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Research into cases of slips, collisions and other movement disturbances occurring in work situations in a hospital environment.

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** This article is a tribute to the memory of our colleague and friend, Michel Monteau, who died suddenly in July 2011.*

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Research into cases of slips, collisions and other movement disturbances occurring in work situations in a hospital environment

Abstract

Slips, collisions and other accidental movement disturbances are very common in work situations and occur in every occupational activity sector. Research into these accidents was conducted at a hospital, based on analysing collectively and in-depth cases of accidents involving movement disturbance. This revealed accident factors of various types as closely associated with the physical environment and task performed as with the work organisation. These factors were categorised under the heading of generic factors and the difference between a situation not causing an accident and a situation causing an accident was characterised for Occupational Accidents with Movement Disturbance (OAMD). Our results provided confirmation of the importance of extracting recurrent scenarios for OAMD in each activity sector and of progressing, from a methodological standpoint, in building these types of scenarios. The concept of “circumstantial hazard” introduced to model the OAMD proved to be wholly relevant in cases of accidents occurring in a hospital environment.

Keywords: slips, trips and falls, movement disturbance, occupational accident, recurrent scenario, hospital.

Research into cases of slips, collisions and other movement disturbances occurring in work situations in a hospital environment

1. Introduction

1.1. Significance of research and accidents targeted

The CNAMTS (Caisse Nationale d'Assurance Maladie des Travailleurs Salariés – [French national health insurance fund for salaried workers], 2012) recorded 669.914 occupational accidents with days lost in 2011 for companies operating under the French general social security system. 32% were slips, trips, jams, collisions or other movement disturbances, except falls resulting from situations involving work at height. The significance of these accidents in terms of both frequency and seriousness is greater in the public hospital administration and private healthcare facility sectors than in all other activity sectors. Hospital employees, irrespective of their occupational activity, are victims of falls during the course of their work and, more generally, of collisions, jamming or other movement disturbances. Bell et al. (2008) report that the rate of occurrence of “slips, trips and falls on the level” at hospitals, calculated by the Bureau of Labor Statistics for the year 2007, was 35.2 per 10,000 full-time equivalent employees, i.e. 75% higher than the calculated mean rate of occurrence for all other private industries. Canteen, emergency medical transport and housekeeping/maintenance services were most frequently concerned, while the largest number of accidents involved the most represented occupations, namely nursing and administrative services staff. An epidemiological study conducted at a hospital in the Netherlands shows that falls are the most frequent accidents and that housekeeping and maintenance employees are those most affected by occupational accidents (Pines et al., 1985). The literature concerning this type of accident focuses mainly accidents designated under the acronym STF (“Slips, Trips and Falls”) (Buck and Coleman, 1985; Chang, 2008; Bentley, 2009) or under “falls on the level” (Ballance et al., 1985). More specifically, “slipping” (Gronqvist and Roine, 1993; Quirion et al., 2008) or “underfoot accidents” (i.e. those in which the initial unexpected event occurs between the foot and the ground) (Manning et al., 1988) have been studied. The range of accidents considered within the scope of this study is, in fact, wider since it includes slips, collisions and any other movement disturbance occurring under working conditions, except for disturbances leading to a fall from a high level. Cases of Occupational Accidents with Movement Disturbance (OAMD) were consolidated into an operational accident (OA) category defined operationally by Leclercq et al. (2009; 2010).

1.2. Current general conception of occupational accident genesis

In the Kjellen (2000) review, current occupational accident models integrate *contributing factors* and *root causes* upstream of the accident process, in which the risk manifests itself. However, OAMD are very often only attributed to floor condition or victim carelessness. In-depth analysis of such accidents has nevertheless revealed contributing factors distant from the injury, such as equipment usage (Kines, 2003), access system configuration (Leclercq et al., 2007), work system design (Derosier et al., 2008), work organisation (Leclercq and Thouy, 2004) or safety management (Bentley and Haslam, 2001).

1.3. Recurrence of accident factor combinations

Studies focusing on analysis of this type of accident at a number of companies have shown that the same accident factor combinations often result in bodily injury (Leclercq and Thouy, 2004; Leclercq et al., 2007). These findings have oriented further research towards identifying such combinations in each activity sector or company. The authors designate these combinations of factors as recurrent scenarios (Cuny et al., 2010). Representing accidents by combinations of factors, rather than by isolated factors, allows us to characterise more closely accident-causing situations since an isolated accident factor (congested floor, person running, etc.) is more representative of a usual work situation than of an accident. Furthermore, an event that has contributed to accident occurrence can sometimes only be considered an accident factor in the context, in which it has occurred. It may indeed be a safety-related factor in another context! For example, knowledge of a location is a safety-related factor, when the person anticipates a step (abrupt change in level) at a location where it is unforeseen (e.g. in the middle of a corridor). This same knowledge can be an unsafeness-related factor, when there is an unfamiliar obstruction and the person, trusting his/her knowledge of the location, does not notice it. Characterising an accident by a combination of factors rather than an isolated factor therefore allows us to appreciate the accident genesis in a more realistic manner.

2. Research project development in the field

2.1. Framework in which research was conducted

The management and “Comité d’Hygiène, de Sécurité et des Conditions de Travail” [committee for health, safety and working conditions] (CHSCT) at an “Assistance Publique – Hôpitaux de Paris” [French public hospital in Paris sector] (AP-HP) hospital decided to achieve practical progress in preventing accidents often associated with an occupational movement which, to date, had not been the subject of special attention, despite having been revealed as both frequent and serious. The establishment therefore adopted a prevention

strategy with the ultimate aim of identifying prevention actions suited to accident-causing work situations at this hospital and of making decisions in relation to their implementation. This system fell within the scope of a wider commitment of the hospital to meet both quality and safety requirements. The hospital, providing 459 beds and 22 outpatient vacancies, provides all forms of healthcare. Roughly 1,800 professionals work at the hospital.

