Arboriculture Safety Around The World

ARBORICULTURE SAFETY AROUND THE WORLD

A Thesis Presented

By

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ABSTRACT

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Arboricultural work is inherently dangerous, with more serious injuries and fatalities than most other professions. Safety standards exist in some jurisdictions, but it is unclear how many standards exist, how they compare to one another, and whether (and how many) jurisdictions share standards. To establish a baseline understanding of these issues, my objectives were to (i) develop a database of existing standards, (ii) identify the most frequently occurring safety topics and (iii) describe similarities and differences in safety topics among standards from different countries. I worked with a variety of contacts and traditional university library resources to identify, obtain, analyze, and compare arboricultural safety standards from around the world. I established a database of standards and found that various types of standards exist among countries: most countries used locally developed standards and industry standards were the most common types of standards because of industry professional's expertise in arboricultural work safety matters. I analyzed the contents of 4 areas of arboricultural work categories in standards: General safety requirements (GSR), personal protective equipment (PPE), chainsaw (CS) and tree climbing (TC). GSR and PPE categories had the most proportion of common safety topics as compared to CS and TC. I identified most common safety topics in all 4 categories which shed light onto some of the areas of safety practices which are commonly recognized as important, while least common safety topics suggest areas of

arboricultural work that may or may not be useful in future revisions of standards. There were 7 groups of countries most similar in the types of standards which they use, suggesting that countries can influence one another in adopting safety practices and that there are regional and international cooperation between countries in developing standards. My findings can be used by safety committees around the world in developing standards, as well as for the ISA's International Safety Committee (ISC) to initiate an international safety standard. This study is novel and a stepping-stone for future research in evaluating the effectiveness of standards in reducing arboricultural work incident rates.

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CHAPTER 1

INTRODUCTION

1.1 Arboriculture is a high-risk profession

Arboriculture is an inherently dangerous profession which encompasses high risk operations like working at height, handling heavy loads and powerful equipment, and working around natural tree structures that do not have a fixed or well-known safe working load limit. The work of an arborist requires specialized skills and equipment to safely perform work in a hazardous environment (Blair 1989, Dozier and Machtmes 2005, Julius et al. 2014).

The hazardous nature of tree work is reflected in statistics that report high rates of fatalities and serious injuries of tree workers (Blair 1989, Ball and Vosberg 2010). In the United States, federal government agencies like National Institute for Occupation Safety and Health (NIOSH) and Bureau of Labor Statistics (BLS) track and report incident statistics. Analyses of incident data have shown that the annual fatality rate for tree workers has consistently been at 30.0 per 100,000 U.S. workers, almost eight times higher than the national average of 4.0 fatalities per 100,000 U.S. workers for all other industries—(Ball and Vosberg 2003, Wiatrowski 2005, Ball and Vosberg 2010). NIOSH (1992) reported that during 1980 to 1988, there was an average of 20 tree worker deaths per year, mainly from electrocutions and falls. Castillo (2009) analyzed data from the Census of Fatal Occupational Injuries (CFOI) and found 1,285 fatalities among tree workers, where 44% were pruning a tree when fatally injured and the top 3 most common causes of death in tree work was being struck by or against an object (42%), falls to lower level (34%) and electrocutions (14%). Tree workers also sustain severe injuries like amputations as a result of injury

from mobile wood chippers (Struttmann 2004). The use of hazardous equipment in tree work also caused serious injuries and many emergency room visits are from chainsaw injuries sustained by tree workers (Watsons et al. 2012, Marshall et al. 2018).

Incident data from other countries were similar to those in the United States. In the United Kingdom, the incident rate among rate among tree workers was 83 per 1,000 workers between 2005 and 2010, and there were 34 tree worker fatalities between 2002 and 2012 (Robb and Cocking 2014). Incidents included being struck by felled trees and being cut by a chainsaw while working aloft (Robb and Cocking 2014). In Italy, from 2002 to 2012, the annual average number of tree worker injuries was 1.9 (Proto et al. 2016) and Australia reported that the arboriculture occupation had the highest fatality rate among all industries of the country at 42 fatalities per 100,000 workers, which was 28 times higher than the average fatality rate of the general industry (Arboriculture Australia 2018).

Incident statistics, however, are limited for a variety of reasons. Occupational fatality and injury statistics for arboriculture were difficult to obtain, inaccurate, and inconsistently reported in many studies (O'Bryan et al. 2007, Centers for Disease Control and Prevention, (CDC) 2009, Robb and Cocking 2014, Oschner et al. 2018). In the United States, the Occupational Safety and Health Administration (OSHA) does not require businesses with fewer than ten employees to report incidents (Department of Labor 2005), and tree care companies employ, on average only four workers per company (O'Bryan et al. 2007). Therefore, many tree care companies in the United States are not required to report work-related incidents. As a result, tree-related work injuries and fatalities are either incompletely reported (from the lack of

proper incident reporting guidelines) or not reported at all (Oschner et al. 2018). For similar reasons—many tree workers in Europe are self-employed—workplace incidents in the Czech Republic, Germany, Slovakia, Spain, and the United Kingdom were also under-reported (Robb and Cocking 2014). The United Kingdom was the most diligent in terms of reporting chainsaw related incident statistics for the tree-work industry, yet almost half (43%) of the businesses in this industry did not report workplace incidents because 50% of the industry were self-employed (Robb and Cocking 2014). The self-employed sector had high incident rates but low incident reporting rates (Robb and Cocking 2014).

Statistics for tree worker fatalities are also limited among occupational studies and reports because surveillance data often grouped tree workers with other occupations. In the United States, until 2002, arboriculture was classified in the category of ornamental shrub and tree services under the North America Industry Classification System (NAICS) (Wiatrowski 2005). However, in 2003, the U.S. Department of Labor started reporting injuries and fatalities associated with tree-related services into the broader category of landscape services, which also included occupations like landscape construction, design, and maintenance (Wiatrowski 2005, O'Bryan et al. 2007). In 2002, the fatality rate for workers in the ornamental shrub and tree services category was 32.9 per 100,000 U.S. workers, but in 2003, BLS reported a fatality rate of 14.1 per 100,000 U.S. workers for the landscaping services (Wiatrowski 2005, O'Bryan et al. 2007). Tree-related work is more hazardous than landscaping services so generalizing the data would not best represent the fatality rate of arborists and affect safety evaluation programs for reducing tree-related work fatalities (O'Bryan et al. 2007). Similarly, in the United Kingdom, the Health and Safety Executive (HSE), which is the local authority governing occupational work

safety, had a separate category of "Tree work" when surveying chainsaw related incidents at work, but the category also includes occupations like hunting, forestry, logging, and fishing (Robb and Cocking 2014). Most European countries, Australia and New Zealand also have occupational fatalities statistics for forestry as the closest tree-related work profession (Robb and Cocking 2014, SafeWork Australia 2016a, WorkSafe New Zealand 2018).

In addition to fatal and serious injuries, arborists may sustain non-fatal injuries, but statistics on non-fatal injuries for tree workers are sparse (Watsons et al. 2012, Marshall et al. 2018). The lack of data on non-fatal injuries is surprising because the average annual rate of injuries in trimming and pruning work increased 35.1% from 1990 to 2007 (Watsons et al. 2012). One reason for the lack of data is that the BLS reports non-fatal occupational injuries for the broad category of landscaping services, which includes not only tree workers, but also a variety of related occupations such as groundskeepers and landscapers (Wiatrowski 2005, Buckley et al. 2008). Consequently, data analysis requires the tedious work of separating out injuries specifically of tree workers (CDC 2009, Watsons et al. 2012, Marshall et al. 2018).

The most common non-fatal injuries are lacerations and punctures (71.0%), with injuries most often to the arms and hands (67.8%) (Watsons et al. 2012). Non-fatal injuries also included chronic injuries like musculoskeletal injuries, typically lower back and wrist pain, and Raynaud's phenomenon. The latter is also known as "vibration white fingers," a condition due to constriction of blood vessels in the fingers, leading to numbness, especially in cold weather. Raynaud's phenomenon can arise from long-term and frequent use of hand-held power tools (like chainsaws) that causes vibration to the hands (Miyakita et al. 1987a, Miyakita et al. 1987b, Futatsuka

et al. 1996, Watsons et al. 2012, Canadian Centre for Occupational Health and Safety (CCOHS) 2017). Exposure to high noise levels from machines like aerial lift devices, chainsaws, and wood chippers is another hazard in tree work that can lead to hearing loss and tinnitus (ringing in the ear) (Futatsuka et al. 1996, HSE 2008, HSE 2018a).

