A SELF-ASSESSMENT TOOL FOR IDENTIFYING BEST RISK MANAGEMENT PRACTICES FOR HAZARDOUS MATERIALS CARRIERS

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ABSTRACT

Although numerous international and national laws regulate hazardous material transportation, it is quite difficult for a carrier to identify what would be the best practices in term of risk management in its organization. This paper presented the methodological steps that lead to the development of a self-assessment tool to help hazardous materials carriers to make the best choice about the sets of organizational safety practices that would help to reduce the risks related to HM transport. A survey has been conducted over 1,485 HM carriers in Quebec. The 211 answers were used to identify the OSPs that are the most used by the carriers. For a following analysis, we obtained individual record of each respondent from the Conduct Review Policy for Heavy Vehicle Owners and Operators (HVOO). The fusion of the two databases helped to understand the factors (size of company, differences between HM classes) that influences the number of safety events reported in the carrier's record. The study lead to the development of a self-assessment tool developed on a spread sheet application that may help HM carriers to pinpoint the best OSP given the size, the type of material and other attributes of the company to prevent accidents.

Keywords: hazardous materials, risk, transportation, logistics, organizational safety practices

INTRODUCTION

In most countries, the transport of hazardous material is strictly regulated to lessen the risks of environmental damage and human exposure. The abundance of regulations, combined to the inherent dangers of carrying such substances have brought the hazardous material carriers to evolve towards a set of organizational safety practices (OSP) ruling their daily operation. The number of OSP that can be put in place is high: company procedures, safety committees, focussed training, specific equipment, etc. At this moment, there is a need for the carriers to choose which OSP are suitable to their operations, which OSP has the higher impact on their risk level, and which one are the most effective to respond to the needs expressed by the population, the governments and their customers. Unfortunately, making such choice is not only to look to best practices of the industry, but also to be able to identify what are the effects of specific OSP.

This paper proposes a tool to help hazmat carriers, to better evaluate their own risk considering their transportation's characteristics (benchmarking among carriers) and also to choose the best OSP to implement to decrease their risk level. The methodology is twofold: first, a survey has been conducted to the 1,400 hazardous material carriers of the province of Quebec, Canada. The survey helped to identify which OSP are used by carriers, according to their characteristics. Second, the survey results have been cross-checked with the associated Heavy Vehicle Owners and Operators's (HVOO) record data (which contain informations on accidents, security infraction and mechanical inspections). This was done to identify which OSP are the most efficient according to the safety index of the carriers. Finally, the result of both steps has been integrated into a self-assessment tool that helps carrier to choose the best OSP according to their profile and their preferences.

The paper is organized as follow. After a literature review on hazardous material risk assessment, the methodology is presented, emphasizing on the design of the carriers survey and the integration of data from the Société d'Assurance automobile du Québec. The paper then presents the results of the survey and the cross-analysis done with the record data. It also shows the tool that has been developed from the results. Finally, the paper concludes with a discussion on the perspectives brought by this study.

BACKGROUND

The following literature review presents some aspects of hazmat transportation that are relevant to this study: risk analysis and the influence of organizational safety practices.

Risk analysis in hazardous materials transportation

In hazardous material transport, the risk is the combination of the probability of an event (accident rate) and its expected outcome (Erkut et al. 2007). Many factors may influence accident rate and their consequences: road type, vehicle type, shipment size, dangerousness of the product, attributes of the environment and the population surrounding

the location of the accident (Hwang et al. 2001). This list shows that many data must be available to correctly assess risk related to hazmat shipments.
Risk reduction measures fall into two categories: prevention (reducing the likelihood of an accident) or mitigation (limiting the consequences of an accident). The literature mostly focuses on prevention, typically through minimum-risk route selection. The goal is to select the road segments that will minimize the risk (combination of occurrence and consequences) on the whole trip (Erkut and Verter 1998). But this approach on routes brings additional costs for companies, because these minimum-risk paths may be twice as long as the shortest path (Abkowitz et al. 1991). Glickman and Sontag (1995) estimate that minimum-risk routes can cost up to 0.7 to 3.4 millions $ more per life saved.

