FPInnovations

Literature Review of Load Securement Technologies and Practices to Reduce or Eliminate Injuries

PROJECT NUMBER: 301014850

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The motion of throwing and securing log load wrappers can cause a great amount of stress on drivers' shoulders and overexertion-related musculoskeletal injuries are quite common among log truck operators. Sections 4.46 to 4.53 of BC's Occupational Health and Safety Regulations outline the requirements for taking steps to prevent musculoskeletal injuries in the workplace. FPInnovations, in collaboration with the Load Securement Working Group (a subcommittee of the Log Truck Technical Advisory Committee that focuses on initiatives that reduce the risk of injuries to log truck operators), has conducted a literature review and surveyed contractors for ideas on how to reduce or eliminate the risk of injury. The result being simple to complex solutions being investigated that had the potential to reduce or eliminate the injuries related to throwing wrappers. The most promising solutions were shortlisted and will be investigated in further detail as part of project phases 2 and 3.

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INTRODUCTION

Load securement in log hauling is a critical step which must be done correctly to ensure the safety of workers and the public. The process of securing a load of logs has historically involved the driver throwing and securing tiedowns, or wrappers (in British Columbia), around the load prior to transportation.

A typical load wrapper used in BC consists of a long section of 9.5 mm (3/8 in) cable with lengths of chain on each end. The weight of these wrappers ranges from 5.9 to 6.1 kg. (13 to 13.5 lb.) for a 9.75 m. (32 ft) long wrapper. The wrapper is coiled, and the driver throws one end over the load. Both ends are secured together with a binder.

This method has been effective for securing log loads, but as shown by WorkSafeBC injury statistics, throwing the wrapper can result in driver injuries, primarily shoulders. These injuries are often caused by repetition, poor technique, weight of the wrappers, inadequate risk assessment, limited availability and/or understanding of load securement options and other human or operational factors. WorkSafeBC has recorded 89 overexertion injury claims from 2013 to 2018 that occurred when the driver was securing the log load. Of these, 60% occurred while throwing wrappers, 33% while cinching wrappers and 10% when removing wrappers. The overall cost of injuries related to log load securement has been more than $4 million in the last 10 years (WorkSafeBC 2021).

Section 26 of the WorkSafeBC regulations specifically deals with log load securement. This section is currently under review and some changes are anticipated. With these changes, there is an opportunity to identify improved load securement options, processes, techniques, tools, and resources that could be efficiently and effectively utilized by industry. The Load Securement Working Group (LSWG) proposes to investigate solutions such as the Jo's Easy Wrap, the JB Cable Slinger, synthetic ropes, platforms, tie-downs, loader assistance and lightweight wrappers to reduce load securement related injuries. In addition, solutions to eliminate load securement related injuries will also be explored, which will include automated load securement systems.

The expected benefits of having the appropriate technologies and practices to manage load securement related injuries include:

- Prevention of injuries caused by throwing log load wrappers
- Lower WorkSafeBC claims
- Improved operational efficiencies
- Improved worker retention and recruitment

OBJECTIVES

The objectives of this report are to:

- understand available load securement practices and technologies through a literature review and stakeholder survey

- present preliminary cost-benefit analysis of the most promising load securement solutions

In this phase of the project, a literature review, a contractor survey, and preliminary cost-benefit analysis were conducted. The goal was to improve the understanding of load securement practices and to identify the most promising solutions that have the potential to reduce or eliminate load securement related injuries while still meeting operational and regulatory load securement requirements.

METHODOLOGY

Some load securement options had already been identified by the LSWG, but the review was far from complete. FPInnovations revisited these options and further reviewed practices and tools used within North America and other parts of the world to provide a more comprehensive technical review. For all options, the advantages, disadvantages, costs, impacts on operational efficiency, and benefits were investigated. Log hauling contractors were surveyed in collaboration with the LSWG to gather their suggestions on potential solutions for their operations. Given that amendments to Part 26 of the OHS regulation are underway, it's expected to allow the use of tiedowns for log load securement, both, tie downs and lighter weight wrappers were also included in the review. In addition, more information on automated load securement systems was also gathered. Based on the information collected, the most promising load securement options were shortlisted. Factors considered in the analysis include:

- Technical comparison to the status quo
- Benefits/drawbacks of the proposed options
- Associated costs (purchase, maintenance, and in use)
- Compatibility with various truck configurations, and ability to retrofit
- Impact on operational efficiency
- Durability in BC's variable operating conditions
- Longevity or replacement interval
- Ability to implement

RESULTS

The hierarchy of controls for addressing workplaces hazards are:

- Elimination i.e., physically remove the hazard
- Substitution i.e., replace the hazard
- Engineering control i.e., isolate the workers from the hazard
- Administrative control i.e., change the way the hazardous task is performed
- PPE i.e., protecting the worker with personal protective equipment

In this hierarchy of controls, elimination is most effective whereas the use of PPE is least effective in addressing a hazard. All control measures used around the world to address load securement-related injuries were explored and benchmarked against the load securement techniques currently used in the BC forest industry.

Improved Throwing Techniques

Mackie and Ashby (2011) developed a chain throwing injury risk model that helps to understand the factors contributing to overexertion-related injuries. These factors are: the number of throws per day, the driver's physical and psychological capability, load securing intensity, direction of chain throw, the speed and acceleration required to throw the chain over the load, the technique used, and chain resistance. Mackie and Ashby (2011) recommended techniques such as the skipping rope technique (which requires 5 m of space between the driver and the truck/trailer), and other slight variation of standard throwing technique to reduce the overexertion related to throwing wrappers.