2.2. System set up

A system was set up based on an in-depth study of accidents, in other words phenomena whose origin and genesis lie in the operation of a specific system for producing goods or providing services, whose performance mechanism is recognised as complex.

A group of more than 20 persons was formed. This was composed of an occupational physician, CHSCT members, the local manager responsible for working conditions, hospital and administrative department management personnel and, subsequently, a medical representative in charge of health surveillance. This group was led by an AP-HP internal occupational risks prevention consultant. After collection, the study data was duly processed and developed. For this purpose, group members were trained¹ in recording information and applying a method of systemically analysing occupational accidents called the “Causal tree” (Krawsky et al., 1972) or the “INRS model” (Kjellen, 2000). This method allowed us to highlight all the work situation-generated events, which contributed to injury occurrence. “Causal Tree” method which is sometimes confused with FTA method (Fault Tree Analysis Method) is presented in Krawsky et al. (1972) and in Monteau et al. (1997). Lastly, it must be pointed out that regarding the system set up, qualitative approach was favoured in this research.

2.3. Recording of relevant data and their initial usage

A team of analysts excluding all persons from the department, in which the accident took place, therefore intervened as soon as possible after the accident and, collected the accident-causing events, working in pairs when possible. These events were then subjected to systematic examination based on application of the “Causal tree” method, starting from the injury-causing event (first known event) and, for each subsequent known event, by asking “What event was necessary for its appearance?” and “Was another event necessary?”. This process was continued until a “no” answer was given. The events required for generating a known event then constitute a combination of background events relevant to this known event. The results obtained for each case characterised in this way formalise the logical combination of factors involved in the accidental injury, as shown in Figure 1. These results

¹ The analysis group also complied with a number of ethical rules, such as refusing to investigate responsibilities in terms of personal implication, refusing to interfere in recognition or dismissal of the accident’s occupational nature for compensation purposes, voluntary participation of victims, witnesses and the manager of the department, in which the accident occurred, and respect for their anonymity, when reporting the analysis.

were then discussed and validated by the victim, the witnesses and the manager of the department, in which the accident took place².

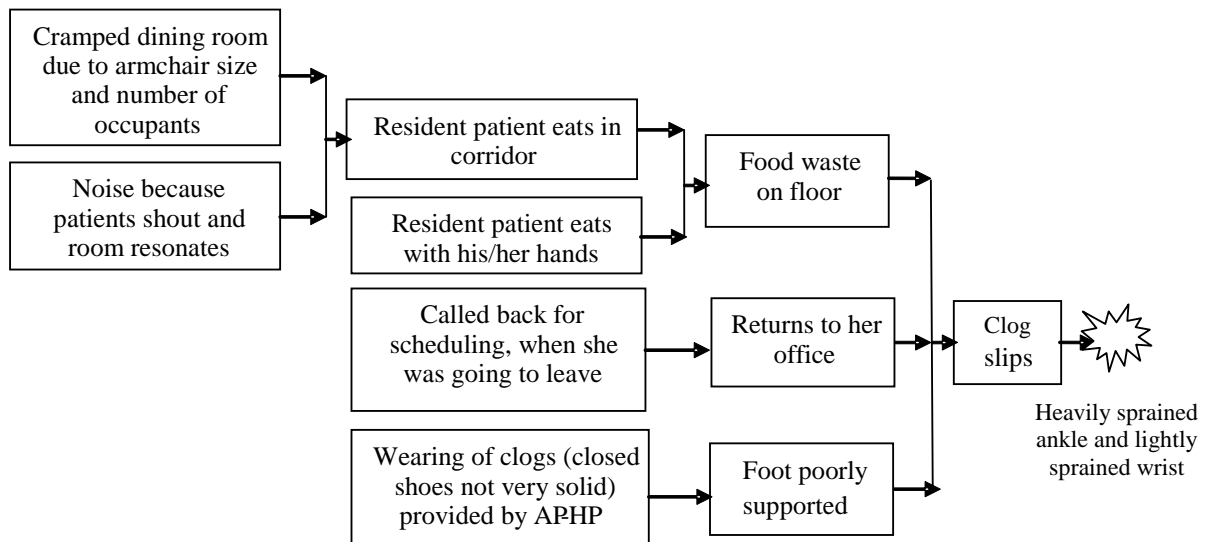


Figure 1 : formalisation of results for a specific accident provided by analyses inspired by the causal tree method

The methodology has been defined to minimize the subjectivity inherent in any analysis of accident and in particular in analysis of OAMD where the part played by some accident factors in the injury genesis may be debatable.

2.4. Grouping of OAMD singular factors under generic factors

Construction of recurrent scenarios, a notion that is detailed in the introduction and described by Leclercq and Cuny (2007) and Cuny et al. (2010), requires extraction of combinations of factors, which have contributed to an injury and are common to several accidents, from a set of OAMD. At least a hundred analysed accidents are required to achieve this objective, which also assumes that singular accident factors, by definition specific to the accident to which they refer, are consolidated under the heading of generic factors, which become factors common to the genesis of several accidents (Cuny et al., 2010).