The influence of organizational safety practices on risk levels

Hence, risk reduction in hazmat transport literature is mostly dedicated to technical aspects of the problem: routing, location, hazmat networks designs, equipment design, etc. However, organizational factors can also have a significant influence on risk. Studies report that human errors are often seen as the cause of most hazardous material accidents, but it seems that the working environment of carrier's employees could trigger these errors (Turner 1978, Glendon and Stanton 2000). According to Denis (1998), industrial accidents can have different causes: technological, environmental, human, organizational and even cultural.
Fernández-Muñiz et al. (2007) report that organizational factors that influence risk levels can be caused by a lack of instructions, procedures, training, safety rules or safety culture. Safety culture is complex to identify and therefore researchers often measure the safety climate of a firm instead, which is the manifestation of the safety culture at a specific time (Guldenmund, 2000).
Safety culture, revealed in this study by organizational safety practices (OSP), is a relatively new area of research. It is especially difficult to measure the impact of OSP on accident rates, but the link between them cannot be denied. Kawka and Kirchsteiger (1999) have shown that about 66% of all accidents are caused by safety management failures within companies. Another study found that the strength of corporate culture is negatively correlated with the accident rate (Silva et al. 2004). With such results, it seems that companies should pay more attention to OSP as a way to assess risks.
In hazardous materials transport, the decision making process is often shared between companies: producer, shipper, carrier, user. Producers and shippers may make strategic decisions like choosing the transport mode and the delivery frequency; however, the carriers, at the end, must find a way to carry the hazardous material in the less risky manner. In a previous study on hazardous material practices, we showed that while producers and shippers take appropriates on-site measures on site, they tend to overlook important security aspect in transportation (Leroux et al. 2010). For instance, few fixed installations always have long-term contract with carriers and many believe that a hazardous material transport accident involving subcontracted carriers would have no impact on their activities. In a context where manufacturers tend to increasingly outsource transportation, either partially (27.6%) or completely (53.3%) (Jalette 2003), this gives the burden of carriers to adopt OSP that will help them to assess the increasing risks of hazardous material transport.

METHODOLOGY

This section explains the three main methodological elements of this study: the carrier survey, the carrier' record database analysis, and the building of the self-assessment tool.

Carrier survey

The goal of the survey was to highlight hazmat motor carriers' practices, with a focus on safety management and the organizational factors that could influence risk levels.. It follows a survey conducted on companies handling hazmat (Leroux et al. 2010). We developed and mailed a questionnaire to a total of 1,485 hazmat motor carriers in the province of Quebec, Canada. These carriers were chosen because they have declared hazardous materials transportation activities in their annual registration process with the Commission des Transports du Québec (CTQ) registry. We received 211 answers, for a response rate of 14,6%.
The questionnaire contained 61 questions divided into 9 themes (Table 1). The questions were designed to enable the identification of about 45 OSP within the answers.

Table 1: Survey questionnaire

#	Theme	Contents
A	Firm's characteristics	Name, contact, no. of employees (3 questions)
B	Plant's characteristics	Location, no. of drivers, service territory, classes of HM carried (11 questions)
C	Transportation and storage	HM transport frequency, intermodality, transport phases, HM storage (6 questions)
D	Technology	No. of trucks, fleet management system, on-board devices, technology investments (5 questions)
E	Drivers and training	Pay per km or hour, driver training, training material, training frequency, specific training, documentation (11 questions)
F	Costs	HM additional costs (equipment, training, dedicated staff, insurance), part of costs brought by HM (2 questions)
G	Outsourcing	Outsource or not, why, criteria for subcontractor choice (6 questions)
H	Safety management	Risk analysis, investigations if accidents, accident registry, written procedures, information sources, internal committees (9 questions)
I	Emergency preparedness	Impacts of accidents, emergency team, emergency plan, exercises (8 questions)

The surveys answers have been analyzed with classical descriptive statistics methods and Mann-Whitney comparative test for some subanalyses. For a more detailed description of the carrier survey methodology and results, please see Peignier et al. (2010, 2011, 2012).

Quebec's carrier's record database

The second source of data for this study comes from the Conduct Review Policy for Heavy Vehicle Owners and Operators (HVOO) under the responsibility of the Société de l'Assurance-Automobile du Québec (SAAQ, Quebec Insurance Board). To enforce the policy, the SAAQ maintains a record on each carrier of the province. The HVOO files are divided in 2 sections: one about the administrative data (name, address, number of vehicles…), the other about Ongoing conduct Review. The events considered in the ongoing conduct review are those observed on the road. They continue to be listed in the record throughout the two-year window covered by the review.
We obtained the record for each of our survey respondent. Among the elements found in the company profile:

- road accidents involving the company vehicles (where the company is responsible);
- road safety violations by drivers while driving company vehicles (speed tickets, driving under influence, prohibited license, etc.);
- violations to goods movement rules (excessive load, absence of escort, prohibited vehicle, bad documents, etc.);
- unfavourable vehicle inspection reports (mechanical condition violations, etc.).

A weighting system from 1 to 5 is applied depending of the severity of the violations, and a global safety index is calculated for each carrier. The size of the carrier company is taken into account.

Cross-analysis of carrier's record database with survey responses

An analysis of the two databases will be presented in following the 2 concepts behind the tool we want developed.