Warming up before throwing wrappers is also a practice that could reduce the risk of injury. The BC Forest Safety Council (BCFSC) has valuable driver training resources on shoulder and upper back exercises to warm up the muscles prior to throwing wrappers to help prevent musculoskeletal injuries. The link to these warmup exercises can be found here: https://www.bcforestsafe.org/resource/preventing-msis-log-truck-driver/

When throwing wrappers in a conventional or traditional overhand fashion, the BC Forest Safety Council recommends a warmup and the use of the "Total Physiotherapy" throwing technique that takes advantage of the larger and stronger muscle groups to throw the wrapper over the load, thereby reducing stress on the shoulder joints. The following link has more details on this throwing technique: https://www2.bcforestsafe.org/files/BCFSC_Logging_Poster_Technique_Throwing_Wrappers_0.pdf. A video that demonstrates this throwing technique can be found here: https://www.youtube.com/watch?v=hDD5gzrjFJM

Loader Assist

In BC, loader assist typically involves the driver placing one end of the wrapper into the grapple of a log loader and the log loader draping the wrapper over the load, whereas in Scandinavia, tools are used in a draping process that does not involve the driver.

Loader Assist With Driver Involvement

Shetty (2013) studied loader assist with driver involvement at a BC logging operation. The technique consists of the following five steps:

1. The driver places about one-third of the wrapper into the closed grapple,
2. The loader operator drapes the wrapper over the load,
3. The loader operator immobilizes the load so that the driver can tighten the wrappers,
4. The driver reaches under the load with the wrapper hook to retrieve the end of the wrapper, and
5. The driver cinches the load.

This technique is effective in eliminating wrapper throwing related injuries. However, in certain situations, other hazards such as loader driver proximity interaction, ground condition, weather and light conditions need to be considered before using this technique. A video of the loader assist technique with driver involvement can be accessed via the following link: https://www.youtube.com/watch?v=WX2nWni4FOI

The Trucking and Harvesting Advisory Group (TAG) has developed guidance for using loader assist which can be found at this link : https://www.bcforestsafe.org/wp-content/uploads/2021/02/TAG_Loader-Assist-070220.pdf and https://www2.bcforestsafe.org/files/files/lng_1128_Load_and_Unload_Logs.pdf

One way to minimize driver loader interaction is by the loader placing one of the logs on the ground and driver laying the wrappers on top of this log as shown in this video (watch from 3:30). The loader then picks up this log and moves it over the load until the wrappers' one end is on the other side of the load. Finally, this log is restored on the log deck.

Loader Assist Without Driver Involvement

To minimize the interaction between the loader and the driver, a chain holder and lashing hook can be used. This technique is generally used by self-loading truck operators in Scandinavia. The chain holders are connected to the bunks, and the lashing hook is attached to the one end of the chain. The hook rests on the chain holder along with the coiled chain. The loader grapple pulls the lashing hook and drapes the wrapper over the load. The cost of the chain holder and lashing hook set is around 52 Euros (i.e., CAD $78) and together weigh around 2.2 kg per set. A video of this technique can be found here: https://www.youtube.com/watch?v=lwFmD_khDBM (watch from 6:50).

Another concept uses a spring-loaded lever mechanism, where the loader operator drapes two chains at a time, thus reducing the load securement time. Exte has developed this system under the name Long Life System. Each hooks weighs around 1 kg (2.4 lbs.) and the cost for two bunks is around $500 to $800. Patient (2021) reported that it takes 40 seconds to drape the chains over the load with this system. The link that connects the two chains could be painted with a high visibility color to make it more visible for the loader operator at dusk or nighttime. A logger in Australia developed a similar system and a video can be found here: https://www.youtube.com/watch?v=IlUmbIO0igs

Throw Assist

Tools to aid drivers in throwing the wrappers or tie downs would be helpful in reducing the throwing related injuries. Some of the tools identified for this are lead ropes, triangular hooks, exoskeletons and slingshot aids.

Lead Ropes

There are two types of lead ropes. One is a stand-alone lead rope attached to the end of a wrapper one at a time. The lead rope consists of lightweight nylon rope coiled into a ball. This ball is first tossed over the load and the chain is then pulled over the load from the other side.

Patient (2021) reported a reduction in strain on shoulders by a factor of 4 and reduction in throwing force by a factor of 29 with the use of lead ropes. A lead rope costs around $30 and can be sourced at Dynello under Strap ThrowerBall

(https://www.youtube.com/watch?v=kXcHNcaO-2M) and Ancra Cargo under Tie & Toss (https://www.youtube.com/watch?v=YZLjUVqgSKg). Dynello also sells a quick winder product for recoiling the rope.