Workplace injuries and fatalities incur high costs and economic losses, affecting personal and public lives (Biddle 2004, CDC 2009, Lebeau et al. 2014). Costs of occupational injuries can be a measure of risk indicator of an industry. For example, the construction, mining and transportation industries had some of the highest costs of occupational injuries, and these are also the industries with high risk (Biddle 2004, Lebeau et al. 2014, Thepaksorn and Pongpanich 2014). When a worker is injured, the inability to work either temporarily or permanently results in loss of wages that adds to the financial losses, affecting the livelihood of the victim and their families (Lebeau et al. 2014). In Bangkok, 71% ($9.88 million) of total direct cost of occupational injuries was spent on medical expenses and 29% ($3.98 million) for compensation and lost earnings (Thepaksorn and Pongpanich 2014). There is physical and emotional pain and suffering for an injured worker and their families which can affect quality of life such as loss of ability to carry out normal daily activities like household chores. For example, occupational injuries in Quebec resulted in 21,603 years of good life lost and cost $2,837,047,405 (Lebeau et al. 2014).

Businesses also suffer costs from occupational injuries. Employers pay compensation to affected workers and their families: In 2006, the CDC in the United States reported $87.6 billion spent by employers on worker’s compensations for occupational injuries (Sengupta et al. 2006). Occupational injuries also result in a loss of productivity, decreased staff morale, and increased administrative cost (additional

training and resources that the employer needs to invest in to replace an injured worker with a new worker) for businesses (Lebeau et al. 2014, OSHA 2018a). The annual loss of productivity due to worker injuries can be substantial. In a 2005 report, the International Labor Organization found that 4% of the world's gross domestic product (GDP) (or US$2.8 trillion equivalent) was lost to costs in occupational incidents and diseases (International Labour Organization 2005, Takala 2005) and in 1994 in the United States, losses from occupational injuries amounted to $US155 billion dollars which was equivalent to 3% of GDP (Paul et al. 1997). Lebeau at al. (2014) found that from 2005 to 2007 in Quebec, the total loss of productivity from occupational injuries was $Can1,504,613,863, and administrative costs were estimated to be $Can35,595,212.

Few studies have quantified the cost of occupational injuries for tree work. From 1992 through 2001 in the United States, societal costs due to fatalities associated with the use of wood chippers amounted to $US28.5 million (Struttmann 2004). Ryan and Ertel (1988) cited an informal survey of member companies by the National Arborist Association which found that (i) insurance premiums had increased by up to 300% and (ii) of the cost of increased premiums, 70% was for worker's compensation.

With such high cost associated with occupational injuries, there is value for business owners to invest in workplace safety and health management programs such as, providing training for employees and identifying hazards in the work environment. Having safety programs helps to reduce the cost of injuries, fatalities and compensation and improve profit and effectiveness for the business (Ryan and Ertel 1988, CDC 2009, OSHA 2018a, OSHA 2018b).

Considering the dangers of tree work and the potentially high cost of injuries and fatalities, tree worker safety should be a priority for business owners, workers, policy makers and researchers (Ryan and Ertel 1988, Struttmann 2004, Julius et al. 2014, Marshall et al. 2018). In addition to analyzing fatal and non-fatal tree worker incidents to determine most common causes of injuries and fatalities, reviewing safety standards, training, and credentialing pertaining to arboriculture are some prevention strategies to help reduce injuries and fatalities for arborist (Ryan and Ertel 1988, O'Bryan et al. 2007, Julius et al. 2014, Robb and Cocking 2014, Marshall et al. 2018). A better understanding of tree worker safety is imperative because although the industry is still small in some countries like Australia (Department of Employment 2014), it is expected to expand in many countries (O'Bryan et al. 2007, BLS 2014, Francesco Mazzocchi 2015), and there is a need for qualified arborists globally.

1.2 Literature review

1.2.1 Industry and government developed arboriculture safety standards

To address the inherent danger of arboricultural work, safety standards have been developed by the industry to guide work safety and reduce the likelihood of work injuries (Robb and Cocking 2014, Julius et al. 2014). Safety standards are standardized work procedures which are necessary or reasonable to provide a safe and healthful work environment (OSHA 2018a). Safety standards can also be used as a benchmark for an industry's work quality and to increase professionalism (Johnston 2015). Arboriculture safety standards are developed from a consensus (unanimous agreement) of various parties involved in the industry like arborists, arboriculture associations or societies, insurance agencies, government, manufacturers and any other interested professionals in the field (ANSI 2017). Consensus safety standards

are endorsed by nationally recognized but private standards accreditation bodies like the American National Standards Institute (ANSI), Australian Standards (AS) and Australian/ New Zealand Standards (AS/NZ)—the latter is a joint independent organization of two countries. Examples of existing consensus safety standards in arboriculture work operations include those in Europe (EAC 2016), New Zealand (NZARB 2017), Singapore (SAS 2017), and the United States (ANSI 2006).

Some countries have standards developed by government agencies. This is because public and private agencies can work together in occupational safety and health matters since public agencies rely on the technical expertise of private industries to develop work safety related policies or regulations for the public (Cheit 1990). Therefore, in the arboriculture industry, some countries had their public agencies collaborate with private arboriculture industry players to publish safety standards. For example, in the United States, OSHA adopted some parts of the national consensus standard for arboricultural operations, ANSI Z133 into the 1910.269 standard regarding specifications of incidental and utility line-clearance tree trimming (ANSI 2017). In the United Kingdom, the HSE worked with a forestry and arboriculture advisory group called the Arboriculture and Forestry Advisory Group (AFAG) to publish safety standards for the use of chainsaws and tree climbing (Johnston 2015, HSE 2018b). WorkSafe New Zealand, a government agency, adopted the arboriculture safety standard that was developed by the New Zealand Arboriculture Association (NZARB) and the Workplace Safety and Health (WSH) Council in Singapore, also a government agency, collaborated with arboriculture representatives and other public agencies to publish a safety standard for landscape and horticulture operations that includes various aspects of tree work practices (WSH Council 2018)

1.2.2 History of arboriculture safety standards

Among the existing arboriculture safety standards from various countries, the ANSI Z133 was one that developed in response to a fatal tree trimming incident in the United States. Mrs. Ethel M. Hugg's son died in a tree trimming operation and she wrote to federal and state authorities and various organizations to have measures to make tree trimming safer. The Accredited Standards Committee Z133 was set up to develop a standard for the arboriculture industry. The Z133 committee was comprised of representatives from the industry, academics, government, manufacturers and other experts (OSHA 2016, ANSI 2017). In November 1969, the secretariat of the Z133 committee was the International Shade Tree Conference which is now known as the International Society of Arboriculture (ISA). The Z133 committee developed the first Z133 safety requirement for arboriculture operations in 1971. ANSI approved the Z133 on 20 December 1972, making it a national consensus standard that has been adopted and reference for many safety programs in the United States (ANSI 2017).

The development in technology and use of more mechanized equipment in arboricultural work were other reasons that arboriculture safety standards developed in the United States and United Kingdom. In both countries, innovations and development of mechanized tree care equipment like chainsaws, aerial lifts, brush chippers, safety harnesses and climbing ropes increased the sophistication of tree care practices (Campana 1999, Johnston 2015). The concerns for potential hazards associated with such specialized equipment called for more regulation and control in the United Kingdom so the British Standards Institution (BSI) published a number of arboriculture standards, which also included work safety standards (Campana 1999, Johnston 2015).

Occupational health and safety laws also influenced the arboriculture industry in the United Kingdom, New Zealand and Singapore to develop safety standards. In the United Kingdom, the implementation of the Health and Safety at Work Act of 1974 increased awareness for occupational safety and created a more risk adverse society which led the arboriculture industry to become more focused on work safety considerations (Johnston 2015). As a result, the Arboricultural Association (AA), an industry association, set up a working party called the Arboriculture Safety Council to review all practices in arboriculture work safety and set up standardized work procedures (Preston 1991). In 1992, New Zealand's Health and Safety in Employment Act aimed to develop regulations and standards (also called codes of practice) for the country's labor industries and hazardous work practices (Occupational Safety and Health Service 2000). Because of this Act, the first arboriculture safety standard, Approved Code of Practice (ACOP) for Safety and Health in Tree Work Part One: Arboriculture, was published by the Occupational Safety and Health Service of the Department of Labor, in 1994 (M. Roberts, personal communication, 10/18/18) as a document stating preferred work methods for arboriculture work (Occupational Safety and Health Service 1994). In Singapore, the Workplace Health and Safety (WSH) Act of 2011 extended coverage to the landscaping industry, which included tree work, publishing a standard as a guide on work safety practices and legislative requirements that are applicable to the landscaping industry (WSH Council 2018).

1.2.3. The impact of safety standards on occupational incident rates

Many studies have assessed the effectiveness of federal safety standards and regulations in reducing the rate of occupational injuries, but the results were inconsistent. While studies showed that OSHA standards on mandatory eye protection

(Lipscomb 2000), trench excavation (Suruda et al. 2002) and steel erection (Leite 2016) were effective in reducing the number of injuries, other studies did not find a significant impact of federal regulations in reducing the rate of occupational injuries for the construction (Derr et al. 2001, Darragh et al. 2004, Bulzacchelli 2007, Lehtola et al. 2008, Molen et al. 2018), mining (Monforton and Windsor 2010), and maritime industries (Monforton and Windsor 2010, Lappalainen et al. 2013).