- (1) Do some transportation characteristic of the carrier increase the probability of having an unsafe conduct (being involved in accident, no respect of the load limits, offence related to highway safety…)? We try to find if the characteristics of the hazmat carrier (coming from the survey) had significant effects on the probability of having an accident. In order to find out, we first made a correlation table to see if the variable were interdependent. Then we used a probit and an ordered multinomial probit model ($\tilde{y} = \beta x + \varepsilon$). We searched which variables X within the ones described in Table 2 has a significant impact ($p < 0,1$) in affecting the different variables of the unsafe conduct which are the number of out of order vehicles, the number of operational safety events, the number of compliance with the loads limits events, the number of involvement in accidents. We used probits and oprobit because it allow us to know among all the characteristics of transportation, which have the most influence on the probability of having an accident. It helps the carrier to know if its own activity is more at risk than others (if he belongs to higher or lower scores group of the HVOO variables).

Table 2: Attributes of the survey retained for the record database analysis

HM Characteristics	HM Class	Transportation's logistical characteristics
• Bulk HM transportation • HM transportation using a tank • HM transportation requiring ERAP	• Class 1 • Class 2 • Class 3 • Exclusively Class 3 • Class 4 • Class 5 • Class 6 • Class 7 • Class 8 • Class 9	• Carrier with more than 5 drivers • Carrier with more than 7 vehicles • Part of activities related to HM >80% • Frequency of transport weekly or less often • Delivering to multiple clients • Temporary storage • Transportation over a long distance

• (2) Do some Organizational safety practices (OSP) implemented by carriers decrease the probability of having an unsafe conduct? In a second time, we try to find out the different OSP the hazmat carrier can implant in their companies in order to improve their HVOO files (and thus, decrease their probability of accidents). To measure the influence of OSP implementation on the probability of decreased the risk (represented by the HVOO's record data), we used negative binomial regression with the OSP as independent variables and the HVOO's data as dependant variable. We choose negative binomial regression instead of Poisson regression because of overdispersion (variance is different from the expected value).

Tool development

The tool is developed on a Microsoft Excel spreadsheet, a medium that can easily be used by hazardous material shippers' technical staff and managers. The results of the analysis of the survey and the record database are aggregated, reformatted and put in hidden sheets of the workbook. Then, a link is created between an interface worksheet and to result to estimate the best carrier choice accordingly to the attributes and needs of the hazardous material shipper.

RESULTS

This section first presents some of the survey responses, then show the results obtained from the carrier's record database analysis. Finally, the section concludes with the results from the cross-analysis of carriers' record database with survey responses.

Results of the survey of carriers

Respondent profile

The sample is mostly made up of small facilities (71.2% have fewer than 20 employees), but also a few larger facilities (15.1% have 20 to 49 employees, and 13.7% have 50 employees or more). This is representative of the Quebec carriers industry. Their involvement in

hazardous material transport is variable. Figure 1 shows that 58% of the respondents are mostly dedicated to HM transport (80% or more of their transportation activities). Meanwhile, about 20% of the carriers declare that less than 20% of their transportation activities are hazmat-related.

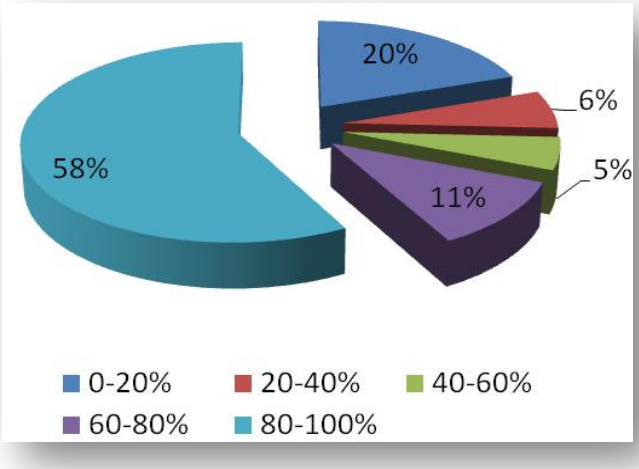

Figure 1: Distribution of carriers accordingly to their HM activity

Flammables liquids are the HM mostly carried by truck, followed by gases and corrosives substances. Table 3 compares these results to those coming from the fixed site survey (Leroux et al. 2010). In Quebec fixed sites, corrosive HM are also important but are most of the time carried by rail or ships.

Table 3: Most carried classes

Most transported classes			
	Flammables	Gases	Corrosive
Motor carriers	58 %	37 %	28 %
Fixed sites	73 %	45 %	58 %

Organizational safety practices

From our survey, we define 45 organizational safety practices that cover all aspects of a safety management system for a hazmat motor carrier. We rank them by use rate among hazmat motor carriers in Quebec. Table 4 shows the OSP the most used by HM carriers in Quebec. These practices are considered as almost standard for the industry. The majority of OSP most used by hazmat carriers in Quebec directly affect the driver Apart from that, guidelines and procedures are the most popular because they are less costly to apply and sometimes required by law.