In the same way as the singular accident factors included in Figure 1, generic factors are combined to build up a partial genesis of the accident, which led to injury. In this genesis, occupational accident models distinguish the final sequence of the accident specific to this phenomenon (Cuny, 2003). This sequence is called the “accident process” by Kjellen (2000)

² The analysis group then discussed and assessed possible prevention actions emerging from the relevant accident case. Their cost, implementation time, scope, possible transfer of risk caused by their implementation and impact on quality of patient care were specifically discussed. The analysis results and the prevention actions were subsequently consolidated in a document and forwarded to the hospital general management and the CHSCT for decision.

or the “accident sequence” by Laflamme (1990). Monteau et al. (2009) and Leclercq et al. (2009) have modelled this sequence in cases of OAMD. This model, illustrated in Figure 2, represents the logical sequence of generic events, which led to injury in OAMD cases, focusing on the accident final sequence. In these particular accident cases, the injury results from interaction between the victim’s (disturbed) movement energy and an element of the environment, e.g. a wall, when the victim injures himself/herself when colliding with the wall. This environmental element, which contributes to causing the injury, very often does not appear dangerous at first sight unlike, for example, machine parts that are moving and accessible or a high voltage electrical source (referred to as obvious hazards in Figure 2). Moreover, this element only contributes to injury if it is combined with movement disturbance. This is why the authors have suggested calling this element a “*circumstantial hazard*”. Generic factors will be identified based on this model and by consolidating singular factors under a generic heading.

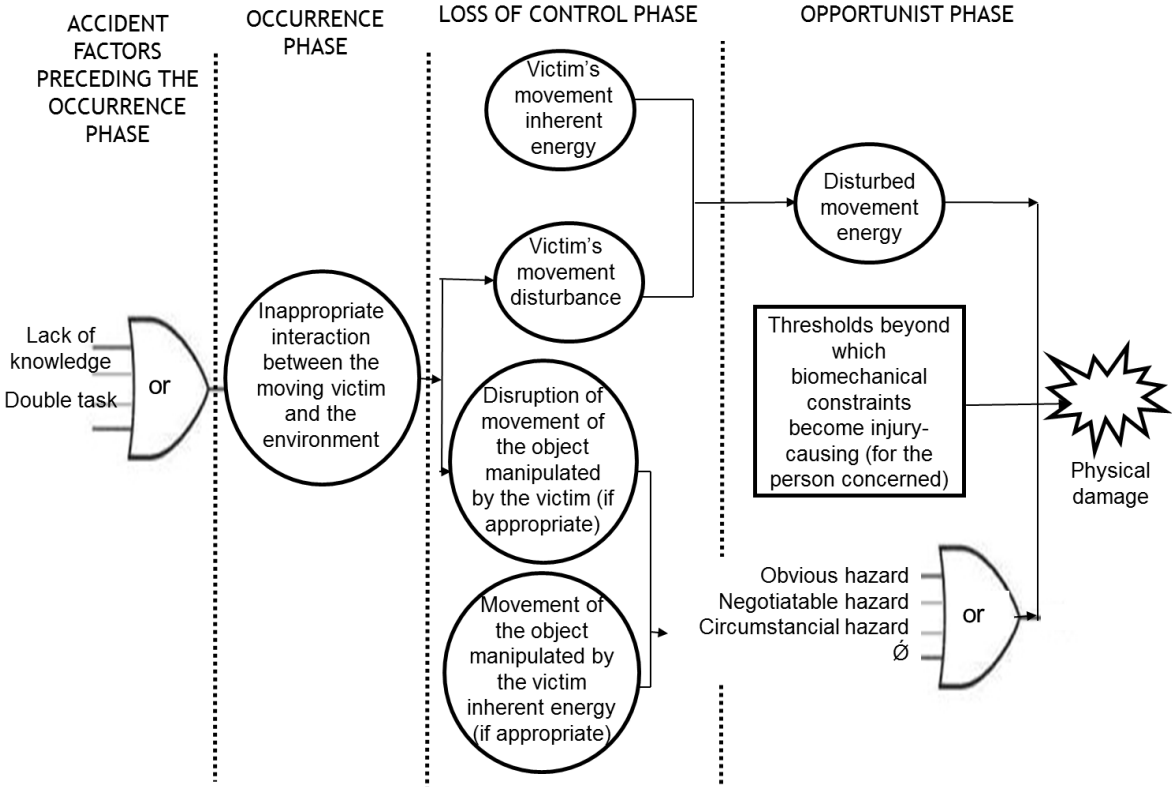


Figure 2 : Model of the final sequence of an accident caused by victim movement disturbance (taken from Leclercq et al., 2009)

3. Results

3.1. Singular OAMD factors

Investigation and analysis of each accident took place over a period of two months on average. This time period can be explained by the necessary phase involving group analysis tool apprenticeship and self-sufficiency and by the need to respect multi-disciplinary work. Only 10% (18) of the accidents that occurred were analysed for these reasons. Among these 18 accidents, 15 complying with the OAMD definition provided by Leclercq et al. (2009; 2010) were considered for inclusion in this paper. Thirteen of these 15 accidents were sustained by healthcare personnel, 1 was sustained by an administrative employee and another by a laboratory technician. Nine of the 15 accidents concerned led to no lost days of work and 6 led to lost days of work. At least 5 of these accidents occurred within one hour of arriving at work or during the hour before leaving work. All accidents took place inside the buildings (corridor, hall, patient's room, laundry room, document storage room, changing room) composing a pavilion-based hospital facility. Most of them occurred when walking, even though the victim was often performing another motor activity at the same time (carrying a stretcher or object, opening a door, moving a meal tray closer, etc.). The analyses revealed "permanently or long-term" existing accident factors in certain accident situations (insufficient lighting in an airlock, improperly fixed floor plate, etc.) and other events encountered more or less occasionally (damp floor after cleaning, dust accumulation after work in an electrical cabinet, etc.). They prompted implementation of actions involving not only walking surface evenness, decongestion and room lighting but also available equipment, activity organisation and the therapeutic design for one patient.