Studies have also assessed the effectiveness of voluntary safety standards in reducing injury rates. In product safety, the implementation of voluntary safety standards concerning baby walker regulations and drawstring requirements for children's upper outerwear garment were found to be effective in reducing the number of stair fall injuries and drawstring-related fatalities respectively (Rodgers and Leland 2005, Rodgers and Topping 2012). And Navia (2012) found that the industry safety standards of youth football helmets in the United States were ineffective in reducing the number of head injuries sustained by youth football athletes because testing standards developed by trade associations had not been updated and there was no oversight in monitoring market production of new or defective helmets.

1.2.4 Comparative studies of occupational safety policies among different countries in various industries

Studies have compared safety standards for other high-risk occupations like commercial fishing (Windle et al. 2008) and construction (Raheem and Hinze 2014), but there do not appear to be any studies comparing arboricultural safety standards. For the commercial fishing and construction industries, inaccurate and inconsistent national occupational incident statistics for fishing and construction made comparison of safety outcomes between countries difficult (Windle et al. 2008; Raheem and

Hinze 2014). Instead, Windle et al. (2008), Raheem and Hinze (2014) reviewed literature of text regarding safety policies which included national, international policies, regulations, safety standards and incident reporting procedures pertaining to fishing and construction respectively. While Raheem and Hinze (2004) did not seek to conduct a comprehensive analysis of the safety standards in the construction industry but only selected 4 aspects of the safety standards to analyze, Windle et al. (2008) conducted a comprehensive review of international fishing regulation regimes and developed a public database for reviews of fishing policies to provide a source of reference for future comparative studies. Windle et al. (2008) also described the similarities and differences between fishing policy regimes among countries. Windle at al. (2008), Raheem and Hinze (2014) described qualitative methods which were potentially useful and applicable for safety research in the arboriculture industry. Since the arboriculture industry is limited in incident statistics among countries, but there are safety standards known to exist in different countries, a descriptive and comparative approach is an alternative to quantitative studies for arboriculture safety research.

1.2.5 Current studies in arboriculture safety research

The arboriculture industry had studies in work safety research of its field: In the United States, Julius et al. (2014) assessed the compliance of tree care companies to the industry ANSI Z133 safety standards; Dozier and Machtmes (2005) evaluated the safety performance of arborists in Louisiana; Proto et al. (2016) investigated causes and most common types of injuries sustained by arborists during tree climbing operations in Italy. However, no previous studies have assessed the effectiveness of industry or government developed arboriculture safety standards in reducing injury

rates or evaluated the contents of arboriculture safety standards used in different countries of the world. It is also unclear how many countries with an arboricultural industry even have any safety standards. Since safety standards provide recommended working procedures and safety measures, analyzing the contents of these documents may lead to discovery of important safety concepts that can help in understanding why and how certain clauses exists in these documents. There is also no global database for arboriculture safety standards, which is useful as a reference to conduct analyses and correlation of the effectiveness of safety standards to reducing arboriculture accidents. Therefore, analyzing arboriculture safety standards is a potential novel area of research and there is value in pursuing in-depth studies in this field.

1.3 Objectives of the study

The goal of this study was to develop an understanding of the existing arboricultural safety standards around the world. My objectives were to:

1. Obtain and develop a database of arboricultural safety standards from with an ISA component;
2. Identify the most frequently occurring safety topics among the standards;
3. Describe the similarities and differences between standards with respect to safety topics.

CHAPTER 2
METHODS

2.1 Scope of study

The study population was 34 countries in which there was a component(s) of the ISA (Table 1, Figure 1). ISA is the only professional association with individual members from around the world. ISA has actively cultivated new components globally, and I assumed that the likelihood of a coherent and regulated arboriculture industry outside of countries with an ISA component was low. In addition, an ISA survey showed that eighty percent of countries with an ISA component reported that there was some form of safety regulation (general workplace safety regulations or regulations specific to arboriculture) in the country (ISA 2016). Since the ISA emphasizes safety in its educational materials, I expected that an arboricultural safety document(s)would exist in countries that have an ISA component(s). Furthermore, funding and time constraints precluded a comprehensive global search for arboricultural safety documents. The terms “country” and “countries” in this study refer only to those with an ISA component.

I selected arboricultural safety standards which are safety standards for arboricultural work operations which were specifically applicable to tree workers, who are individuals working on urban tree pruning, maintenance, and removal operations. Throughout this document, any reference to a “standard” or “standards” indicates an arboricultural safety standard(s). For each country, I selected the broadest relevant standard(s)—i.e., applicable to all tree workers in a country. If a national standard was not known to exist in a country, I selected the next broadest level of a state or provincial standard for that country. In some countries, multiple standards exist. For example, in the United States, the ANSI Z133 is an industry consensus standard, and the

Occupational Health and Safety Administration (OSHA), a federal agency, regulates safety for all workers. Since OSHA does not have regulations explicitly for tree workers, I only included the ANSI Z133 in the analyses. The United Kingdom had industry and governmental standards, however, the government standard ["AFAG (Arboriculture and Forestry Advisory Group) 401 - Tree Climbing Operations," "AFAG 308 - Top-handled Chainsaws," "INDG317 - Chainsaws at work" and "A guide to good climbing practice"] applies to tree workers, while the industry standard ("Industry Code of Practice for Arboriculture") did not include as many topics as those included in the government standard. Therefore, for the United Kingdom (and other countries with industry and government standards that both applied to tree workers), I analyzed all relevant standards as if they were a single standard for that country. In other countries, it was unclear whether both industry and government standards applied to tree workers. Given the uncertainty of categorizing standards as industry or government for different countries, I did not compare industry and government standards. In the rest of the thesis, I used the term "standard" to indicate a single standard for countries in which only one standard was applicable (e.g., the United States) or to indicate multiple applicable standards in a country (e.g., the United Kingdom) that I grouped together for analysis.

2.2 Locate and obtain safety standards

To search for standards, I used the database of ISA components <http://www.isa-arbor.com/Who-We-Are/Our-Network> to identify official websites and contacts in all 34 countries with an ISA component(s). I retrieved information of standards from these websites and contacted representatives of each ISA component outside of the USA to obtain information about standards. However, the websites of ISA components in Belgium, Croatia, Finland, Iceland, Japan, Lithuania and the

Netherlands did not have information about standards. From the ISA website, I found contact information for members of the Council of Representatives (CoR), which includes a representative from each ISA component. I contacted a member of CoR from each country listed previously and received responses from Australia, Austria, Brazil, Canada, Colombia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Latvia, Malaysia, Mexico, Netherlands, New Zealand, Norway, Poland, Slovakia, Singapore, Spain, Sweden, Switzerland, Taiwan, United Kingdom and United States.

I also searched websites for relevant government standards in each country with an ISA component. The searches sometimes produced public databases available from agencies such as OSHA and NIOSH in the United States, HSE in the United Kingdom, WorkSafe Australia, WorkSafe New Zealand, and the International Labor Organization (which has a collection of labor laws, general workplace health and safety acts of countries in the world).

I was able to obtain standards applicable in 33 countries. Despite repeated contacts and much online searching, I could not obtain standards applicable in Belgium, the Czech Republic, Finland, Iceland and Lithuania. Belgium, the Czech Republic, Finland and Lithuania are members of the EAC <https://www.eac-arboriculture.com/members.aspx>, so I assumed that the EAC's guidelines ["A Guide to Safe Work Practice (Third Edition)" and "European Tree Worker"] applied in those countries. Because I could not determine whether standards applied in Iceland, I excluded it from the analyses.

2.3 Analyze standards

2.3.1 Develop main categories and subcategories of arboricultural work safety topics for coding.

To compare the textual content of standards, I initially developed four main safety categories and their respective subcategories from the industry standard used in the United States (ANSI Z133). I used the ANSI Z133 because (i) it was readily available and in English, (ii) it is an established standard with a long history of revision, and (iii) ISA (the only international organization for professional arborists) is a member of the committee that developed the ANSI Z133. In addition to its global membership, ISA has developed professional credentials, and hosts annual, international events dedicated to arboricultural safety (e.g., the International Tree Climbing Competition) and education (e.g., the ISA Annual Conference) (ISA 2018). ISA also includes an International Safety Committee (ISC). Since ANSI Z133 is one of the standards used in the education materials and certification programs disseminated internationally by the ISA, the ANSI Z133 would be a reasonable reference safety standard that can be used to compare arboricultural safety standards from other countries.

The four main categories: General Safety Requirements (GSR), Personal Protective Equipment (PPE), Chainsaw (CS) and Tree Climbing (TC) were developed by, first, using the industry standard used in the United States (ANSI Z133) as a reference to understand what were the types of existing arboricultural work operations (e.g. tree pruning, removal, brush chipping, tree climbing, using mobile devices, aerial lifts, hand tools like pole saws or hand saws, power tools like chainsaws or other mechanized tree-related equipment) and their associated safety topics.