Another type of lead rope is a triangle hook lead rope where multiple wrapper chains can be hooked to the lead rope and pulled over the load simultaneously, thus reducing the load securement time. A video of this hook used in New Zealand can be found here: https://www.youtube.com/watch?v=F4t0LlGWpok

Jo's Easy Wrap is a product developed in Canada, consisting of a lightweight puck that is thrown over the load with an underarm motion and two or three wrappers connected to the triangular hook can be pulled from the other side of the load. A video on the use of Jo's easy wrap in operation can be found here: https://www.youtube.com/watch?v=akLOWFWW8NY&t=1s

Wearable Exoskeletons

Wearable exoskeletons are designed to transfer the load from arms to hips using a mechanical cable pulley system for workers performing shoulder level and overhead tasks. The link to an information video could be found here. These devices weigh around 1.8 kg (4 lbs.) and are being used by construction and automotive workers. Studies done by Maurice et al. (2020) and Schmalz et al. (2019) demonstrated that exoskeletons can reduce the load on muscles and shoulder joints by up to 47%.

Hilti Group's Exo-01 is such a wearable exoskeleton device and costs US $1600 (CAD $2000). Although the suitability of this device to help throwing load wrappers has not been determined, it seems promising for drivers that have restricted upper body mobility. Since it is lightweight, it could potentially be integrated within a high viz vest. In addition, this device could also be helpful to address MSI injuries resulting from other physical activities such as those outlined in IMIRP (1999) truck driver tool kit.

Slingshot Aid

Another approach to throwing wrappers or straps over the load is to use a trebuchet or catapult throwing technique and mechanism. The chain or straps can be flicked using a long pole with a special attachment on top. The cost for such devices varies from $30 to $800 depending on the manufacturers.

JB Cable Slinger is Canadian-based company producing such an aid at a cost of around CAD $30. A video of their device can be found here: https://www.youtube.com/watch?v=4508rX-hOgY

Trucker's Barre is a Canadian company that sells a strap thrower that costs around CAD $220. A video of the Trucker's Barre tool for throwing straps using can be found here: https://www.youtube.com/watch?v=9CyIx_gVRbU&t=7s

King Cobra High Load Tie-Down Thrower is a company that has US and Canadian patents for their design. The cost of the King Cobra is around CAD $800. A video of the Cobra tool for throwing straps can be found here: https://www.youtube.com/watch?v=5bAZmNuzdmw&t=14s

GT Factor is a UK-based company that manufactures pole and attachments for throwing straps. Their tool costs only CAD $64.

Cargo Stop is also a UK-based company that sells a pole with different attachments. The device costs around $300. One attachment can be used to throw the wrappers while another can be used to pull the wrapper during unloading. Here is a link to the video showing different attachments: https://www.youtube.com/watch?v=gpf84gmeCl4&t=40s

Strap-A-Pult uses a catapult approach with a crossbar attached to trailer and a pole swivel around the crossbar to generate the force for throwing the strap over the load. This concept would need further development for fixing the device to side of a log truck trailer. The cost of this device is around CAD $375. The video of this tool can be found here: https://www.youtube.com/watch?v=6jDu4pVwYHA

Angle Assist is an Australian company, and their strap thrower costs around CAD $189. More information can be obtained here: https://www.angleassist.com.au/products/strap-thrower?variant=39369321185329

The Dynello Fling Clip is a simple clip that attaches to a strap roll that is thrown over the load with a slingshot motion. The cost for 32 clips is CAD $132. A video demonstrating this tool can be found here: https://www.youtube.com/watch?v=zfd6vu4uqwM

Alternate Practices

Alternate practices for securing log loads for BC log truck operators would be to use tie downs and platforms. Tie downs are not extensively used in BC due to regulatory restrictions. However, with the anticipated changes to OHS Regulation Part 26 they could potentially be used in the future.

Tie Downs

Tie downs are exclusively used in Eastern BC, and through the US for semi-trailer log hauling combinations. With the upcoming changes in the OHS regulation part 26, tie downs will now also be available for use throughout BC. As in Scandinavia, the lashing set connected to the bunk at one end allows the loader to drape the chain/tiedown over the load using a lashing hook, this same technique could potentially be used in BC. The chain at the other end could then be winched with an auto tensioner such as the Exte Luftman, TU, Elphinstone load binder or Innovex cinch.

Platforms

Industrial platforms or high lift machines with rough terrain capabilities could potentially be used to make it easier to throw wrappers over the loads. The use of a platform is especially useful at reload sites or mill yards where one wide platform could be used to secure two trucks at the same time with one truck on each side. The drivers could use the platforms for reducing the throw height in combination with the use of a safer underhand motion rather than the overhand motion that is often used when throwing wrappers from the ground. The safety risks associated with using platforms or high lift machines in harvest sites would require further investigation.

Lightweight Tie Downs or Wrappers

Lightweight wrappers made from synthetic materials, or a smaller diameter steel cable and chain could be used as an alternate to those currently used to secure the log loads. However, these alternate materials must meet the WorkSafeBC OHS regulations and NSC Standard 10 load securement requirements. The NSC standard 10 states that the aggregate working limit of tie downs used to secure each stack of logs shall be at least 1/6 the weight of the stack on framed or flatbed vehicles, where the aggregate working load limit is the sum of one-half of the working load limit for each end section of a tie down that is attached to an anchor point (CCMTA 2010). The amended WorkSafeBC OHS regulation that is going come in effect on Dec 1, 2021 (WorkSafeBC 2021) recommends grade 70 or higher for chains, a wire rope or chain with a safety factor of no less than 4, a polyester rope with a safety factor of no less than 7, and the synthetic ropes with a safety factor of no less than 12. In addition, each wrapper or tie down installed on a log load, and each tie down's anchor points, must have a working load limit of at least 8.9 kN (2000 lbf) for log length less than 10.7 m (35 ft) and 13.3 kN (3000 lbf) for log length greater than 10.7 m (35 ft). Appendix A presents the log load securement regulations for different regions of the world.