Table 4: OSP that are the most used by carriers

Most frequently used OSP	**% of use**
Means of communication with the driver	94.7
Guidelines for driver safety	93.2
Guidelines for driver action to safeguard the public	91.8
Guidelines for communication with authorities	91.8
Written procedures for inspection prior to shipping	90.3
Quebec Ministry of Transport HT guidebook	83.9
Additional training on emergency preparedness for drivers	83.7
Operational hotline	82.3
Hourly rate remuneration for short distances	81.6
Investigation after accident/incident	77.8
Guidelines for communication with clients	76.6
Written procedures for risk communication with employees	75,0

On another hand, some OSP are not as developed within the HM carriers industry. The training, auditing and contractual links with subcontractors is missing most of the time. The responsibility seems to be transferred to the subcontractor..Regular training is also lacking throughout the respondent pratices.

Table 5: OSP that are the less used by carriers

Least frequently used OSP	**% of use**
Long-term contracts with subcontractors	35.7
Training of at least one day	35.1
Written procedures for risk communication with citizens	33.9
Refresher courses at least every 2 years	33.3
Vehicle maintenance software solutions	30.2
Simulation of emergency situations	29,0
Use of software for establishing routes	26.6
Written procedures for subcontractor selection	24.2
Dynamic vehicle stabilization systems	22.9
Safety audits by subcontractors	22.9
Practical examination to validate training	21.3
Training offered to subcontractor employees	21.1

The survey also reports on other aspects like HM related costs, training characteristics, transport phases, etc. More results can be found in Peignier et al. (2010, 2011, 2012).

Carrier's record data analysis : descriptive statistics of our sample

The carrier's record data confirm that the majority (52,7%) of them are made up of small companies with fewer than 7 vehicles.
Owners are assessed based on the number of mechanical inspections carried out on their heavy vehicles during roadside inspections and the number of vehicle out-of-service orders resulting from such inspections. In our sample of the HVOO files, we have 47% of the carriers who didn't get any vehicles mechanical inspection. Among carriers that have been inspected at least once, 66% had no vehicle out-of-service orders

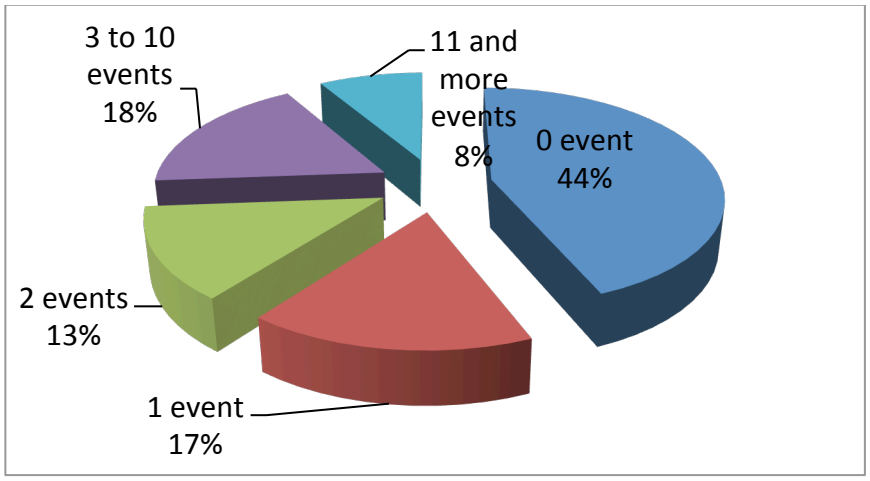

Figure 2: Number of event concerning the operational safety

About the number of events concerning the operational safety, corresponding to any offence related to highway safety, Figure 2 shows that 43,9% of carriers did not commit any infractions and among the one who committed infractions, the majority (53%) had less than 2 infractions.