Next, I used the word frequency count in NVivo 11 (QSR International Pty Ltd, Doncaster, Victoria, Australia) to determine the most frequently occurring words in all the standards I obtained. The most common words among standards were "safety," "equipment," "manufacturer," "chainsaw," and "rope" (Figure 2), which suggested potential arboriculture work topics associated with these words and I read all the standards to verify that the words were used in the context of related safety topics. For example, a potential category would be tree climbing because it is a work activity which requires equipment and ropes which were words most often found among arboricultural safety standards, therefore suggesting that most standards mention safety topics regarding tree climbing work. "Manufacturer" was also a common word which can be associated with adhering to manufacture's instruction to operate and maintain a good piece of equipment. It was also important to read all standards to have a qualitative sense of which arboricultural work operations were most common among all standards. I found that all standards mentioned safety practices in general safety requirements for tree work, use of PPE, chainsaw, tree climbing, but the standard from France did not include chainsaw use. Standards from Austria, Canada (Quebec), France, Germany, Italy, Spain and Switzerland were not written in English, so I used the Translator function in Microsoft Word to translate the documents.

Finally, I also considered arboricultural incidents reported in the literature; for example, being stuck by an object or piece of equipment and falling from height were two of the most common causes of fatalities among tree workers (CDC 2009, TCIA 2016). The chainsaw is a common yet dangerous power tool used in arboricultural work that has caused serious injuries (Watsons et al. 2012, Marshall et al. 2018). Tree pruning and climbing activities are hazardous operations with risks like chronic, nonfatal injuries and falling from height (Mazzocchi 2015, Proto et al. 2006, Watsons et al.

2012). Within the four main safety categories, I considered subcategories, which were explicit instructions for work safety, based on the ANSI Z133.

In addition to using clauses from the ANSI Z133 to develop subcategories for PPE, I added two subcategories that were not included. In §3.3.8 of the ANSI Z133 (ANSI 2017), there is an instruction for wearing cut-resistant leg protection while using a chainsaw on the ground. I added subcategories for (i) wearing cut-resistant leg protection while operating a chainsaw aloft and (ii) wearing cut resistant leg protection when operating a chainsaw regardless of whether the worker is on the ground or aloft. I also included subcategories found in standards from other countries, but not found in the ANSI Z133. A list of all subcategories within each main category is in Table 2.

I used key words of technical arboricultural terms like "drop-start," "uncontrolled pendulum swing," "tie-in points," "climbing lines," "ropes," "arborist saddles," "cut-resistant leg protection," "moving rope system," or "stationary rope system" as a guide to determine whether a subcategory was present or absent in a standard. However, text in the safety standards did not need to contain the exact phrase or words as the sub-categories to qualify as being present because other standards may phrase a work procedure or use a technical term differently even though the meaning or intent could be the same. For example, §6.3.8 in ANSI Z133 states, "When a chain saw is being carried more than two steps, the chain brake shall be engaged, or the engine shut off." The Arborist Industry's Safe Work Practices (2011) safety standard from Ontario (Canada) mentions "the engine shall be shut off when moving the power saw from one location to another, except when trees are in close proximity and the approach is unobstructed. When moving from tree-to-tree with the engine running, the chain brake shall be applied." Although Ontario's standard was not phrased exactly the same as the ANSI Z133, which mentioned "more than two steps," the intent of both phrases

is the same – they refer to the need to switch off the engine of the chainsaw or engage the chain brake when the chainsaw has to be moved over a longer distance and the same procedure of shutting off the chainsaw or having the chain brake on is not necessary for an operator moving within short distances. Another example is the use of the term "tie-in point" in ANSI Z133 and the term "anchor point," which Australia, Singapore and New Zealand's arboricultural safety standards use. "Tie-in point" and "anchor point" are not exactly the same, but both refer to the use of a spot in the tree (like a branch or a part of the trunk) to loop a climbing rope over as a means for supporting a climber or an object (Global Organization of Tree Climbers 2007). While key words can be useful in classifying text into the appropriate sub-categories for comparison, it was more important to identify and match the intent of the words or phrases in an arboricultural safety standard to the sub-categories.

2.3.2 Data analysis

I parsed the content of each standard into appropriate categories and subcategories with binary codes of 0 (the standard did not contain the category or subcategory) and 1 (the standard contained the category or subcategory). I entered the codes into Excel 2016 (Version 3.0, Microsoft Corp., Redmond, Wash., USA) and tabulated the total counts and percentages of 1's and 0's among countries, safety standards, categories and subcategories.

For each of the four main categories, I used Microsoft Excel to create similarity matrices to determine the proportion of subcategories within each main category that were shared by each pair of standards. I repeated the similarity analysis for all subcategories together. In the similarity analysis, the sum of the total number of

subcategories shared by two standards is divided by the total number of subcategories (either within a main category or all together).

I grouped countries according to how similar they were based on the standard(s) used in the country and the similarity matrices. Countries that use the same standard(s) would have the identical patterns of subcategories occurrences and be 100% similar. One example was the United States, Colombia, Mexico, and Japan, which were the only countries that exclusively used the ANSI Z133.

CHAPTER 3

RESULTS

3.1 Types of Standards

Table 1 includes a list of countries which have at least one ISA chapter or component, the type(s) of standard in each country, and whether a response was received to confirm the use (or not) of a standard. Responses were not received from representatives in Iceland and Lithuania. Because the latter is a member of the European Arboriculture Council (EAC), it was assumed that the EAC's guidelines for safe work practices (EAC 2016, 2018) were used in Lithuania. It could not be determined whether a standard existed in Iceland, so it was excluded from further analysis. Of 34 countries for which it was determined whether a standard existed, 29 (85%) have a standard(s). Of four countries without a standard, standards are being drafted in Brazil and Malaysia, but they were not available at the time of this study.

The ANSI Z133 is exclusively used in four countries (Colombia, Mexico, Japan and United States), but it is also used in four countries (Hong Kong, Poland, Sweden and Spain) that have another standard(s) (Table 1). The remaining 21 countries used either a locally developed standard or, for members of the EAC and Hong Kong (the only non-EAC member country to use EAC guidelines), EAC's safe work guidelines (EAC 2016, 2018). In nine countries (26%), a government standard exists; all but one, France, also have an industry standard. Industry standards were much more common than government standards, existing in 28 countries. In addition to government or industry standards, three countries (Austria, Germany and Switzerland) also have standards developed by social insurance organizations.

3.2 Main Categories

With one exception—France—standards in each country met each of the main categories (Table 3). The government standard in France does not include guidelines for safe chainsaw use; consequently, CS was the only main category that not all standards included. The absence of CS in the standard for France was also reflected in the smaller mean and much larger range in the proportion of subcategories included in CS compared to the other main categories (Figure 3). Among the main categories, the proportion of subcategories included in standards was greater for GSR and PPE (Figure 3).

3.2.1 GSR

The standards in only two countries (Austria and New Zealand) included all ten of the GSR subcategories, but standards in all countries included at least seven of the ten subcategories (Table 4). Standards in all countries included six GSR subcategories: “adhere to manufacturers' instruction for equipment use,” “emergency procedures and readiness,” “job briefing and work site set up,” “traffic control,” “establishing good communication between workers,” and “trained and competent workers,” (Table 4). Only the ANSI Z133 did not include the subcategory “safety considerations when working under heat or extreme weather conditions.” And 51% or fewer standards included the following subcategories: “fire protection,” “physical fitness,” and “restrictions on employment of youths.”

For standards that did not include all ten subcategories, the missing subcategories were not always consistent among standards. For example, of standards that included at least nine of ten subcategories, the subcategory “fire protection” was absent from standards in Germany, Ireland, and the United Kingdom; but the

subcategory “restrictions on employment of youths” was absent from standards in Australia, Canada, Hong Kong, and Singapore.

3.2.2 PPE

The standards in five countries included all sixteen of the PPE subcategories, and standards in four additional countries included fifteen of sixteen subcategories (Table 5). Standards in all countries except France included at least 11 (69%) of the subcategories. The standard in France included only one subcategory (“handling defective PPE”), which meant that no PPE subcategory was included in the standards of all 29 countries. But 7 subcategories (“appropriate use,” “employer’s responsibility to provide PPE,” “head protection,” “eye protection,” “hearing protection,” “clothing,” and “appropriate footwear”) were included in 28 of 29 standards and 4 other subcategories [“handling defective PPE,” “steel toed capped boots,” “hand protection,” “cut resistant pants (no spec)”] were included in at least 24 standards. Of 5 subcategories included in 52% or fewer standards, 2 [“cut resistant pants (ground)” and “cut resistant pants (aerial)”] were closely related to the subcategory “cut resistant pants (no spec).”