3.2. Generic OAMD factors

Although the number of available cases in this study does not allow application of statistical methods of extracting generic factor combinations, it nevertheless does prompt progress in consolidating singular OAMD factors under the heading of generic factors, existing in hospital environments.

3.2.1 Linking of two generic events characterising the accident final sequence

Among all those leading to injury, a linking of two generic events characterises most accidents involving movement disturbance: disturbance of the movement during task performance followed by the injury-causing event. This linking, shaded in Figure 3, is preceded by a factor combination of variable structure and component factor type.

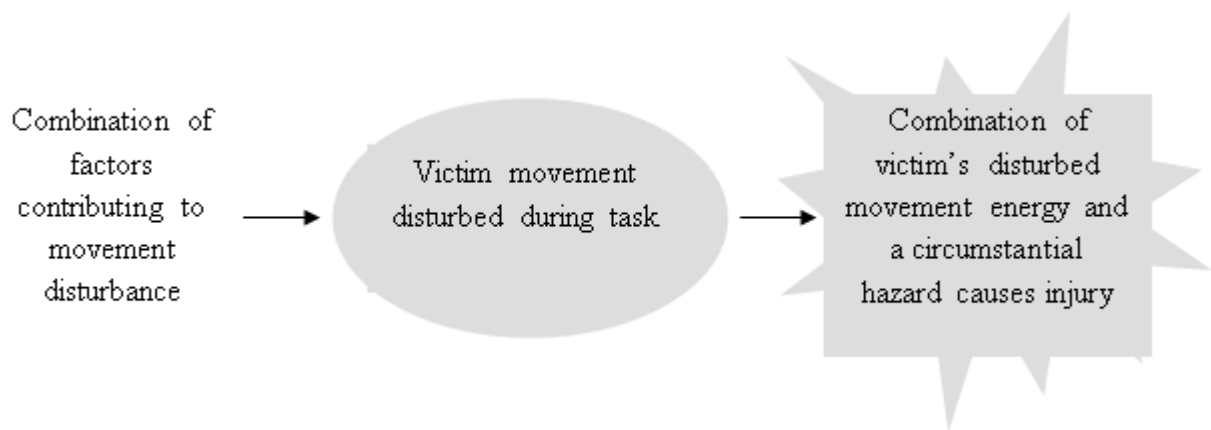


Figure 3 : Logical linking of generic factors in 15 OAMD cases

In the 15 accident cases considered, the physical cause of injury was a “circumstantial hazard”, in other words an element of the environment close to the victim which, neither a priori nor a posteriori, called for any prevention measure but which played a part in inflicting an injury. This physical element has been termed an “agent associated with the accident” in an IRSST study of accidents occurring in a hospital environment (Saint Vincent, 1995). Four types of “agent associated with the accident” were identified: usual room furnishings (item of furniture or equipment generally present in a hospital room on a permanent basis, except for wheelchairs), wheelchair, another mobile equipment item and a structural element (door, wall, window, floor).

Unlike in the IRSST study, healthcare personnel does not, in this case, form the only considered population and the patient’s room is not the only location of accident occurrence. Three general categories of “circumstantial hazard” or “physical cause of injury” can be envisaged here: a structural element (door, floor, etc. in 11 cases), a fixed item of furniture or equipment (cupboard, etc. in 1 case) and a mobile item of furniture/equipment (stretcher, wheelchair, etc. - in 3 cases). These distinctions may be helpful in describing more accurately the final accident sequence during recurrent scenario building.

Table 1 consolidates singular accident factors associated with movement disturbance, during task performance, and singular factors associated with the injury inflicting event. Generic factors were hence defined by extension, i.e. after consolidating singular factors based on an equivalence criterion considered relevant to causing the accident and on the content of each class thereby created. One or more levels of generality can be considered, depending on the degree of accuracy of the factor title (cf. Table 1).

Movement disturbance during task performance assumes widely varied forms: A slip (9 cases), a collision or a trip (3 and 2 cases respectively), jamming (1 case). In every case, the movement made during the work activity was unexpectedly disturbed.

Table 1. Consolidation of singular factors associated with final sequence of an accident involving movement disturbance (cf. Figure 3) – Each generic factor is associated with the number of singular factors consolidated under its title shown in brackets.

| 3rd level of generality generic factor | Movement disturbance | | | Injury causing event | | |
|--|--|--|---|--|--|--|
| 2nd level of generality generic factor | Victim's movement is disturbed during task (15 cases) | | | Combination of victim's disturbed movement energy and circumstantial hazard cause injury (15 cases) | | |
| 1st level of generality generic factors | Victim's movement is disturbed when walking when walking (10 cases) | Victim's movement is disturbed when handling an object (3 cases) | Victim's movement is disturbed when transporting or handling a patient (2 cases) | Combination of victim's disturbed movement energy and structural element cause injury (11 cases) | Combination of victim's disturbed movement energy and mobile furniture/equipment item cause injury (3 cases) | Combination of victim's disturbed movement energy and fixed furniture/equipment item cause injury (1 case) |
| Examples of singular factors | <ul style="list-style-type: none"> • Victim collides with a wheelchair when walking with a pillow to give to a patient • Victim slips when walking and directing a resident patient • ... | <ul style="list-style-type: none"> • Victim slips when moving the meal tray closer to a child • Victim's movement is disturbed when opening a fire door • ... | <ul style="list-style-type: none"> • Victim collides with cupboard when installing resident patient in a wheelchair • Victim is pinned between recovery room door and stretcher, when transporting a patient with a colleague | <ul style="list-style-type: none"> • Bruised knee when falling on floor • Bruised when colliding with left-hand door, • ... | <ul style="list-style-type: none"> • Bruised when pinned between door and stretcher • Injured when hitting oneself on the chair back, • ... | <ul style="list-style-type: none"> • Elbow injured when colliding with the cupboard |