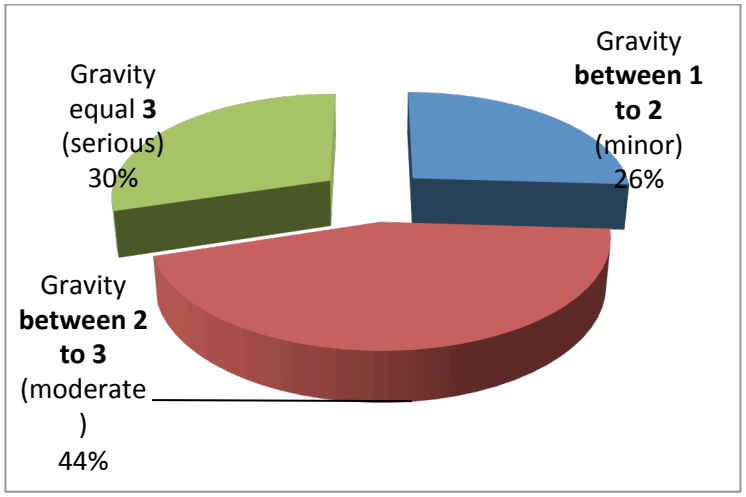

Figure 3: Gravity of events concerning the operational safety

What is more important than the number of event is the gravity of them. For having a measure of that, operators are assessed based on the total number of points assigned for events in each conduct area. Each event considered is assigned a weight based on its degree of severity. There is two types of weighting: a weighting of accidents (4 points are attributed to accidents with injuries, moreover, for accident with property damage only (PDO): 1 point for a PDO accident occurring in the territory of the island of Montréal and the suburb and 2 points for a PDO accident occurring somewhere else), and a weighting of offences (the number of point is attributed considering the gravity of the offence. For minor offence, 1 point, for moderate, 2 points, for serious offence, 3 points, and for offence under the *Criminal Code, 5 points).*
Among carriers with event related to operational safety, the average gravity of event is 2.4 (more than a moderate offence). Figure 3 shows the distribution of these events within the sample data.

Concerning the compliance with load limits, only 25.8% of carriers committed infractions, and among them, more than the average (63%) have less than 2 infractions. The average gravity of the event is 1 which correspond to minors offenses.

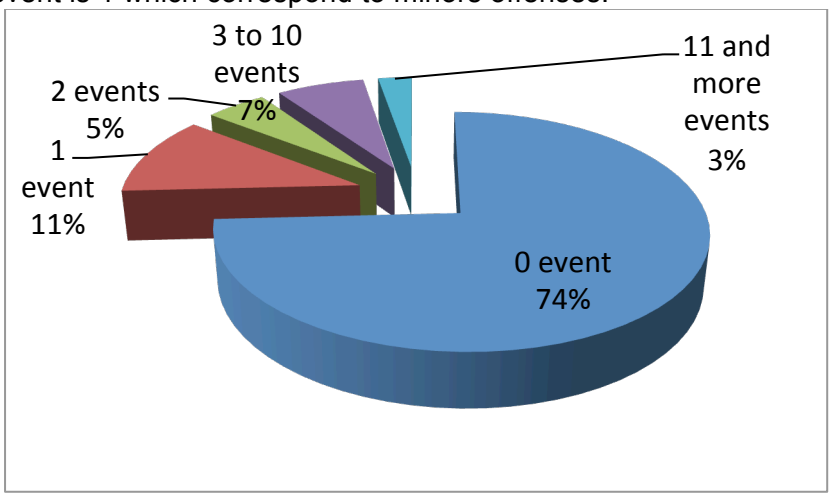

Figure 4: Number load non-compliance events

Another interesting variables is the involvement in accident. While 75.4% of the carriers were never involved in an accident during the 2 year period, 7% were involved in more than 3 events. These accidents did not always lead to severe property and environmental damages, nor causualities; however these events could have heavy potential consequences. Then, among carriers who are involved in accidents, the average gravity of event is 2.7 (that is to say between a moderate (2) and a serious (3) offence) and the maximum is 4 (accident with injuries).

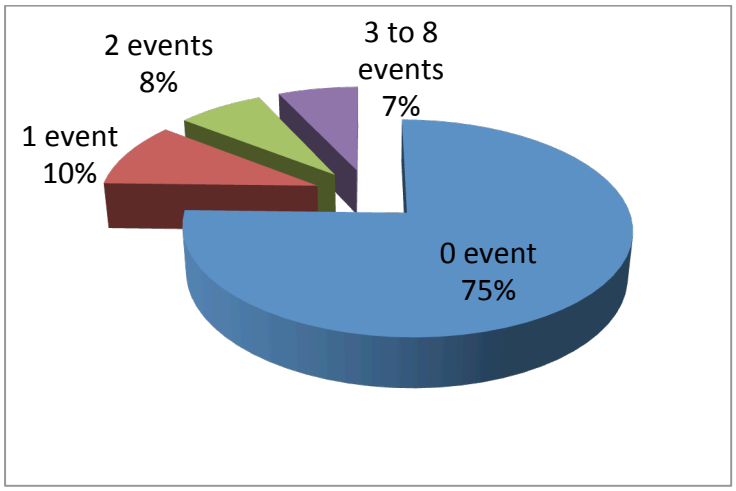

Figure 5: Number of accident events reported in the database

Table 6 synthesizes the results of the HVOO database analysis. It shows that most carriers have non or few events, and the average gravity of events is moderate for the whole group.