Standards that did not include all subcategories differed in which subcategories were missing (Table 5). Except in the standard used in Canada, which was only missing the subcategory, “trained to use PPE,” all standards were missing the subcategory, “cut resistant pants (aerial).” The standards in Austria, Germany, Italy and New Zealand included twelve of sixteen subcategories; they did not include the following subcategories: “cut resistant pants (ground),” “respiratory protection,” and “cut resistant pants (aerial)”. The standards in Austria and Germany did not include the subcategory, “trained to use PPE,” while the standards in Italy and New Zealand did

not include “face protection”. Among standards which included eleven of sixteen subcategories, all were missing the subcategory, “cut resistant pants (aerial)”. But the ANSI Z133 (used in the United States, Japan, Mexico and Colombia) did not include the following subcategories: “handling defective PPE,” “steel toed boots,” “hand protection,” and “cut resistant pants (no spec);” while the EAC’s guidelines (used in Belgium, Croatia, Czech Republic, Denmark, Finland, Latvia, Lithuania, Netherlands, Norway, Slovakia and Switzerland) did not include the following subcategories: “face protection,” “trained to use PPE,” “cut resistant pants (ground),” and “respiratory protection.”

3.2.3 CS

Standards in four countries included all seventeen of the CS subcategories, and one included sixteen of seventeen subcategories (Table 6). Standards in 10 additional countries included at least 76% of all subcategories. In contrast, standards in thirteen countries met fewer than half of all subcategories, including the standard in France, which, as previously noted (Table 3) did not include CS. Because of the latter, no subcategory was included in all of the standards, but six subcategories (“chainsaw protective clothing,” “start chainsaw with chain brake on,” “two hands,” “second tie in point when using chainsaw at height,” “chain brake on or engine shut off when setting the chainsaw down,” and “chain brake on when transporting the chainsaw in more than two steps”) were included in all standards except the standard in France (Table 6). An additional subcategory (“chainsaw selection”) was included in all standards except the standard in France and the ANSI Z133. Seven subcategories (“stable body positioning when using chainsaw,” “stable body position before cutting,” “safe way to carry chainsaw,” “no drop start,” “kickback,” “technical features of a chainsaw” and “exceptions to drop start”) were included in fewer than

half of all standards. Additionally, one subcategory ("exceptions to drop start"), appeared in only four standards (Australia, Canada, Hong Kong, and Singapore,).

Standards from countries which did not include all seventeen subcategories were all missing "Exceptions to drop start" (Table 6). Among countries which had fourteen of seventeen subcategories, Ireland and the United Kingdom were missing "safe way to carry chainsaw" and "no drop start" but Poland, Spain and Sweden were instead missing "kickback" and "technical features of chainsaw". Austria differed from the United States, Mexico, Japan and Colombia in missing "Stable body positioning when using chainsaw," "stable body positioning before cutting" and "no drop start" while the latter 4 countries were missing "Chainsaw selection," "Kickback" and "technical features of chainsaw".

3.2.4 TC

Only standards from Hong Kong included all 48 subcategories (100%), and standards in 8 additional countries included at least 92% of all subcategories (Table 7). Standards in the remaining countries included at least 50% of all subcategories. Thirteen subcategories (1 – 13, see Table 2) were found in all standards while 21 subcategories (27 – 48, see Table 2) were included in 52% or fewer of all standards. Subcategories 28 – 48 were not included in standards in Belgium, Croatia, Czech Republic, Denmark, Finland, Italy, Latvia, Lithuania, Netherlands, Slovakia, and Switzerland. Standards that included more than half of the subcategories sometimes differed with respect to which subcategories were missing, even if the proportion of subcategories was the same (Table 7). For example, standards in Colombia, Japan, Mexico, Singapore, and the United States all included 92% of subcategories, jointly missing "SRT techniques and procedures." However, Singapore was missing "no

placement of climbing lines on stem without lateral limb unless it can be choked," "never leave climbing line unattended in the tree," "when line is damaged, secure with lanyard and replace the line," while the ANSI Z133 (used by Colombia, Japan, Mexico, and the United States) did not include, "select an anchor point that is structurally sound," "ascenders, descenders, rope grabs," and "pulleys". Standards in Canada, Ireland, and the United Kingdom all included 75% of subcategories, and they were all missing "termination knots at rope ends," "place false crotch or climbing line in a way that does not slide," "when line is damaged, secure with lanyard and replace the line," "climbing spurs' gaff length requirements," "climbing lines requirement for SRT," "SRT techniques and procedures," and "load-rated screw links." The standard in Canada was also missing "handsaw," "secured at all times from start of work until the end," "no placement of climbing lines on stem without lateral limb unless it can be choked," "do not link carabiners and snap hooks," and "do not alter arborist saddles and lanyard," while standards in Ireland and the United Kingdom were missing "three points of contact while climbing," "no placement of climbing lines on stem without lateral limb unless it can be choked," "carabiners without captive eye must be load on major axis," "snap hooks," "equipment to secure arborist cannot be used for anything else," "rope ends finished to prevent unravelling," and "never leave climbing line unattended in the tree". Standards in Austria and Germany included 26 of 48 subcategories, jointly missing the following subcategories: ("Select anchor point that prevents lateral movement of the climbing line," "select an anchor point that is structurally sound," "install climbing line or false crotch in main stem/leader/lateral limb," "place false crotch or climbing line in a way that does not slide," "no placement of climbing lines on stem without lateral limb unless it can be choked," "when line is damaged, secure with lanyard and replace the line," "carabiners without

captive eye must be load on major axis," "do not alter arborist saddles and lanyard," "climbing lines requirement for SRT," "snap hooks," "load-rated screw links," "splicing," "climbing line can be used to lower light weight tools," "rope ends finished to prevent unravelling," "never leave climbing line unattended in the tree," "ascenders, descenders, rope grabs" and "pulleys"). But the standard in Austria did not include "ground crew responsibilities" and "transport climbing equipment properly to prevent damage," while the standard in Germany did not include "three points of contact while climbing," "climbing spurs' gaff length requirements" and "equipment to secure arborist cannot be used for anything else". Standards in Italy and Switzerland included 25 of 48 subcategories, jointly missing the following subcategories: "three points of contact while climbing," "select anchor point that prevents lateral movement of the climbing line," "select an anchor point that is structurally sound," "install climbing line or false crotch in main stem/leader/lateral limb," "place false crotch or climbing line in a way that does not slide," "no placement of climbing lines on stem without lateral limb unless it can be choked," "when line is damaged, secure with lanyard and replace the line," "carabiners without captive eye must be load on major axis," "climbing spurs' gaff length requirements," "do not alter arborist saddles and lanyard," "climbing lines requirement for SRT," "snap hooks," "load-rated screw links," "splicing," "equipment to secure arborist cannot be used for anything else," "climbing line can be used to lower light weight tools," "rope ends finished to prevent unravelling," "store climbing equipment properly to prevent damage," "transport climbing equipment properly to prevent damage," "never leave climbing line unattended in the tree," "ascenders, descenders, rope grabs" and "pulleys". But the standard in Italy did not include "tie in point can

withstand loads from pruning or removals," while the standard in Switzerland did not include "ground crew responsibilities".

3.3 Overall

Hong Kong had the highest proportion of all subcategories in its standards, followed by Singapore, Spain, Poland, and Sweden (Table 8). The latter 4 countries were all more than 90% similar to Hong Kong (Table 9). Countries with 100% similarity were United States, Japan, Mexico, and Colombia; Ireland and the United Kingdom; Belgium, Croatia, Czech Republic, Denmark, Finland, Latvia, Lithuania, Netherlands, Norway and Slovakia (Table 9). Singapore was the most similar to Hong Kong (90%); Spain, Poland and Sweden were the most similar (98-100%) among each other; Canada was most similar to Hong Kong (86%); Australia was most similar to Canada, Ireland and the United Kingdom (82%); New Zealand was most similar Ireland and the United Kingdom (79%); Austria was most similar to New Zealand (84%); Germany was most similar to Switzerland (91%) and the latter most similar to Belgium, Croatia, Czech Republic, Denmark, Finland, Latvia, Lithuania, Netherlands, Norway and Slovakia (99%). Standard from France had the least proportion of all subcategories (44%) (Table 8) and the former was also the least similar (45-62%) among all countries (Table 9).

The United States, Colombia, Japan, Mexico, Ireland and United Kingdom were the only countries which had the same proportion (82%) of all subcategories (Table 8) but were missing different subcategories. The former 4 countries were only 67% similar to the latter 2 countries (Table 9).

Of 91 total subcategories, 19 occurred in all standards. Thirteen of them were from TC; the remaining six were from GSR (Table 10). An additional 18 subcategories

occurred in 75% of all standards, and half of all subcategories occurred in at least 86% of all standards. Thirty-one subcategories occurred in fewer than half of all standards; two were from GSR, four were from PPE, seven were from CS, and eighteen were from TC. “Exceptions to drop start” (from CS) was the least common subcategory and was found in only 14% of the standards.

3.4 Similarity to the United States (ANSI Z133)

Since the ANSI Z133 is used in Colombia, Japan and Mexico, they were 100% similar to the United States (Table 11). Standards used in Poland, Spain, and Sweden were at least 90% similar to the ANSI Z133; and standards in Canada, Hong Kong, and Singapore were at least 80% similar to the ANSI Z133. Half of all standards were at least 61% similar to the ANSI Z133, and even the least similar standard, in France, was 53% similar to the ANSI Z133. Other countries whose standards were not as similar to the ANSI Z133 included the following: Belgium, Croatia, Czech Republic, Denmark, Finland, Latvia, Lithuania, Norway, Germany and Slovakia.