Ultra-high molecular weight polythene ropes (UHMWPE) are as strong as steel cables and 15% of the weight of steel with equivalent strength. These UHMWPE ropes are sold under different brands such as Dyneema, Spectra, Plasma, and Amsteel Blue. FPInnovations' destructive testing of used rope samples has shown that the strength of these ropes decreases with use (Jokai (2020), Jokai (2017), Michaelsen et al (2006), Bass et al (2004) and Garland et al (2004)). To address the abrasion and loss of strength issue, Jokai suggested using a larger diameter of synthetic rope with a polyester protective jacket. The outer jacket protects the inner core from dirt and abrasion which may help mitigate the loss in strength that occurs with use.

While industry prefers the use of lightweight wrappers because they are easier to throw over a load, users must ensure that they still meet the WorkSafeBC and National Safety Code Standard 10 cargo securement requirements.

Automated Load Securement

Automated load securement is one way to eliminate typical load securement related injuries and is a promising technology.

Exte Com 90

Exte Fabriks AB is a Swedish company that specializes in log bunks and load securement devices. Their Com90 system is an automated load securement system for the logging industry. It is a fully automated log load securement device that is now used in Scandinavia and Oceania operations. The following information was gathered through an interview with Evans Trailers regarding the Com 90 system used in New Zealand operations.

The Com 90 system adds 600 kg (1300 lb) to an 8x4 truck (1 log bundles – 2 bunks) and 400 kg (880 lb) to a 5-axle trailer (2 log bundles -4 bunks). Translating this to the two common truck configurations used in BC would mean an increase in tare weight of one tonne for the tridem tractor with quad-axle trailer (three bundle load) and 1.2 tonnes for the four bundle B-train. One issue reported was finding the right height to accommodate all cut-to-length log configurations as the wood density and weight limits in New Zealand vary a lot. Currently, the company has shortened the standard height of the arms by 250 mm (9.8 inches) with the current load configuration. Log loader operators need to be careful not to damage any of the lashing arms while loading or unloading. Standard maintenance requires the fiber bushings, pivot pin, key, and potentially pinion gear located at the top of each arm to be replaced every 3000 cycles of the system.

Currently two contractors in New Zealand are using the Com 90 system and more are planned. One contractor is using the Com 90 on a shuttle unit with a very short haul for transferring logs from a holding yard to port berth for overseas shipping. The other contractor is using the Com 90 on a highway haul with a travel distance of around 150 km (93 miles). In terms of impacts to productivity, since it dramatically reduces the time required to secure the load, the shuttle unit doubled the number of loads delivered increasing from 11 to 22 loads per shift. The highway unit delivers anywhere from 3-6 loads per day, depending on travel distance. The time savings from the Com 90 system for the shuttle unit is more than two hours per day and between 30 minutes to one hour for the highway unit. The drivers like the system because they can see the lashing pressures from inside the cab and don't have to get out of the cab for securing the loads.

Other Automated Load Securement Devices

Patchell Industries Ltd, in collaboration with the University of Canterbury and Forest Grower Research, are currently developing an alternative automated load securement system. In addition, students at the University of Maine are working on a pneumatic launcher concept and more information on this can be found here; however, no information on their latest development is available. There are other groups developing automated load securement systems; however, the information available at this time is limited.

Summary

Table 1 summarizes the technologies and practices investigated in this literature review. For each technology/practice, their operational considerations, potential to reduce injuries, initial owning costs, benefits, and drawbacks were considered.

Table 1. Summary of technologies and practices for reduce or eliminate MSI injuries related to the traditional overhand technique of throwing wrappers/tie downs.

Technology/ Practice	Benefits	Drawbacks	Initial Owning Costs	Potential Impact on Injury Mitigation	Operational considerations
Improved throwing techniques	Less strain on shoulder and body.	Depends on drivers consistently using the technique; injury risk still exists.	Training and monitoring cost.	Easiest to implement. However, injury risk is reduced but not eliminated. Applicable to all drivers throwing wrappers/tie-downs.	Ensure the improved throwing techniques does not require significantly more space to throw than required for traditional throwing techniques.
Loader assist With driver involvement Without driver involvement	 Eliminates throwing related injuries. Removes machine and driver interaction hazard, and minimizes load securement time.	 For both options, usage will depend on loading site hazards (may not be suitable in all situations).	 No hardware cost; however, the loader usage cost for load securement activity needs to be accounted for. Additional hardware cost, $100 per bunk. The loader usage time could be reduced in load securement activity.	 Both options could eliminate wrapper throwing related injuries, but other load securement related injuries still exist.	 Site specific hazards need to be considered and assessed. Lashing hook and chain holder are low maintenance items; their usage in BC operations needs to be further explored.
Throw assist	Reduce the required throwing force and strain on shoulders and in some cases reduces time to secure the load.	Drivers' resistance to change. Injuries are only reduced not eliminated (risk of injuries still exists).	$30 to $2000 depending upon the options selected.	Applicable to most of the drivers, helps to reduce throwing related injuries and in some cases reduces load securement time.	Low maintenance requirements, doesn't create any additional hazards and should be easy to implement.
Alternate practices • tie downs	 Shorter or no chain and less force to throw.	 Initial cost to install bunk winches and	 Manual tensioner $120	 Reduces risk of injury and can enable the use of	 Low maintenance and less susceptible to damage.