Table 6: Result synthesis for HVOO database analysis

	% of carriers without events	Maximum number of event per carrier	% of carriers with X events among carriers with events	Average gravity of events (on a 5 points scale)
Operational safety	44%	27	53% less than 2 events	2,4
Compliance with load limits	74%	42	63% less than 2 event	1,0
involvement in accident	75%	8	41% have 1 event	2,7

Cross-analysis of carrier's record database with survey responses

This section presents an in-depth analysis of the HVOO database in relation with the carrier survey responses.

Influence of the characteristics of the company on the HVOO variables

To help the carrier to know if its own activity is « more at risk » than others, we measure the influence of some characteristics of transportation on the probability of having an accident.

As expected, the characteristics of the company may influence the frequency and the magnitude of events reported in the carrier's record database. The variables that influence out-of-service orders (mostly due to mechanical problems) are shown in Table 7 (non significant variables have been removed from the table, as for following tables ; but the probit model is based on 21 independent variables). The probit has a R^2 of 0.33, meaning that these variables explain about the third of the variations. Which type of carrier have the higher probability of having more than 1 vehicles out-of-service orders ?

Carriers who are involved in transportation over a long distance (transport at provincial, national or international level) have a higher probability to have more than one vehicle out of service order. Globally, 17% of carriers have one or more vehicle out-of-service orders, comparatively to 31% of carriers who made transportation over a long distance. On the contrary, carriers dedicated to HM, with lower frequency of transport, who transport exclusively class 3 HM or class 8, have a higher probability of having 0 vehicle out-of-service orders.

Table 7: Probit result for the number of out of service vehicles (significant variables only)

Probit regression	Log likelihood = -46,12514 Number of obs = 150 LR $\mathbf{X}^2$ (21) = 46,09 Prob > $\mathbf{X}^2$ = 0,0012 Pseudo R^2 = 0,3332			
Number of out of services vehicles	**Coefficient**	**Std. Error**	**z**	**P>|z|**
More than 80% of activities related to HM	-0,8676139	0,4742819	-1,83	0,07
Frequency of transport	-1,381866	0,8048894	-1,72	0,09
Transportation over a long distance	0,7348968	0,3879683	1,89	0,06
Exclusively Class 3	-1,385776	0,7301683	-1,9	0,06
Class 8	-1,081463	0,6305307	-1,72	0,09

The variables that raise the probability of having more than one operational safety event are (Table 8): the number of drivers of the company, the transportation over a long distance and the transportation of class 5 HM (gases). 27% of the variation is explained by the model. On the other hand, carriers with HM transportation requiring an Emergency Response Assistance Plan have a higher probability to have 0 event related to operational safety.

Table 8: Probit result for the number of events of operational safety (significant variables only)

Probit regression	Log likelihood = -114,5022 Number of obs = 150 LR $\mathbf{X}^2$ (21) = 85,04 Prob > $\mathbf{X}^2$ = 0 Pseudo R^2 = 0,2708			
Number of events of operationnal safety	**Coefficient**	**Std. Error**	**z**	**P>|z|**
More than 5 drivers in the company	0,8952999	0,3186935	2,81	0,01
Transportation over a long distance	0,7799832	0,2691209	2,9	0,00
HM transportation requiring ERAP	-0,4308506	0,2276261	-1,89	0,06
Class 5	0,8408715	0,4552067	1,85	0,07
More than 7 vehicles	0,7058253	0,3116971	2,26	0,02

For events related to compliance with load limits, the variables explain 45% of the observations. Which are the determinants who explain the number of events related to compliance with load limits? We can see (Table 9) that carriers with more than 5 drivers, who transport hazmat over a long distance, who transport HM using a tank or transport class 4 HM have a higher probability of having more than one event related to compliance with load limits.

Table 9: Probit result for the number of events concerning the compliance with load limits (significant variables only)

Probit regression	Log likelihood = -47,70693 Number of obs = 150 LR $\mathbf{X}^2$ (21) = 78,56 Prob > $\mathbf{X}^2$ = 0 Pseudo R^2 = 0,4516			
Number of events concerning compliance with load limits	**Coefficient**	**Std. Error**	**z**	**P>|z|**
More than 5 drivers in the company	0,9603589	0,4918319	1,95	0,05
Bulk HM transportation	1,308299	0,714503	1,83	0,07
HM transportation using a tank	1,304962	0,7605357	1,72	0,09
Transportation over a long distance	0,9903401	0,3637848	2,72	0,01
Class 1	-1,103061	0,6239681	-1,77	0,08
Class 4	1,939705	0,8688564	2,23	0,03

The R^2 for the involvement in accident is 0.37. We notice in Table 10 that carriers with more than 5 drivers, and who transport class 6 HM have a higher probability to be involved in more than one accident, while carriers who transport explosives have a higher probability to be involved in 0 accident.