3.2.2 Generic factors preceding accident final sequence

The whole point of accident analyses is to explain the movement disturbance. In 7 out of 15 cases, a visible element in the work situation indicated higher risk of movement disturbance (e.g. food waste on the floor or cables hampering a displacement). These factors are obviously insufficient for explaining the disturbance since, most of the time, an employee applies the controls required to continue his/her activity by bypassing the obstruction, for example. In the other 4 cases, the victim's movement disturbance could not be visually anticipated. It was either an immediate consequence of the movement itself: a plate lifting, when a person puts his/her foot on it, and obstructing the course of the other foot or a door leaf, which is projected towards the victim when he/she pulls the other door leaf, or a colleague's actions when transporting a patient on a stretcher or those of a patient who stiffens, when moved, contribute to the victim's movement disturbance.

The results of the 15 in-depth analyses will allow us make statements and put forward hypotheses in relation to the accident factors that combine at a given moment to cause movement disturbance in hospital work situations. Table 2 consolidates singular factors, which appear prior to movement disturbance in the accident genesis, under the heading of generic factors (see Figure 3).

Table 2. Consolidation of singular factors involved in factor combinations logically preceding the final sequence of an OAMD – In brackets, number of singular factors consolidated under the relevant generic heading

| 2nd level of generality generic factor | 1st level of generality generic factors | Examples of singular factors |
|--|--|---|
| Dimensions and/or congestion and/or lighting and/or cleaning of rooms/areas make the movement/walking required for task somewhat difficult (8 cases) | Room/Area dimensions make the movement required for task somewhat difficult (2 cases) | <ul style="list-style-type: none"> • Bed very near cupboard • Tight turns to reach endoscopy |
| | Room/Area congestion makes the movement required for task somewhat difficult (3 cases) | <ul style="list-style-type: none"> • Corridor congestion • Cables running above floor • ... |
| | Room/Area lighting makes the movement/walking required for task somewhat difficult (2 cases) | <ul style="list-style-type: none"> • Poor lighting • Unlit airlock |
| | Room/Area cleaning makes the movement required for task somewhat difficult (1 case) | <ul style="list-style-type: none"> • Floor made more slippery by housekeeping |
| Equipment characteristics make the movement required for task somewhat difficult (3 cases) | | <ul style="list-style-type: none"> • Brake scarcely usable and bed in locked position • Wheelchair difficult to handle • ... |
| Interruption of activity | Victim's task in progress interrupted by an external event (4 cases) | <ul style="list-style-type: none"> • Telephone call in supervisor's office • Post-recovery patient requests pillow • ... |
| | Coactivity (1 case) | <ul style="list-style-type: none"> • Housekeeping in progress in sector |
| Interference between activities | Succession of activities (1 case) | <ul style="list-style-type: none"> • Partial cleaning after work in cupboard electrical cabinet |
| | Boundary area (2 case) | <ul style="list-style-type: none"> • Work nearby for about one month and a half • Work nearby |
| Task requires resources necessary to movement control | Situation requires working in emergency conditions (2 cases) | <ul style="list-style-type: none"> • Imminent arrival of sick child's mother, when child pulls out drip |
| | Situation requires a close attention to the task (1 case) | <ul style="list-style-type: none"> • Patient in difficulty and victim comes to assist doctor |
| Difficulties inherent to patients | | <ul style="list-style-type: none"> • Uncooperative patient |

4. Discussion

4.1. Changes in perception of OAMD and implemented prevention actions at hospital

Conducting the investigations and in-depth accident analyses prompted changes in the perception usually associated with this type of accident prior to the research project. Only two explanatory factors were usually advanced within hospitals: wearing of high-heeled shoes and the fact that floors were wet. However, the victims of the analysed accidents were wearing shoes provided by the facility and floor slipperiness was subject to multiple causes: food waste, dust, sprayed deodorant deposition in the room interacting with emulsion protecting and waterproofing the floor, occasional cleaning of a stain. Moreover, revealing of factors as varied as “a system malfunction allowing the patient’s bed to be moved”, “the fact that the victim was assisting the doctor with a patient in difficulty” or “presence of work nearby” also contributed to altering the view on these accidents. The individual’s attention or the state of the floor is no longer the only implicated factor. The task performed and, in the broadest sense, the environment, in which it is performed and the equipment used also play a part. Activity organisation is especially implicated because it partly determines the conditions, in which occupational displacements and movements are performed.

This project was the chance to formalise and make everyone aware of a healthcare personnel work characteristic, namely “usually walking fast”. The accidents studied in fact frequently revealed the victim’s rapid pace, although this did not represent a variation with respect to the usual pace, at which healthcare personnel moves.

Although initially perceived as an inevitable outcome, slipping or colliding was thus transformed as the first fruits of a service improvement process involving not only safety, but also quality of patient care.

The scope of implemented prevention actions is variable in both time and space. For example, fixing the floor plate in the archiving room prevents tripping on this unfixed plate. The scope of this action is very limited in space, while, its scope in time depends on how much the archiving room is frequented. The scope in time and space of building or maintenance work preparation to curtail coactivity will be all the greater, if many such sites are planned within the hospital. Thus, a posteriori analysis of OAMD enables a priori management of risk.