Technology/ Practice	Benefits	Drawbacks	Initial Owning Costs	Potential Impact on Injury Mitigation	Operational considerations
		driver's resistance to change.	per bunk, weighs 5 kg Auto tensioner $1500 per bunk, weighs 19 kg (FRA 2015).	automation technology.	
• platforms	Underarm throw possible.	High initial cost.	Platform - $1500 to $70,000.	Reduces risk of injury via reduction in throwing height and can be used in combination with an underarm throwing technique.	Platform should have the ability to transfer multiple wrappers up to the top of the platform. Platforms are more applicable to reload and mill yards. Can also be used in a dynamic operating environment where intermittent relocation is required.
Alternate lightweight tie downs or wrappers	Reduction in wrapper weight reduces risk of injury.	Synthetic cables' strength deteriorates over time and 5/16 steel cable is not allowed for use under current regulations.	Synthetic wrapper - $200. Lighter weight steel wrapper - $40.	Weight reduction and corresponding force required to throw these wrappers reduce risk of injury.	Dirt and abrasion reduce the strength of synthetic cables, so jacketed ropes are recommended. Synthetic wrappers are more susceptible to damage, require more frequent inspections, have a reduced service life and are more expensive than steel cable wrappers.
Automated load securement system	Eliminates the risk of load securement related injuries.	Currently very expensive.	$100,000 for Exte system. (Explore other alternatives to bring the cost down). Uncertain if system meets regulations.	Potential to reduce cycle time for short trips with more than 4 loads a day; will have a high impact on reducing load securement related injuries.	Change in work practices while loading/unloading may be required. Operators need to be careful to avoid damaging the arms. Exte system is not designed for trailers to be piggy backed.

Contractor Survey

Log Hauling contractors were surveyed from many areas of the province including the Interior, Peace, and Kootenay regions to improve the understanding of operational requirements. Figure 1 presents the actions taken by the contractors to address the risk of injury related to load securement activities within their operations. Of the contractors surveyed, 76% have tried loader assist, 21% have tried throw assist and 14% have tried lead rope, 5/16" steel wrappers and synthetic wrappers to reduce the load securement related injuries, 7% have used platforms while 3% have used tie downs.

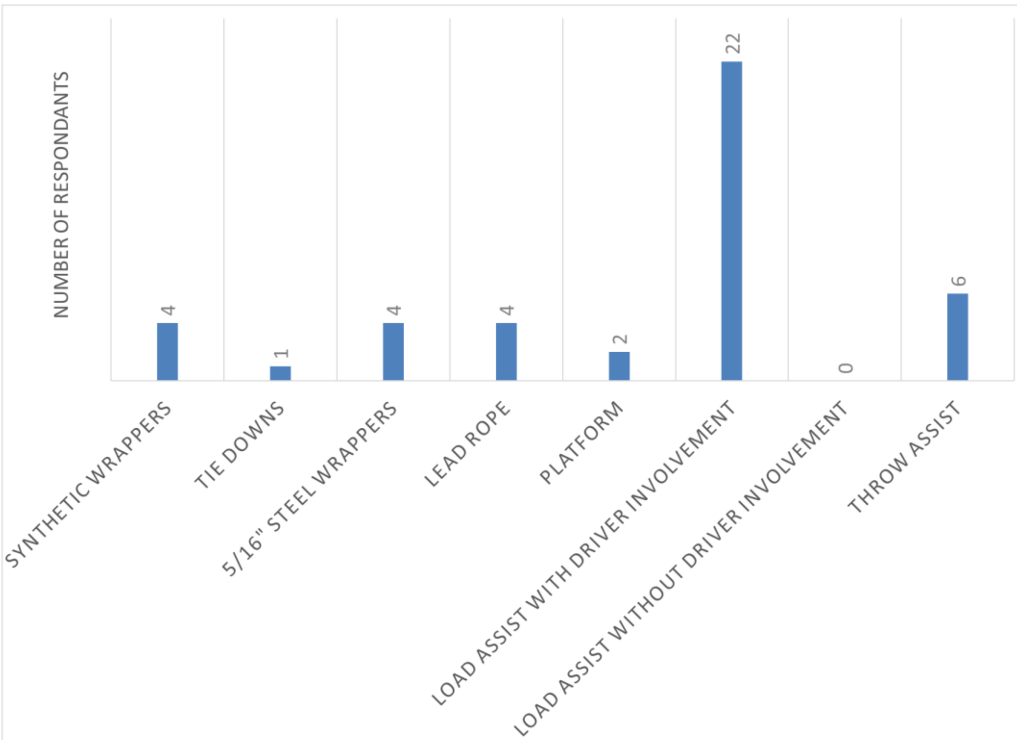

Figure 1. Corrective actions taken to reduce load securement related injuries

Of those surveyed, 28% of the respondents consistently use loader assist, 48% used this approach upon driver request, 10% have tried it at least once and 14% have never used this technique (Figure 2).