3.5 Groups of countries

I organized the 29 countries into seven groups (Table 12). Group 1 included countries that exclusively use the ANSI Z133 (Colombia, Japan, Mexico and United States); they were 100% similar in all categories and subcategories (Table 11). Group 2 included countries that use the ANSI Z133 and the EAC standards: Poland, Sweden, and Spain (Table 13). The countries were 100% similar for subcategories within GSR, PPE and CS. There is also a local standard in Spain, which is why the standards in Poland and Sweden were only 94% similar for TC and 98% similar overall (Table 13). The standard used in France was the least similar in PPE, CS, and overall to the standards used in Spain (Table 13).

Group 3 included Ireland and the United Kingdom, which used the same local standards and were 100% similar in all categories and subcategories. Germany was 100% similar to Group 3 in GSR, and Singapore, Australia and Hong Kong were 100% similar in PPE (Table 14). Singapore was most similar (84%) for all subcategories (Table 14). The standard for Group 3 was least similar to Group 1 in GSR and TC, and least similar to France in PPE and CS (Table 14).

Group 4 included countries which exclusively used EAC guidelines (Belgium, Croatia, Czech Republic, Denmark, Finland, Latvia, Lithuania, Netherlands, Norway and Slovakia) and those that used EAC guidelines and either a local standard (Italy and Switzerland) or social insurance (Austria and Germany) (Table 1). Countries that only used the EAC guidelines were consistently 100% similar for all categories and subcategories. The standards in Switzerland were 100% similar to the EAC standards in GSR, PPE and CS, but only 98% similar in TC, so the overall similarity index was 99% (Table 15). Standards used in Asia (Singapore, Hong Kong and Japan) and North and South America (Canada, Colombia, Mexico and United States) were consistently least similar (less than 60% overall) with those in Group 4. Of EAC countries that also used another standard, standards in Germany and Switzerland were overall 91% similar (Table 16). The standards in Germany were 88% similar to those in Austria (Table 17) and Italy (Table 18). Furthermore, Germany and Italy were 11% different between categories: both countries were more similar in CS and TC (94%) compared to GSR and PPE (70% and 80% respectively) (Table 16 and 18).

Hong Kong, Australia, Canada and Singapore used different standards but were largely similar (Tables 1 and 13), so I included them in Group 5. Hong Kong, Australia, Singapore and Canada were most similar (100%) in GSR, and CS, with the former three countries additionally being most similar (100%) in PPE (Table 19).

Group 5 countries also had high standard deviation of similarity (15-18%) across all categories, because their standards' TC category was the least similar (65-69%) (Table 19). Canada was also overall closely similar to Singapore (88%), Hong Kong (86%), Australia (82%) (Table 20).

New Zealand and France were placed into Groups 6 and 7 respectively (Table 12). The standards in New Zealand are local; they were 100% similar in GSR and overall similarity of all subcategories to Austria, 100% similar in PPE to Italy, and varied similarity index compared to all other countries in the respective categories (Table 21). France also used their own standard which did not have CS category, so France's standard had high standard deviation of similarity across all categories and it was the least similar among countries. (Tables 11, 13-21).

CHAPTER 4
DISCUSSION

4.1 Standards in countries

Arboricultural work operations are inherently dangerous, so standards were developed to promote best practices for work. I compiled a database of standards from different countries and my findings are novel because there had been no prior documentation of standards. Consequently, it was unclear how many countries have standards and what types of standards exist internationally.

Even though this study is novel, there are some limitations: First, translating arboricultural technical terms from standards which were not written in English often resulted in unclear phrases or phrases in which their exact meaning was lost. This study used Microsoft Word (MS Word) to translate arboricultural safety standards of other foreign languages like Spanish, French, German, Polish and Italian to English. However, the software could only translate these foreign languages and their words directly to their literal meaning in English. For example, Quebec's standard was written in French and a direct translation with MS Word yielded a phrase "chainsaw less than 4.3kg should not be started on the fly". "started on the fly" has a vague meaning, subject to interpretation, but it was still possible to have a sense of the intent of this phrase suggesting that the chainsaw is not on the ground or that it is being carried on the move. In Italy's standard, a section describing the dangers of falling objects from height when working in the tree had a sentence which translated from Italian to English said that "During the hair shift phase, it is necessary that the tools and other accessories used by workers are hooked to their harness or to the seat of other instruments" (INAIL 2016). "Hair shift phase" possibly came up as a literal translation of an Italian term, which suggested moving in the tree crown. Because of

the use of words in context and the nature of different languages, translating technical arboricultural jargon would be more effective if carried out by a professional. But such efforts are time-consuming and expensive; even professional translators may not be familiar with arboricultural jargon. International co-operation through volunteers or having arboricultural representatives from each country translate their safety standards would be useful for future studies in analyzing contents of these arboricultural safety documents.

There were other aspects of arboricultural work practices that this study did not examine. While this study focused only on some common arboricultural work practices like general safety requirements, PPE, chainsaw and tree climbing, there are still other hazardous aspects of arboricultural work practices like working near electrical power lines and the use of specialized tree care equipment like brush chippers and aerial lifts. In the United States, many studies have shown that electrocutions was one of the leading causes of arboricultural work fatalities and many (NIOSH 1992, TCIA 2019a) and brush chippers have resulted in high incidences of severe injuries like amputations and loss of limbs (Struttmann 2004). Operating aerial lift devices requires specialized training and knowledge (Palmer 2011) and hazards associated with using aerial lift devices includes fall from heights, contact with electric power lines and equipment collapses or tip overs (Pan et al. 2007, TCIA 2014, Schillaci 2018). The limited time frame of this study allowed only a detailed analysis of a small category of arboricultural work practices and future studies can include a wider range of arboricultural work practices for more extensive and in depth understanding of arboricultural work safety.

The study was also limited to broad or general description of arboricultural work safety concepts and did not analyze finer details such as specific descriptions of

work procedures or product specifications. For example, the CS subcategory, “two hands,” only identified countries’ standards which mention having two hands on the chainsaw. Thus, merely mentioned to use two hands or both hands on the chainsaw qualifies as that safety concept being present in the arboricultural safety standard of its respective country. Other than mentioning using two hands to operate a chainsaw, some arboricultural safety standards further explicitly described that the two hands must be the right hand and thumb gripped around the rear handle, left hand and thumb gripped around the front handle (AFAG 2003, HSE 2013b, ANSI 2017). Since chainsaws are not made for ambidextrous use (right hand must always be on the front handle and left hand on the rear handle regardless of whether the operator is right or left handed) (Husqvarna 2004, Knull 2018) and it is an important concept that each hand be placed appropriately on the chainsaw’s handles to reduce injuries. Therefore, future studies can further examine the frequency of standards having explicit details of their contents in safety practices.

Countries may have the same frequencies of total subcategories present in each of the 4 categories but have different similarity index because they varied in which subcategories were missing. The scope of this study was only to describe similarities and differences in missing subcategories among countries in each of the 4 categories. While it was possible to identify patterns of similarities and differences among standards in countries, it was often unclear why subcategories did or did not occur in the latter, because some occurrence could happen as a result of coincidence. Furthermore, there is limited literature in arboriculture work safety that could be used as reference to understand choice of such topics in standards, so most of the explanations for the latter (as well as for other areas of discussion) in this study were

based on personal communications with industry professionals from different countries, which were anecdotal.

Finally, this study's database only covered ISA components and was not a census of the world's population of countries, therefore excluded some countries like Bulgaria, Russia, Greece and Serbia that were EAC members but not ISA components. Being EAC members suggested that the latter countries could have arboriculture practices and may or may not have relevant standards, in which including these countries in the database can also affect the frequencies and counts of countries with standards. It was also for this reason of a biased sample of ISA components that I found that most countries have a standard because ISA emphasizes safety in its educational offerings.

While most countries have a standard, I found that countries also used different types of standards, which probably indicates the current measures countries use to regulate tree workers' safety. Most countries use industry standards rather than government standards. In general occupational studies, Cheit (1990) found that industry standards were written by industry stakeholders who were more technically experienced than public agencies, so the latter type of standard was more common than government standards. Similarly, for arboriculture, standards in most countries were predominantly initiated by industry stakeholders, showing their intent to provide guidelines to regulate work practices for the local arboriculture industry. Furthermore, some countries like Canada, New Zealand, Singapore, United Kingdom also had local industry stakeholders collaborate with public agencies to develop government standards (Arborist Industry Safe Work Practices Committee 2011, ACOP 2012, WSH Council 2018, HSE 2019), which probably shows the importance of industry

professional's experiences in developing standards in a country. In the United States, OSHA has a seat on the ANSI Z133 Committee for just this reason.