4.2. Generic factors and OAMD

Based on singular factors, usage of only 15 accidents allows us to extract generic factors, most of which occur recurrently in usual hospital work situations: time constraint, task interruption, floor slipperiness, etc. Just one of these factors is insufficient for causing the accident and none is permanently present in the work situations; **it is the unexpected combination, at a given moment, of “usual” events that causes this type of accident.** The factors involved here express better all the variability of usual work situations than the deviations with respect to more or less formal safety instructions.

Among these 15 accidents, recurrent appearance of certain factors (task interruption by an event external to the victim – present at the same level of the factor logical tree and leading to injury in 4 accident cases) and knowledge concerning factors likely to have an impact on movement control performance (emergency/cognitive load) support the hypothesis of these factors playing a part in accident occurrence. Their necessary consideration in explaining the OAMD comes up against difficulties, such as their difficult objectification in some cases and uncertainties in their movement control action mechanisms. Kim and Young (2003) call factors, which influence operator behaviour, “Performance Shaping Factors” (PSF). Blatter et al. (2008) refer to influencing factors: “in every accident, there are events whose cause-effect relationships with the accident cannot be easily demonstrated, but which should not be definitely discarded and lost for this reason alone. We have called these possibilities of unproven causes “influencing factors”. Unproven or unprovable for a single accident, they can turn out to be invaluable in understanding accidents, if they are encountered with extensive correlation in a significant set of accidents of the same type”. This observation would partly explain the analysis difficulty, when an OAMD is involved.

These OAMD analyses show that the floor condition- and carelessness-related problems, to which we often reduce these accidents, indeed only represent the tip of the iceberg. In a population of only 15 OAMD, we in fact recurrently observe the presence of the following phenomena, more or less specific to this type of accident:

- **Recovery.** Taken up again by Faverge in 1977 and defined as follows: “a worker is in a recovery situation when he has to perform an unfamiliar, unforeseen task to restore a usual course of work”. Later, in 1980, the same author provided an extendable definition of recovery by assimilating it to adjustment and control. Thus, an operator in a work situation develops an activity aimed at performing the task entrusted to him/her and which requires adjustments and even recovery. For example, when a medical incident occurs (the child pulls out his/her drip), the employee implements every possible measure to restore the usual course of work (he/she returns the child to his/her bed and reconnects the drip). Specifically, the employee needs to displace himself/herself and move the child to achieve this. More generally, performing any activity requires executing movements and/or displacements, in which control is more or less easily maintained. Processes similar to recovery, which could be termed “**micro-recoveries**” are implemented at this level of activity (the movement). For example, in 2 OAMD cases, the moving victim changed itinerary in reaction to an obstruction or a difficulty (damp area, congestion) and returned a little later to the planned itinerary. This phenomenon (micro-recovery) is clearly similar to a recovery. However, its purpose in this case is to recover the planned itinerary and not the usual course of work.

- **Interference between activities**, whose accident-causing character was revealed in the early 1970s (Faverge, 1970 and 1977; Monteau, 2010) appears in different forms, when analysing these accidents:
 - ✓ **Interruption of activity in progress** by an event, to which the victim must respond and which requires modification of his/her movement/displacement, appears recurrently (in 4 accident cases) just before movement disturbance in the accident's genesis. Here again, accidentology research has already reported the impact of task interruption on activity performance (Merz, 1969). Work concerning management of interfering tasks has also provided information on the difficulties of this management, especially in work situations characteristic of healthcare personnel, in which the person is confronted by unforeseen occurrence of tasks for which it is difficult to implement control strategies based on anticipation (Prunier Poulmaire and Gadbois, 2004). OAMD analyses support the hypothesis that healthcare personnel movement control could also fail due to unforeseen interruption of their task.
 - ✓ **Co-activity**, a situation described and given this name by Cuny (CECA, 1969) appears in one accident case. It corresponds to task performance by persons pursuing different production objectives and required to share simultaneously the same workplace. **Succession of activities**, corresponding to uniqueness of workplace and not of time, appears in two accident cases and **boundary areas**, corresponding to different workplaces and simultaneous activities, appear in one accident case.

- **Employee inexperience or unfamiliarity with work practices** appears in one accident case. In this specific case, a colleague newly arrived in the department, who was carrying a stretcher with the victim did not comply with usual movement practice and this caught out the victim.

- **Other work organisation-related factors** such as delay in removing equipment written off or medical examination scheduling procedures.

- **Characteristics of working areas or specific difficulties when using equipment** (when they do not facilitate movement performance or displacement required by the task) appear recurrently in OAMD occurrence. In particular, working area dimensions are sometimes unsuitable for the function dedicated to this area, thereby contributing to occurrence of these accidents.

- **Factors expressing the fact that, at a given moment, the task requires missing resources for efficiently controlling the movement:** moving in an area, in which there are always cables (in the recovery unit), while responding to a medical emergency, walking while putting on gloves or giving full attention to a patient in difficulty.

- **Difficulties inherent to patients** appear in two OAMD cases. For Saint Vincent et al. (1999), these difficulties, in particular unexpected patient behaviour, represent the most common factors involved in accidents occurring when transferring patients.