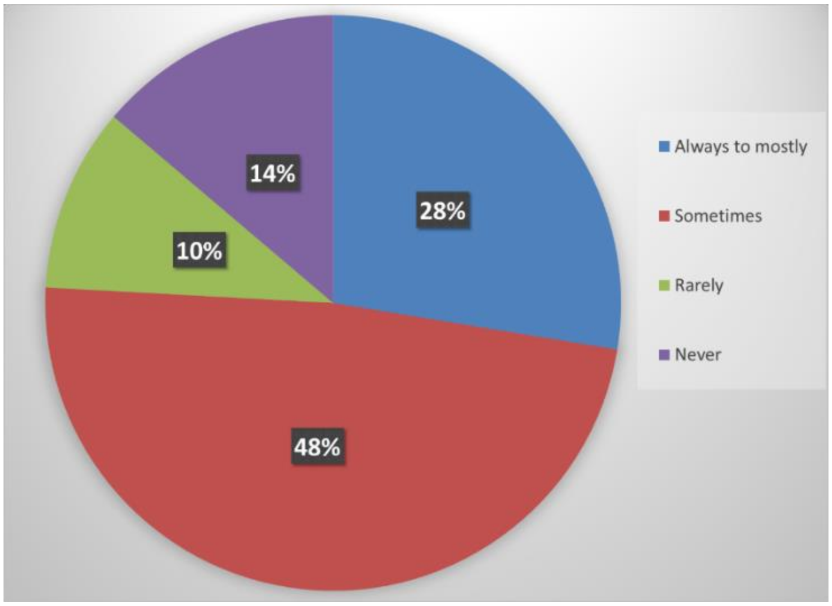

Figure 2. Loader assist usage

All loader assists activities currently being used in BC involve the drivers aiding in the process. There is some resistance to this approach because of the risk of having the driver too close to the loader when the wrappers are put into the grapple. This problem may be addressed by removing the drivers from the draping process and making use of the lashing hooks and chain holders like those used in Scandinavian operations. This solution would require further investigation. In all cases, other potential hazards in the load securement area would need to be evaluated such as log decks, loaders on slope, unstable slopes, deep ditches, slippery ground conditions, heavy snow on ground, limited space, and poor light conditions.

With the loader assist technique involving drivers, 76% of respondents reported increased cycle times (Averaged around 10 minutes per truck load depending on the driver's physical condition, terrain, light and weather conditions, and loader operator's ability), 10% abstained and 14% reported no increase in cycle time.

Ranking

The most promising technologies or practices to reduce or eliminate load securement related injuries were shortlisted based on a ranking system. The ranking was based on the following eight criteria: readiness, market penetration, ownership/direct cost, operating cost, injury elimination/reduction, risk controls used, durability, and ease of use. The rationale used for each criterion is summarized below:

- Readiness is the technology's readiness to deploy within operations
- Market penetration includes the applicability of technology or practice to overall truck population based on operational considerations and ability to implement

- Owning cost includes initial purchase cost and any equipment cost used in load securement process
- Operating cost includes maintenance and any recurring costs
- Injury reduction includes ability to reduce injuries during the load securement process
- Risk control involves the controls used to reduce or eliminate the injuries related to the load securement process
- Durability involves the ability of the technology to withstand standard operational use
- Ease of use includes the ability of the technology to be used with minimal required training

Appendix B describes the point system and weight used for each criterion. Table 2 presents the ranking of load securement related technologies and practices.

Table 2. Ranking of load securement related injury reduction technologies and practices

Category	Technologies/ practices	Readiness	Market penetration	Owning cost	Operating cost	Injury reduction	Risk controls	Durability	Ease of use	Rank
Improved throwing technique	Improvised variation of standard throwing technique	5	5	5	5	2	2	5	5	**3.95**
Loader assist	Loader assist with driver involvement	5	4	1	4	3	4	5	5	**3.75**
	Loader assist with the use of lashing hooks	5	4	2	4	4	4	4	5	**4**
	Loader assist with a spring-loaded lever mechanism	5	4	2	3	4	4	3	5	**3.8**
Throw assist	Lead rope	5	3	5	4	3	2	4	4	3.6
	Wearable exoskeletons	5	2	3	4	4	2	2	4	3.5
	Triangle hook lead rope	5	3	4	4	3	2	4	4	3.7
	Jo's easy wrap	5	5	4	4	3	2	4	4	**3.9**
	JB cable slinger	5	5	4	4	3	2	4	4	**3.9**
	Dynello Fling Clip	5	2	4	4	3	2	2	5	3.55
	King Cobra High Load Tie-down Thrower	5	5	4	4	3	2	4	4	**3.8**
Alternate practices	Platforms	5	3	3	3	4	4	4	4	**3.75**
	Tie downs	4	4	3	3	3	4	3	4	3.45
	Pneumatic strap launcher	1	2	3	3	3	3	3	3	2.65
Alternate Wrappers	Synthetic ropes	5	4	5	3	3	3	3	4	3.65
	Lightweight steel wrappers	5	4	5	5	2	2	5	5	**3.80**
Automated Load Securement	Exte Com 90	4	2	1	3	5	5	3	5	3.65

Based on the rankings in Table 2, it is proposed that the top five technologies/practices be evaluated in the second phase of this project. These five include:

- improved throwing techniques
- loader assist (with driver involvement laying wrapper and without driver involvement by using lashing hook or spring-loaded lever mechanism)
- throw assist such as slingshot aid (Jo's easy wrap, JB cable slinger, King Cobra)
- lightweight wrappers such as synthetic and 5/16" steel wrappers, and compare risk reduction between 3/8, 5/16 steel wrappers and synthetic ropes
- platform for the sites where volume of fibre hauling is high

In the long term, the benefit of switching to automated load securement will be investigated as the injuries related to load securement could be eliminated. Currently, there is only one available system on the market: Exte's Com 90. This device will be tested in Canadian forest operations as part of the phase 3 of this project to better understand the limitations and benefits of this system in Canadian operations' context.