I expected government standards to be mandatory and legally binding, but only France's standard was a national law (L. Pierron, personal communication, 4/6/18, Ministry of Agriculture and Fisheries 2007). Additionally, social insurance programs—found only in Austria, Germany and Switzerland—required mandatory compliance to private insurance companies' requirements for workers to be trained and certified before workers can obtain the necessary occupational insurance before they are legally allowed to work (J. V. Hofmann, personal communication, 9/12/17, SVLFG 2017, F. Rinn, personal communication, 9/13/17, SVLFG 2019). It is unclear whether different types of standards, or whether compliance with standards is voluntary or mandatory, might more effectively reduce the number of tree-related work incidences. Future studies can evaluate the effectiveness of different types of standards in reducing the number of tree-work related incidents and assess whether there is any effect of a standard being voluntary or mandatory.

It was also unclear why countries might choose a certain type of standard, although one possible reason was that countries might choose a standard based on influence from another country. For example, Singapore developed its industry standard by referencing Australia's standard (SAS 2017). Additionally, countries may also adopt standards through regional or international memberships or cooperation like how some Europe countries are part of the EAC and adopt their guidelines and countries like Colombia, Mexico and Japan were ISA components which adopted ANSI Z133 standard. To gain a deeper understanding of the rationale for choosing a

type of standard, future studies can consider interviewing publishers of standards—or committee members—to trace the history of different standards.

4.2 Main categories

The four main categories were common types of arboricultural work operations, and I expected these categories to be included in all standards. And this was true, with the exception of CS, which was absent from the standard used in France. For this reason, France was placed in its own group. Although France had government legislations regarding chainsaw use for forestry workers, which could be applicable to arboricultural work operations, at the time of this study, there was not a chainsaw safety standard in France that applies specifically to arborists (Legifrance 2016, L. Pierron, personal communication, 12/12/18).

Each of the main categories had a different proportion of standards having all its respective subcategories. The greater proportion of subcategories present in standards for GSR and PPE was presumably because both categories are fundamental safety practices applicable to many tree work situations, and they are some of the most effective ways to reduce accidents at work (Cal/OSHA 2014). For example, GSR informs of the safety practices such as having proper emergency response protocols, setting up appropriate traffic control measures or ensuring all equipment use and maintenance complies to manufacturer's recommendations. Similarly, PPE are basic protective equipment which can provide additional protection for tree workers when they are exposed to hazards at the work site (TCIA 2019b). On the other hand, CS and TC categories included arboricultural work techniques and both categories had more variations in safety topics occurring in standards among countries, which suggests differences in understanding or practices in arboriculture

work involving chainsaw operations and tree climbing. Since GSR and PPE are common to many types of arboricultural work, they can be included in international standards, while the differences in CS and TC implied that having an international standard would be beneficial in standardizing work practices in the latter two categories.

Some countries included 100% of subcategories from one main category but not another category, which may give a measure of how much content a standard covered in the respective category and could imply that a standard described more safety topics in one (or more) category. For example, Austria had 100% in GSR but not in the other 3 categories, suggesting that standards from this country covered more general safety practices rather than those relating to PPE, CS or TC. On the other hand, Hong Kong was the only country which had 100% in 3 categories, except GSR, implying that standards used in Hong Kong covered many topics in these categories. This occurred because Hong Kong used many standards from other countries like Australia, European and British standards (S. Ma, personal communication, 11/13/18) and using different types of standards would affect the frequency of subcategories occurrence since subcategories were referenced from various standards. Identifying the existing proportion of safety topics in the latter's respective categories may help publishers' of standards to gauge if their standard(s) cover many aspects of arboricultural work activities or if their standards were skewed more towards certain types of arboricultural work, like tree climbing, chainsaw use or working at height with mobile devices.

4.2.1 GSR

Six of ten GSR subcategories were found in all standards because they were safety practices prior to starting an arboricultural work operation, which is applicable to all tree work situations. This presumably indicates that arborists in many countries view these safety practices as important, regardless of the type of arboricultural work a job might entail. "Safety considerations when working under heat or extreme weather conditions" was another common safety theme among standards from countries because adverse weather is hazardous or dangerous (NZARB 2017, AA 2015, Arborist Industry Safe Work Practices Committee 2011) and working under adverse weather conditions is risky for tree workers. Colombia, Japan, Mexico and the United States were the only countries that did not have "Safety considerations when working under heat or extreme weather conditions", because they exclusively used the ANSI Z133, which was the only standard that did not have this subcategory. ANSI Z133 did not include this subcategory because professionals in the United States considered the latter subcategory as a safety topic more associated with first aid practices which is covered in arboricultural work training courses or other relevant safety guidelines (H. D. P. Ryan, personal communication, 7/12/19).

"Fire protection" was not a common safety topic. This was probably because tree-related work incidents or injuries that resulted from fire outbreak on the work site were not reported in existing studies (NIOSH 1992, Ball and Vosberg 2003, Wiatrowski 2005, Ball and Vosberg 2010, Robb and Cocking 2014, Proto et al.2016), so incidents arising from fire did not appear to be common. The "Fire protection" subcategory was adopted from the ANSI Z133 and addressed best safety practices when working near flammable sources, such as how all workers need to know where and how to operate vehicle-mounted fire extinguishers, how to store flammable

liquids appropriately, ways to fuel equipment safely, avoiding open flames or other sources of ignition and prohibiting smoking work working near flammable sources. Since this subcategory was applicable to tree work situations, “fire protection” can also be a potential topic to include in future tree work safety standards.

“Physical fitness” was found in only nine standards. The nine standards commonly recognized that tree work is physically demanding, because it involves manual lifting, moving heavy tree parts and equipment, and tree climbing. Although this subcategory occurred in some countries, the former may or may not be an important topic to include in standards because it is unclear whether fitness of a worker is a cause of tree related work incidents: existing studies on arboricultural work incidents (NIOSH 1992, Ball and Vosberg 2003, Wiatrowski 2005, Ball and Vosberg 2010, Robb and Cocking 2014, Proto et al.2016) did not mention physical fitness of workers as a common cause of fatalities or injuries. Furthermore, while there are possible ways (such as through medical tests and job interviews), to measure or better understand an individual’s level of physical fitness if the latter were included in standards, the practicality of implementing this safety topic in standards would probably be better determined with the understanding of countries’ arboriculture industry profiles, work incident statistics and experiences of industry stakeholders or professionals

“Restrictions on employment of youths” was the least common GSR subcategory and the former was only present in Austria, Germany, Ireland, New Zealand and the United Kingdom’s standards, which suggested that these countries specifically recognized the tree care industry hiring youths for work and the latter has potential dangers. Other countries like United States, Australia, and countries in the European Union addressed hiring of youths in their national labor laws which are not

specific to the tree care industry but broadly applicable to all industries (Singapore Attorney-General's Chambers 2000, NSW Government 2001, DOL 2019a, DOL 2019b, European Commission 2019).

Youths working in the tree care industry could be a potential problem for many countries and that should be addressed considering that arboriculture work is dangerous. For example, studies in the United States found that the fatality of workers in the shrub and tree care industry ranged from mid-teens to 65 years old and above in the period of 1992 to 2002 (Wiatrowski 2005). In 2003 to 2008, fatally injured ground maintenance workers (also includes tree workers) tend to be younger than all fatally injured U.S. workers, where there was a small percentage (11%) of fatal work injuries which tend to occur to ground maintenance workers below 20 years old (Pegula and Utterback 2011). Both studies suggested that there are youths hired in tree work, and since in the United States, young workers below the age of 18 years old cannot use power tools at work, the latter age range were not specifically defined, so there is still a lack of detailed information on youth employment in arboricultural work in this country. Younger workers have a higher chance of being injured in tree work because of the lack of experience and accidents can happen to young workers during the period of their learning curve to become competent (Ball and Vosberg 2003), so additional work safety considerations like having more strict supervision, designing specific training courses catering to youths, giving clear verbal instructions to youths and assisting them with risk assessment on site may be required for youths working in the tree care industry (Stigas 2019).

Arboriculture industry profiles and work-related incident reports can help countries to determine if youths in the tree care industry are common and of whether youths have a high rate of incidents. The United States and Australia had studies on

their arboriculture industry profiles (O'Bryan et al. 2007, Department of Employment 2014) but many other countries do not. Furthermore, work-related incident reports in the latter are limited and if conducted, may be underreported or inaccurate (O'Bryan et al. 2007, CDC 2009, Robb and Cocking 2014, Oschner et al. 2018). Therefore, countries can consider conducting studies on their own arboriculture industry's profile. Information on the latter might provide a better understanding of most current demographics of the local arboriculture industry in the respective countries to determine if minors working in the tree care industry are a safety issue.

4.2.2 PPE

It was not surprising that "Appropriate use"–which recommended that workers need to wear the right PPE for the job—occurred in all standards except France because not wearing the appropriate PPE was a common cause of arboriculture work incidences (Proto et al. 2016). "Appropriate use" did not occur in the standard in France because the standard focuses primarily on tree climbing work. Therefore, the scope of the standard was not in PPE use. PPE also mitigates personal hazards at work and there were studies which recommended the need to recognize the hazards at work and use the right equipment to guard an operator against it (Blair 1989, Proto et al. 2016).

