider that developing the ability to work on both sides of the body is important so they can choose the best position and avoid overusing one side. It is difficult to say to what extent workers can compensate for this asymmetry to avoid differential fatigue. In contrast, results are compatible with the Multivariate Interaction Theory. However, more than interactions, the study shows the importance of context in interpreting risk. For example, when a case is stuck, a sudden release will probably lead to a loss of balance that can be compensated in various ways depending on the context. If a box is high and far, the shoulder will be in a vulnerable position and will absorb the recoil at the limit of its capacity. The roll of the feet in controlling balance (foot placement direction, foot placement width) is well known (Holbein and Chaffin, 1997; Pan et al., 2009). The effect of the recoil is thus exacerbated if the worker is in a climbing position. The compact dimensions of the support slabs or areas have been shown to hinder control (McClothlin et al., 1996). Thus, seriousness of injury may increase due to the convergence of several factors.

The study also demonstrated the complexity of interactions, not necessarily through numbers, but by understanding the various difficulties that manual handlers may face. For example, it is plausible to assume that the work has become more difficult for shorter people (or those with shorter arms); on the other hand, the latter have an advantage in a climbing position. At the psychosocial level, strained customer relationships are a source of stress for which accelerating the pace may be one response. The desire to finish in order “to beat the traffic” also increases the pace and therefore the risk of injury. However, these psychosocial factors seem to be primarily determinants, or contextual factors, and addressing them as risk factors creates confusion.

Indeed, the study evidenced another type of interaction: to avoid incidents, delivery workers developed various modus operandi to adjust to the transformations. This adaptation process would explain the decrease in the severity of injuries associated with suddenness observed at the fourth year. However, these adjustments may have promoted the development of chronic conditions by increasing workload or strain for some joints. In particular, to prevent cases from becoming stuck, deliverers/handlers began moving them over an edge by lifting them rather than sliding them horizontally; this was reported as hard on the wrist, as the hand must be in supination and the shoulder in external rotation. The strain is particularly significant when the cases are high. Delivery workers held more fragile cases from the bottom, a precautionary practice that systematically increases length of effort.

Finally, the analysis shows that none of the risk factors for which evidence of risk is considered clear (Marras, 2000)—presence of lifting/forceful movements, awkward postures, whole body vibrations—played a significant role here. Delivery workers are exposed to whole body vibrations but not for long periods. This, however, may contribute to accidents through back fatigue. Lifting/forceful movements were not particularly characteristic of this type of work, in which the most important part of handling activities consist in pulling (with a small vertical component) and guid-
ing prior to deposing. None of these risk factors were significantly cited in the accident description. Nonetheless, the work performed clearly involves risks that can be described more than they can be measured.

Indeed, the role of incidents and deviations as risks has been little studied or considered in the development of MSDs and are essentially unaccounted for in existing standards and rating systems. Furthermore, the determinants that play an important role in their occurrence are also unaccounted for in recommendations. An example here is the quality of cardboard: the less thick the cardboard, the more easily bottoms of boxes catch or break.

4.2. The impact of organizational transformations on MSDs, and the importance of context

In a case study of a serious accident that occurred in a dynamite factory, Le Coze (2009) showed how organizational transformations and the decision-making process played an important role. In our case, an increase in work periods produced a series of cascading effects, the most important being the acquisition of larger trucks, which resulted in higher loads requiring more climbing. As explained previously, working at heights increases the difficulties for the upper limbs. Climbing increases the work required to maintain balance and hinders transfer actions since the feet cannot move freely. Foot mobility, as such, helps avoid twisting of the back and plays an important role in incident recovery. Other decisions had an impact on increasing unexpected events or making conditions more difficult (the above-mentioned thinner cardboard boxes, warping of poorer quality pallets, less quality control, etc.). Another effect, as explained above, was the use of less efficient strategies to prevent potential accidents.

Kjellen et al. (2008) stress that losses due to accidents should be weighed in the decision-making process alongside other issues. In our case, there is no evidence that the study of past accidents would not have been useful in predicting the impact of decisions. Nevertheless, the data was helpful in understanding what actually happened. Indeed, only a thorough knowledge of the handling activities of delivery workers would have allowed raising flags, and the potential impact of several decisions was indeed predictable.

The study shows the necessity of developing knowledge and tools that are more attuned to the issues on which decisions are made, which is a complex task. Such decision-making under complex conditions in which market conditions and alliances change rapidly and economic pressure is high; these elements are rarely included in prescriptive accident research (Dyrberg and Jensen, 2004; Rasmussen and Svedung, 2000). Various systemic models (e.g., strategizing models) try to integrate contextual theory concepts and approaches and to capture the “continual interaction contextually rooted within, outside, and between firms” (Dyrberg and Jensen, 2004). These strategizing models bring an awareness of context in understanding and affecting local activities. Data on the circumstances of accidents and the activities taking place at the time of accidents contains information on the role of context and provides clues that musculoskeletal injuries may also benefit from these perspectives.

This is also in line with the demands of practitioners in other areas, including health, in which two criticisms have taken shape in recent years. The first is that knowledge is produced and organized within a problem-solving perspective rather than a decision-making process (Woof et al., 1999; Browman, 2001), as is the case here. The second criticism is that recommendations do not sufficiently take into account the context and complexity of situations for which action is required (Carlsen and Kjellberg, 2010; Sankaran, 2006).

4.3. Limits of the study

Accident studies working from archives are invariably dependent on the quality of such archives, which, in this study, was good. In most cases, it was possible to decipher what had actually happened. Of course, the reporting of an accident is subjective. Nevertheless, the most important limit of the study is that the results are contextual. The picture may have been quite different in another company or in other sectors. Length of absences may have differed for sectors in which injured workers could be relocated. This data is sensitive to how the company is managed. However, this being an intra-company study, the first cohort may be considered a control cohort.

All analytical strategies have their limits and are a compromise. Here, the sequence of events was not directly considered. Scenario analysis would have allowed identifying the most frequent sets of combinations and their impacts. Regression analyses would have provided bases for modeling.

5. Conclusion

In general, most studies (and resulting norms or recommendations) are focused on four broad categories of factors: load characteristics (size, weight, grip, etc.), amount (duration, frequency), spatial context (height, distance, etc.), and posture (flexion, asymmetry). This study shows the potential importance of other factors whose action is contextual. Analyzing accident descriptions, which are an often overlooked and underutilized source of material, allows exploring these elements, identifying practical transformation avenues, and better grasping the impact of transformations based on an understanding of interactions. Accidents and MSDs result from a complex set of factors that interact and that must be understood according to their own logic. The problem is to operationalize such analyses and to find a balance between the simplicity of risk analysis and the complexity of systemic models.

Acknowledgment

This study was supported by the Natural Science and Engineering Research Council of Canada and the participating company.

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Stress 17 (4), 321–336.