PRELIMINARY COST BENEFITS ANALYSIS

Based on the preliminary cost/benefit analysis with assumptions made, improved throwing techniques, throw assist/slingshot aids and lighter steel wrappers have a higher benefit to cost ratio than loader assist and platform. Even though the benefit/cost ratio for automated load securement was relatively poor for the low number of truck loads per day considered in the analysis, this concept shows potential for eliminating load securement related injuries with improved efficiency.

Appendix C illustrates the benefit/cost analysis for the shortlisted technologies and practices.

CONCLUSION

In the effort to reduce or eliminate driver injuries caused by throwing log load wrappers, new and existing technologies and practices, along with operational considerations, were identified in phase 1. Based on the review and survey, there is clear potential to implement some of these technologies and practices in BC's logging operations to reduce or eliminate the risk of injury to the driver during load securement activities, while still meeting operational and regulatory load securement requirements.

As an intermediate solution, the following technologies/practices were shortlisted to assist log hauling contractors and licensees in reducing their current load securement related incidents and injuries:

- Improved throwing technique – The simplest way to reduce current load securement related injuries would be through driver training for improved throwing techniques
- Loader assist – With and without driver involvement. Where driver involvement is not required in the loader assist process, the use of tools such as lashing hooks or spring-loaded levers will improve the acceptance of this method

- Throw assist – The use of slingshot aids can reduce the amount of stress exerted onto the shoulders and overall body
- Light weight wrappers – The use of light weight wrapper will minimize the force required to throw the wrappers over the load; thereby reducing the risk of injury related to throwing wrappers
- Platform – The use of a platform seems promising for the sites where the volume of fibre hauled is high, although the use of platform's actual benefits will need to be quantified through operational trials

Phase 2 will adapt and analyze these shortlisted technologies/practices in the actual operations that would help to further develop recommended practices and improve industry's acceptance of these technologies/practices.

Phase 3 will evaluate automated load securement systems and further develop these systems' effectiveness in eliminating all injuries related to load securement in Canadian operations.

NEXT STEPS

For phase two, the following steps are:

- Seek the guidance from the TAG and LSWG on the proposed options
- Evaluate the shortlisted load securement options in actual operations
- Identify operational considerations, procedures, costs, risks, and mitigation techniques that could be efficiently and effectively utilized by industry
- Quantify risks and benefits, safety, and human related factors that will increase awareness and engagement by licensees, workers, contractors, and regulators
- Develop recommended practices for implementation with safe work procedures that align with current regulatory requirements

As part of phase three, automated load securement systems will be evaluated and further developed to eliminate load securement related injuries. This phase may be done concurrently with phase 2. Guidance from TAG and LSWG on executing this phase need to be obtained.

The objectives of this third phase will be to:

- Identify automated load securement options (such as Exte, Patchell system etc.) that are applicable to the BC log hauling environment
- Explore the options and possibly adapt, if needed, these systems to BC needs, e.g.: develop the automated system in collaboration with industry members, universities, or colleges
- Conduct trials with the most promising options
- Quantify risks and benefits, and safety, that will increase awareness and engagement by licensees, workers, contractors, and regulators
- Develop recommended practices for implementation with safe work procedures that align with current regulatory requirements

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APPENDIX A LOG LOAD SECUREMENT REQUIREMENTS AROUND THE GLOBE

Australia

Load Restraint Guide https://www.ntc.gov.au/sites/default/files/assets/files/Load-Restraint-Guide-2018.pdf

Canada

National Safety Code Standard 10 Cargo Securement https://www.ccmta.ca/web/default/files/PDF/NSC_Standard_10-_June_2013.pdf

WorkSafeBC Occupational Health and Safety Regulation Part 26 https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-26-forestry-operations#SectionNumber:26.67

Europe

International Guidelines on Safe Load Securing for Road Transport https://www.hsa.ie/eng/Vehicles_at_Work/Load_Securing/Guidance_and_Publications/IRU_Guidelines.pdf

New Zealand

Log Load Securing Requirement- Industry Standard https://logtruck.co.nz/wp-content/uploads/2020/05/177.001-LTSC-Industry-Standards-Manual_Section5_Log-Load-Securing-Requirements_FEB20_WEB.pdf

United States

FMCSA Cargo Securement https://www.fmcsa.dot.gov/regulations/cargo-securement/drivers-handbook-cargo-securement-chapter-2-general-cargo-securement

North America Cargo Securement Harmonization https://www.cvsa.org/events/cvsa-workshop/north-american-cargo-securement-harmonization-public-forum/