Conclusion and prospects

The research described in this paper implements and utilises in-depth analysis of 15 OAMD cases, which occurred in a hospital environment. It confirms the variety of factors contributing to movement disturbance genesis and the importance of such analyses, when conducted locally and collectively to prompt emergence of priority actions that should be initiated in the work situations considered. The multidisciplinary structure of the accident analysis group and the contribution of both the victim and his/her departmental manager allow us to compare existing logics and viewpoints and to develop proposals based on the reality of work. However, this type of research requires extensive time, which may restrict the number of cases collected in a facility producing goods or providing services. Nevertheless, it does contribute to not only improving safety, but also promoting the other missions of such a facility. The quality of care offered to patients was also effectively enhanced within the scope of the presented project, whose aim was to improve the safety of hospital staff.

A number of factors were identified based on the OAMD occurring at hospitals. These reflect the specific characteristics of work situations in a hospital environment, for example interruption of the healthcare worker's task to answer a patient's call or slipperiness of floor coverings, which are often smooth for reasons of hygiene. This prompts one to seek OAMD scenarios based on activity sector. Finally, an OAMD victim explained that she had not been aware of floor slipperiness because, when she was walking over it a few minutes earlier, it was not slippery and nothing in the work situation had led her to believe that it would become slippery. She had therefore acted according to the view she had of the work situation at that specific moment. Hence, it appears important to understand in depth how an employee in a necessarily changing, given situation ensures his/her movement control and thus his/her safety, while performing his/her task.

Within the scope of this project, research on OAMD reveals or confirms three characteristics of these accidents, which make their analysis and/or prevention especially difficult. Firstly, the idea of circumstantial hazard highlights the fact that, in very many OAMD cases, no intrinsically harmful element is a direct cause of injury, unlike a high-voltage source or machine moving parts. Every element in a work physical environment is likely to contribute to causing injury, when it happens to be combined with the operator's disturbed movement energy. The concept of hazard in accidentology frequently refers to an element that is obviously and inherently dangerous, and external to the victim (e.g. Khanzode et al. (2012)) and takes little account of this specific characteristic of OAMD. The latter effectively precludes implementation of actions intended to prevent contact of a target with a hazard, a priori identified as such, and makes a-priori risk assessment more difficult (Leclercq et al., 2010).

Secondly, certain OAMD cannot be correctly interpreted without seriously considering factors, whose contribution is not easy to reveal due to uncertainties with regard to their way in which they intervene in movement control. For example, these could be factors such as tiredness or stress. The recurrent presence of these factors in accident-causing situations reinforces both their potential role in accident occurrence and hence the importance, already highlighted, of extracting recurrent OAMD scenarios.

Thirdly, an OAMD is often caused by a novel combination of usual events occurring at a given moment. For example, none of the following accident factors is permanent in the work situation, but each one is occasionally observed: “temporary equipment storage to meet the needs of the activity”, “arrival of a number of patients exceeding reception capacity” and “emergency call for a nurse already otherwise occupied”. None of these events refers to non-compliance with instructions and each of them may be more or less frequently present in a usual work situation. The difference between accident and accident-free situations is therefore difficult to detect from a single accident factor in most OAMD cases, which makes a-priori risk assessment especially problematic. This difference echoes the concept of deviation, which is central to accidentology and, as Lortie (2012) stresses, is nevertheless rarely taken into account in the event of a fall or collision.

Finally, this research confirms that it will be possible to identify recurrent scenarios by analysing more OAMD cases. These will contribute to a more exhaustive a priori assessment of a major occupational risk existing in every activity sector and will further predispose those concerned to implement collective, local prevention strategies. While representing one of the prime accident categories in terms of frequency and seriousness, OAMD are in fact almost never targeted by such strategies, which tend to target risks specific to a facility. In a hospital environment, these would be musculo-skeletal disorders related to handling and accidents resulting from exposure to blood.

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References

Ballance, P.E., Morgan, J., Senior, D., 1985. Operational experience with a portable friction testing device in university buildings. *Ergonomics* 28(7),1043-1054.

Bell, J.L., Collins, J.W., Wolf, L., Grönqvist, R., Chiou, S., Chang, W.R., Sorock, G.S.,

Courtney, T.K., Lombardi, D.A., Evanoff, B., 2008. Evaluation of a comprehensive slip, trip and fall prevention programme for hospital employees. *Ergonomics* 51 (12), 1906-1925.

Bentley, T., 2009. The role of latent and active failures in workplace slips, trips and falls : an information processing approach. *Applied Ergonomics* 40, 175-180.

Bentley, T.A., Haslam, R.A., 2001. Identification of risk factors and countermeasures for slip, trip and fall accidents during delivery of mail. *Applied Ergonomics* 32, 127-134.

Blatter, C., Blanchet, F., Barthelme, S., Leblois S. et Mazeau, M., 2008. Analyse des accidents du travail : vers une nouvelle approche pour l'analyse des causes. 16^{ème} Congrès de Maîtrise des Risques et de Sûreté de Fonctionnement – Avignon, France 6-10 octobre. Communication 7C-1, 8 p.

Buck, P.C., COLEMAN, V.P., 1985. Slipping, tripping and falling accidents at work : a national picture. *Ergonomics* 28(7), 949-958.

CECA, 1969. Recherche communautaire sur la sécurité dans les mines et la sidérurgie, Etude de physiologie et de psychologie du travail N°4, Luxembourg, CECA.

Chang, W.R., 2008. Special Issue on STFs – Preface. *Ergonomics* 51(12), 1797-1798.

CNAMTS, 2012. Statistiques Nationales des accidents du travail, des accidents de trajet et des maladies professionnelles. Paris: CNAMTS.

Cuny, X., Monteau, M., Leclercq, S., 2010. The typical scenario : towards extension of STF analysis. International Conference on Fall prevention and Protection. NIOSH, Morgantown, USA.