Table 10: Probit result for the number of accident involvement (significant variables only)

Probit regression	Log likelihood = -53,39515 Number of obs = 150 LR $\mathbf{X}^2$ (21) = 63,00 Prob > $\mathbf{X}^2$ = 0 Pseudo R^2 = 0,371			
Number of involvements in accidents	**Coefficient**	**Std. Error**	**z**	**P>|z|**
More than 5 drivers in the company	1,06602	0,4174565	2,55	0,01
Class 1	-1,082001	0,5981133	-1,81	0,07
Class 6	1,671078	0,8218216	2,03	0,04

To conclude, there are some characteristics that more often increased the probability of being involved in accidents or being involved in events related to operational safety: transportation over a long distance and to have more than five drivers in the company. On the opposite, there are some characteristics that more often decreased the probability of

being involved in accidents: HM transportation requiring Emergency Response Assistance Plan and transportation of HM class 1.

Influences of the OSP implementation on the probability of decreased the risk

In the previous section, we have identified which characteristics of the carriers will raise the value of the event variables of the HVOO files. In this section, we will try to find out which organizational safety practices (OSPs) can a carrier implement in order to reduce hazmat-related risks (values of the HVOO files). We use negative binomial regression to explain the decrease of the selected variables (like for example : number of involvement in accidents…) where indepedant variables are the OSP implemented by carriers.
Table 11 shows the result for the binomial regression related to the number of operational security events. It shows that only two OSPs help to significantly decrease the number of events: a hourly rate remuneration for long distances and a hazmat accident prevention program. However, the analysis also shows that belonging to a professional association will increase the risk. This is quite counterintuitive and would suggest that the number of observations is not sufficient to perform such in-depth analysis.

Table 11: Negative binomial regression result for the number of events concerning security (significant variables only)

Negative binomial regression *Number of operational security events*	Log likelihood = -180,448 Number of obs = 94 LR $\mathbf{X}^2$ (21) = 48.97 Prob > $\mathbf{X}^2$ = 0.0028 Pseudo R^2 = 0.1195			
	Coefficient	**Std. Error**	**z**	**P>|z|**
Hourly rate remuneration for long distances	-0,7431	.3911671	-1.90	0.057
Hazmat accident prevention program	-0,89109	.40651	-2.19	0.028
Membership in a professional association	1,131241	.3296434	3.43	0.001

Deceiving results were also obtained for the compliance with load limits events where only the Quebec Ministry of Transport hazardous materials transportation guidebook allows a decrease of the number of events. Concerning the involvement in accident, there are 2 OSPs that explain a significantly decrease in the number of events: a secured access to hazmat carried and the existence of an in-house emergency response team.

SELF-ASSESSMENT TOOL

This tool is curently used with Excel but we would like to develop a software version so that all carriers could use it more easily.
Below is the user interface of the tool.

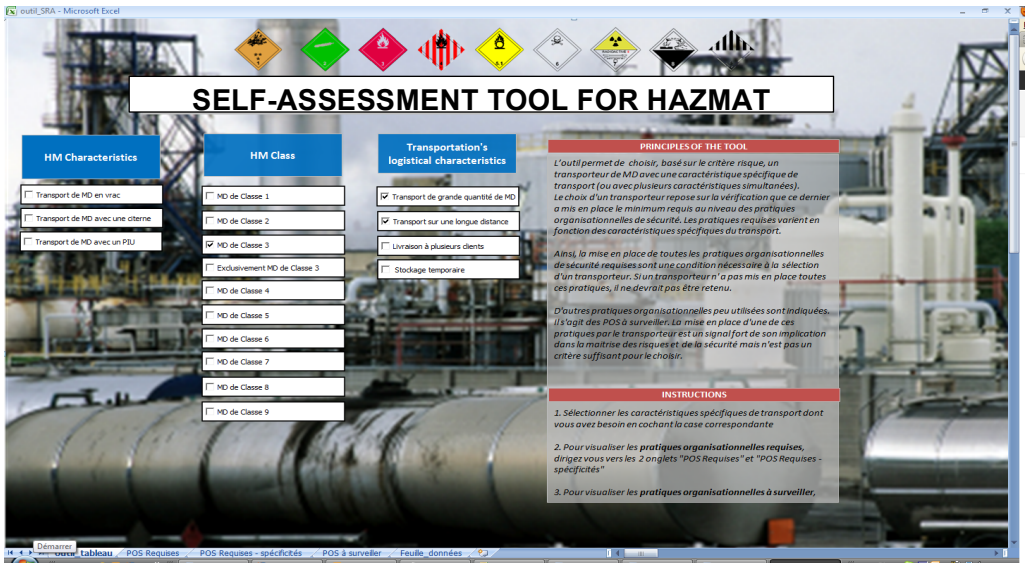

Figure 6: User interface of the self-assessment tool

First, the carrier selects his firm's characteristics in the tool. First of all, he can compare his HVOO's record within the record of carriers in Quebec with the same transportation's characteristics. Second, the tool could also help the carrier to know if its own activity is « more at risk » than others. Indeed, the tool tell him which of its characteristics of transportation have an influence on the probability of having an accident
Finally, knowing its situation, what can the carrier implement as organizational safety practices to decrease his risk of accident? The user has to click on the last tab to get a list of the different OSP, considering his characteristics of transportation, he can implement allowing him to decrease his risk of accident.