APPENDIX B RANKING CRITERIA AND WEIGHTING

Table 3. Ranking Criteria

Market		Finance		Safety Performance		Work Performance	
Readiness of technology	Market penetration	Owning cost	Operating cost	Injury reduction	Risk controls	Durability	Ease of use
Development - 1	Less than quarter population - 1	very expensive (greater than $50,000)- 1	very high (greater than $10,000/ year)- 1	unknown - 1	PPE - 1	frequently damaged 1	very complex - 1
Need regulatory & technical change - 2	Quarter population - 2	expensive ($10,000 to $50,000)-2	high ($5,000 to $10,000 per year)- 2	less than 25% - 2	Admin - 2	susceptible to damage - 2	complex 2
Need regulatory change - 3	Half population - 3	moderate ($2000 to $10,000)- 3	moderate ($1000 to $5000 per year) - 3	25 to 50% - 3	Engineering - 3	moderately susceptible to damage - 3	moderate -3
Need just technical change 4	Half to three quarter - 4	cheap ($500 to $2000)- 4	low ($500 to $1000 per year) - 4	50 to 75% - 4	Substitution - 4	less susceptible to damage - 4	simple - 4
Ready to go - 5	Three quarter to full population - 5	very cheap (less than $500)- 5	very low (less than $500 per year)- 5	75 to 100% - 5	Elimination - 5	rugged - 5	very simple - 5

Table 4. Ranking Weight

Market		Finance		Safety Performance		Work Performance	
Readiness	Market penetration	Owning cost	Operating cost	Injury reduction	Controls	Durability	Ease of use
10%	15%	10%	10%	25%	10%	10%	10%

APPENDIX C COST BENEFITS ANALYSIS

Table 5. Benefit/cost analysis for the shortlisted technologies and practices

Parameters	Formulae	Conventional	Improved throw techniques	Light weight steel wrappers	Platform use on reload or mill yard	Throw assist with slingshot aid	Loader assist without driver involvement	Automated load securement
Wrapping time per wrapper (min)	w	3.5	3	3	3	3	1.5	0.5
Log bundle per tier	l	4	4	4	4	4	4	4
Cost of load securement equipment	c	$400 ($50x4 (number of bundles) X2 (number of wrappers per bundle))		$400	$7000 ($70,000/ 10 trucks)	$300	$1,200	$100,000
Installation cost	i				$500 ($5000/10 trucks)		$25	$5,000
Training cost	t		$50		$50	$25	$50	$150
Total initial cost	IC =c+i+t	$400	$50	$400	$7,550	$325	$1,275	$105,150
Annual maintenance cost	a							$5,000
Lost revenue per year	r							$9,000
Truck cost ($/min)	tc	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Loader cost ($/min)	lc						3	
Wrapper time per load (min)	lt	28	24	24	24	24	12	4
Costs per truck load	ct = lt x (tc + lc)	70	60	60	60	60	66	10
Number of truck loads per day	td	3	3	3	3	3	3	3
Number of operating days per year	Ty	240	240	240	240	240	240	240
Total load securement cost per year	LSC=ct x td x Ty	$50,400	$43,200	$43,200	$43,200	$43,200	$47,520	$7,200

Parameters	Formulae	Conventional	Improved throw techniques	Light weight steel wrappers	Platform use on reload or mill yard	Throw assist with slingshot aid	Loader assist without driver involvement	Automated load securement
WorkSafeBC claims per year	WSC	$4,500 ($4,000,000/(89 claims * 10 years)	$2,250 (50% reduction)	$2,250 (50% reduction)	$1,800 (60% reduction)	$1,800 (60% reduction)	$1,800 (60% reduction)	0
Estimated cost savings per year due to reduced time	CS = LSCconv -LSCinter - a - r - WSC		$7,200	$7,200	$7,200	$7,200	$2,880	$29,200
Net present value based on 2% inflation rate (i) and three-year period (n)	NPV = summation (CSt / (1-i)^t) where t is 1 to n		$14,275	$15,132	$15,573	$18,999	$3.115	$84,209
Benefit to cost ratio (BCR)	BRC=NPV/IC		286	38	2	58	2	1

With improved throwing techniques, there will be no major change in the time required to secure a load. The reduction in injuries through improved throwing techniques has been proven through studies with athletes. Studies have shown that with improved technique, performance is improved, and the risk of injuries is reduced for overhead throw sports which put similar stresses on the body as throwing wrappers. (Fleisig et al 1996).

Loader assist without driver involvement should use either a lashing hook or a spring-loaded lever. Using these devices will reduce the load securement time and machine/ driver interactions.

Platform can cost around $70,000 depending on complexity; however, this cost could be distributed over the loads that are secured using the platform. If the volume hauled from the site is high, then the platform's high initial capital cost could be factored over the number of loads, so the cost per load would be quite low. Furthermore, the extra cost of the platform could be offset by the reduced time needed to secure the load.

Lightweight steel wrappers cost about the same as conventional wrappers, so the benefit of their use could be further enhanced with improved throwing techniques.

Automated load securement systems will yield benefits for short trips, more than 5 loads per day, as well as truck configurations with 3 or more bundles. This assumes that the system reduces load securement time by 30 minutes, allowing cycle times to be reduced by the same amount. Other potential considerations include reduced insurance costs, the reduced payload lost revenue, and increased maintenance cost. In the future, it is possible that trailer and truck manufacturers will make these systems part of their standard offering, so the cost may be integrated into the initial truck/trailer purchase cost.

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