Cuny, X., 2003. S'agit-il d'un accident? Essai de caractérisation d'un phénomène particulier. *Performances. Santé et fiabilité humaine*, 9, 7-17.

Derosier, C., Leclercq, S., Rabardel, P., Langa, P., 2008. Studying work practices : a key factor in understanding Accident on the Level. *Ergonomics* 51(12), 1926-1943.

Faverge, J.M., 1970. L'homme agent de fiabilité et d'infirmité du processus industriel, *Ergonomics* 13, 301-327.

Faverge, J.M. 1977. Analyse de la sécurité du travail en termes de facteurs de risque. *Revue d'Epidémiologie et Santé Publique* 25, 229-241.

Faverge, J.M. 1980. Le travail en tant qu'activité de récupération. *Bulletin de psychologie* 23(344), 203-206.

Gronqvist, R., Roine, J., 1993. Serious occupational accidents caused by slipping. In: Nielsen, R., Jorgensen, K. (Eds), *Advances in Industrial Ergonomics and Safety V*, pp. 515-519. Taylor and Francis, London..

Khanzode, V.V., Maiti, J., Ray, P.K., 2012. Occupational injury and accident research: A comprehensive review. *Safety Science* 50, 1355-1367.

Kim, J.W., Jung, W.D., 2003. A taxonomy of performance influencing factors for human reliability analysis of emergency tasks. *Journal of Loss Prevention in the Process Industries* 16 (6), 479-495.

Kines, P., 2003. Case studies of occupational falls from heights: cognition and behavior context. *Journal of Safety Research* 34, 263-271.

Kjellén, U., 2000. *Prevention of accidents through Experience feedback*. Taylor and Francis, London.

Krawsky, G., Monteau, M., Cuny, X., 1972. *Méthode pratique de recherche des facteurs d'accidents*. Rapport 024/RE/A, 27 p. INRS, Vandoeuvre, France.

Laflamme, L., 1990. A better understanding of occupational accident genesis to improve safety in the workplace. *Journal of Occupational Accident* 12, 155-165.

Leclercq, S., Monteau, M., Cuny, X., 2010. Avancée dans la prévention des « chutes de plain-pied » au travail. Proposition de définition opérationnelle d'une nouvelle classe : « les accidents avec perturbation du mouvement (APM) ». *PISTES* 12(3), 16p.

Leclercq S., Monteau M., Cuny X., 2009. Occupational accidents with movement disturbance: in support of an operational definition. *Proceedings IEA2009 Congress*, Pékin, Chine.

Leclercq, S., Thouy, S., Rossignol, E., 2007. Progress in understanding processes underlying occupational accidents on the level based on case studies. *Ergonomics* 1(15), 59-79.

Leclercq, S., Cuny, X., 2007. Characterisation of accident-on-the-level recurring scenarios and risk assessment. *Symposium on Slips, Trips and Falls – Hopkinton (MA – USA)*. August 2007.

Leclercq, S., Thouy, S., 2004. Systemic analysis of so-called “accidents on the level” in a multi trade company. *Ergonomics* 47(12), 1282-1300.

Lortie, M., 2012. Analysis of the circumstances of accidents and impact of transformations on the accidents in a beverage delivery company. *Safety Science* 50 (9), 1792-1800.

Manning D.P., AYERS, I., JONES, C., BRUCE, M., COHEN, K., 1988.

The incidence of underfoot accidents during 1985 in a working population of 10000 Merseyside people. *Journal of Occupational Accidents* 10, 121-130.

Merz, F., 1969. Rôle des caractéristiques de personnalité dans les effets de l'interruption des tâches. In: C.E.C.A. Recherche communautaire sur la sécurité dans les mines et la sidérurgie (A- Sidérurgie). Editions de la C.E.C.A., Luxembourg.

Monteau, 2010. L'organisation délétère – La santé et la sécurité au travail au prisme de l'organisation. L'Harmattan, Paris, 375 p.

Monteau, M. 1997, Analysis and Reporting accident investigation, In *Encyclopaedia of Occupational Health and Safety*, 1, Genève, B.I.T., 57.22 – 57.25.

Monteau, M., Leclercq, S., Cuny, X., 2009. Les accidents consécutifs à une perturbation du mouvement. Nouvelle conception, nouvelle prévention. *Hygiène et Sécurité de Travail* 215, 13-18.

Pines, A., Cleghorn de Rohrmoser, D.C., 1985. Occupational accidents in a hospital setting: an epidemiological analysis. *Journal of occupational accidents* 7 (3), 195-215.

Prunier Poulmaire, S., Gadbois, C., 2004. Temps et rythmes de travail. In: Brangier, E., Lancry, A., Louche, C. (Eds). *Les dimensions humaines du travail. Théories et pratiques en psychologie du travail et des organisations*. PUN, Nancy, 670 p. ISBN : 2-86480-926-5.

Quirion, F., Poirier, P., Lehane, P., 2008. Improving the cleaning procedure to make kitchen floors less slippery. *Ergonomics* 51(12), 2013-2029.

Saint Vincent, M., 1995. Analyse des accidents survenus durant une année dans trois centres hospitaliers. Rapport IRSST, R-093, 85p. IRSST, Canada.

Saint Vincent, M., Tellier, C., Petitjean-Roget, T., 1999. Accidents that occurred in three hospitals in one year. *Safety Science* 31(3), 197-212.

Figures captions

Figure 1. Formalisation of results for a specific accident provided by analyses inspired by the causal tree method

Figure 2. Model of the final sequence of an accident caused by victim movement disturbance (taken from Leclercq et al., 2009)

Figure 3. Logical linking of generic factors in 15 OAMD cases