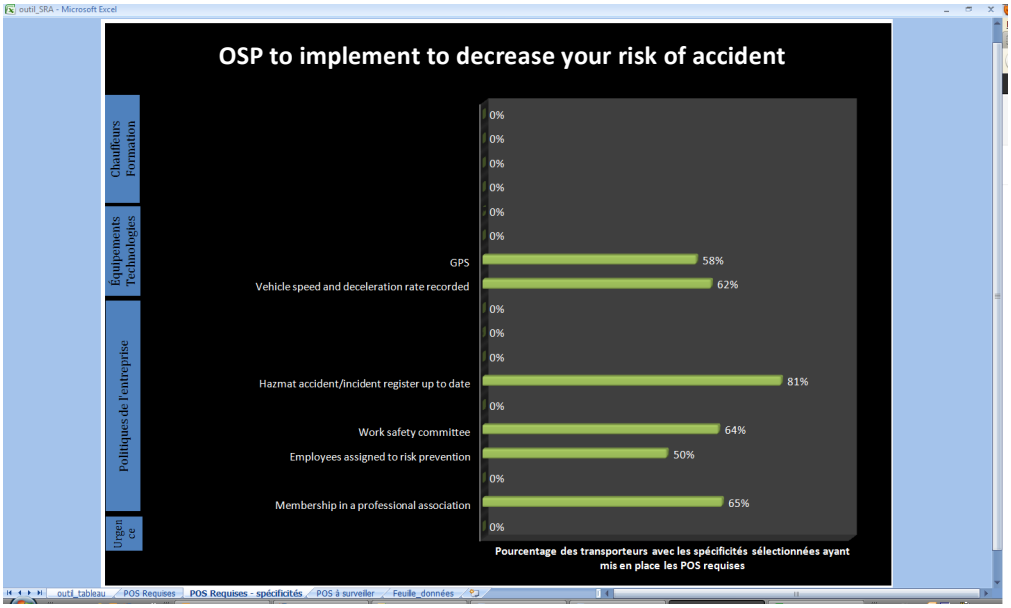

Figure 7: Screen capture of a tab of the tool

This tool can be use as a benchmarking tool for hazmat carriers and provide new ideas for organizational practices to implement to reduce their risk of accidents . This tool should help make hazmat carriers more aware of their responsibilities and enhance the gains made by conscientious risk management.

CONCLUSION

This paper presented the methodological steps that lead to the development of a self-assessment tool to help hazardous materials carriers to make the best choice about the sets of organizational safety practices that would help to reduce the risks related to HM transport. A survey has been conducted over 1,485 HM carriers in Quebec. The 211 answers (14,6% response rate) were used to identify the OSPs that are the most used by the carriers, plus a series of other observations about HM transport in general. Means of communication with drivers and the presence of written procedures and guidelines are amongst the most used OSPs. For a following analysis, we obtained individual record of each respondent from the Conduct Review Policy for Heavy Vehicle Owners and Operators (HVOO). The fusion of the two databases helped to understand the factors (size of company, differences between HM classes) that influences the number of safety events reported in the carrier's record. Finally, the choice of OSPs among respondents was compared to the HVOO file variables, but the results are not so convincing, probably due to the small number of observations, which is a limitation of this study at such in-depth detail. However, the study lead to the development of a self-assessment tool based on an Excel workbook that may help the HM carriers to identify the OSPs used by similar companies of their field of activity.

This work brings new perspectives. First, there could be additional statistical tests to be performed on both data sources, if more information could be obtained from the HVOO file of each respondent (limited information was provided to us). Second, the use of the tool by carrier could be surveyed as well, to obtain additional information on the best practices about OSPs, even though there is no way, for the moment, to check if the choice of OSPs is beneficial. There could be other source of independent data to be used, such as the Quebec workers accident files, or a more detailed road accident database.

ACKNOWLEDGEMENTS

The authors acknowledge the contribution of the various firms participating in the study. They also acknowledge the contribution of the project's partners: the Québec Ministry of Transport, the Centre de sécurité civile of the City of Montréal, the *Institut de recherche Robert-Sauvé en santé et sécurité du travail* (IRSST) and Health Canada. The authors would like also to thank Kathleen Plourde for her help to get the HVOO's record and her very quick response time to our questions and Carl St-Pierre who helped us a lot for the statistics analysis.

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