Other common topics in PPE were related to types of PPE: head, eye, and hearing protection; appropriate clothing; and footwear; which nearly all standards included. This implies that arborists in most countries recognized types of PPE as critical to tree worker safety. Furthermore, being struck by an object (like falling tree parts or equipment) is a common cause of tree-related work injuries and fatalities for groundworkers and tree workers aloft (Pegula and Utterback 2011, Robb and Cocking

2014, Proto et al. 2016, EAC 2016), so wearing PPE like head, eye protection and appropriate footwear significantly reduces impact of objects to cause injuries to the worker. For example, safety helmets protect the head which is a vital body part, where head injuries like skull fractures, are often severe and can lead to fatality (Proto et al. 2016, Springer et al. 2018), and hearing protection is another important PPE because noise from operating powered machineries like brush chippers, chainsaws and stump grinders, is a common hazard in tree work (Futatsuka et al. 1996, WorkCover (New South Wales) 1998, HSE 2008, HSE 2018a).

"Face protection" occurred in slightly more than half of standards from countries suggesting that professionals view this as an important piece of safety equipment, especially when using a chainsaw, because a common cause of fatal injuries was being stuck in the head and neck from chainsaw kickback (Pratt 1979, Robb and Cocking 2014). One reason why "face protection" was not among the most common PPE subcategories was because the former subcategory did not occur in EAC's standards. This resulted in an almost equal number of standards from countries which had and did not have this subcategory. The importance of "face protection" may not have been well reflected by the frequency of occurrence but existing literature (NIOSH 1992, Ball and Vosberg 2003, Wiatrowski 2005, Ball and Vosberg 2010, Robb and Cocking 2014, Proto et al.2016, Arboriculture Australia 2018) on common causes of incidents in tree work was useful to better understand the significance of "face protection" as a shared topic among countries.

Less common PPE subcategories included "trained to use PPE". Its infrequent occurrence was due, in part, to its absence from EAC guidelines. Neither was it included in standards from Austria, Canada, Germany, Switzerland, and France. In Austria, Germany, and Switzerland, it was presumably not included because social

insurance programs in those countries require mandatory training courses in arboriculture. Consequently, workers would already have been trained to use the necessary PPE for work. The standard from France was on tree climbing work practices and did not include many PPE subcategories. It was unclear why Canada did not include this subcategory: One possible reason was that this topic was also covered in their federal labor standards (CCOHS 2019a), so industry professionals in Canada did not think it might be necessary to include this safety topic in their standards and that tree workers were assumed to have undergone training in tree work practices which would have addressed workers being already trained to use the appropriate PPE. In this study, it is important to note that some standards may not include certain subcategories because the latter could have been covered by other relevant, general work industry standards, state or federal labor laws. Hence, future studies that assess standards relevant to tree workers might consider including the latter types of standards to better understand commonly occurring safety topics among the arboricultural industries in different countries.

"Respiratory protection" occurred only in less than half of standards. One reason may be that there has not been many records of tree work related incidences or chronic illnesses pertaining to respiratory issues, since information on tree work related incidences are generally limited (O'Bryan et al. 2007, CDC 2009, Robb and Cocking 2014, Oschner et al. 2018). Another reason for the differences in this subcategory among countries could be due to the work demand of local arboriculture industries. For example, Abbott (1977) surveyed the North America arboriculture industry and found that pesticide application was the next most common (18%) type of arboriculture work (after pruning which was 36%) and the peak activity of tree care was in the summer for spraying work. Therefore, ANSI Z133 may have included this

subcategory because pesticide application had been a long-established common practice for arborist in North America. In a 2012 survey of ISA member countries' arboriculture industry profiles and needs assessment, pesticide application was not listed as a common type of arboriculture work (Avenue M 2012) and the latter could also be a reason why "respiratory protection" was not commonly included in standards from most countries. Additionally, in countries like Canada and the United Kingdom, safety practices in pesticide application may be separately addressed in other standards (CCOHS 2019a, HSE 2019b).

"Cut resistant pants (aerial)" was the least common PPE subcategory and least common when compared to the other three subcategories that addressed types of cut resistant pants. This suggested that arborists in different countries had different opinions on wearing cut resistant pants, particularly when working at height. For example, the AFAG in the United Kingdom advised on wearing a type of cut resistant pants that provides all-round protection for the operator's leg, when working with chainsaw in a tree, but recognized that such pants may be impractical in hot weather and wearing it can cause heat stress to the worker instead (HSE 2019a). In the latter situation, chaps [which are garment that is worn on the outside of the chainsaw operator's trousers and strapped to the legs of the chainsaw operator (AS/NZS 1997, SPI (Health and Safety) 2018)] might be more appropriate when justified by risk assessment (HSE 2019a). However, chainsaw cut resistant pants are improving to be more lightweight and to be made of more cooling material for arborists (Honey Brothers 2019, ArborWear 2019, TreeStuff 2019, WesSpur 2019b) so future revisions of safety standards in different countries may consider advisory recommendations for tree workers to wear cut resistant chainsaw pants when working in the tree to reduce the risk of being cut by a chainsaw. But ANSI Z133 (2017) did not mandate wearing

cut resistant leg protection when working with chainsaw at height because, although chaps provide protection to the front half of an operator's leg, the buckles and straps that hold the chap around the leg can get caught in parts of the tree or by any equipment when the operator works with the chainsaw in the tree (B. Kane, personal communication, 4/5/18).

I found that all standards from countries, except Colombia, Japan, Mexico, United States and France, mentioned the "steel toed capped boots" subcategory: ANSI Z133 and the standard from France were the only standards which did not include "steel toed capped boots". The common occurrence of the latter subcategory in most standards suggests that arborists from most countries probably viewed an appropriate footwear in tree work to include steel capped toed boots (safety boots reinforced with steel protection around the toe area to protect against injuries from impact like falling or rolling objects, accidental chainsaw cuts, which are some of the hazards to foot injuries in tree work.

4.2.3 CS

CS category had the highest variations of subcategories occurrence among standards because Group 4 countries used EAC guidelines which did not include a chainsaw category. EAC's guidelines had less than half of all CS subcategories because EAC (2018) was primarily on aerial tree work operations, which included only some basic chainsaw safety practices (CS subcategories 1-7) applicable even for aerial work. EAC (2016) did not have a section on chainsaw use because the latter recognized that "chainsaws differ from country to country, therefore not described in detailed." Furthermore, France did not have a chainsaw standard for arboricultural operations at the time of this study, so it did not have any of the CS subcategories,

further increasing the variability of the proportion of absent subcategories from the latter which were present in standards.

"Chainsaw protective clothing" occurred in most standards because chainsaws are hazardous equipment and injuries like cuts, hearing damage, vibration white fingers are common among operators, so one way to reduce the impact of these injuries was for operators to wear chainsaw protective clothing such as head, hearing and face protection, cut resistant clothing and gloves. The subcategories "start chainsaw with the chain brake on," "chain brake on or engine shut off when setting the chainsaw down," and "chain brake on when transporting the chainsaw in more than two steps," were also common CS subcategories because those are also safety practices recommended by chainsaw manufacturers (STIHL 1999, Husqvarna 2003, Husqvarna 2004).

"Two hands" also occurred in most standards because using two hands to operate a chainsaw gives the operator a firm grip and good control of the chainsaw (Husqvarna 2004, Maher and Nowatzki 2017). Control of the saw is necessary to reduce the likelihood of injuries, especially from kickback, which is a sudden and rapid throw back of the guide bar of the chainsaw up and towards the operator, when the tip of the guide bar touches an object (STIHL 1999, Koehler et al. 2004). "Second tie in point when using chainsaw at height" was also a common subcategory, which suggests that most professionals recognized the safety practice of using a secondary attachment point when working with a chainsaw at height as important. Having another attachment point provides two points of contact, providing added stability for a tree climber to cuts on the tree with the chainsaw (Ankeny 2015) and also acts as a preventive measure against falls. "Chainsaw selection" was common in most standards. This subcategory highlights the safety practice that a chainsaw should be

chosen for its suitability to the work [WorkCover (New South Wales) 1998]. Since "chainsaw selection" occurred in more than 80% of standards, and choosing the right chainsaw is an important safety consideration (Walsh 2016), policy makers or industry stakeholders can consider including this safety topic in future standards.

"Exceptions to drop-start a chainsaw" was the least common CS subcategory, which probably implied that there are varying opinions from arborist professions among countries regarding drop-starting, which is a dangerous method of starting the chainsaw because the operator may lose control of the chainsaw and injure themselves or damage the equipment (STIHL 1999, Husqvarna 2003, Husqvarna 2004, Echo Incorporated 2019). For example, an arborist professional from Singapore explained that drop-starting a chainsaw when working aloft was allowed in its local standard because of the limitations of safer or more practical methods of starting the chainsaw in the tree (R. Thomas, personal communication, 4/9/19). However, In the United States, Ball and Shepherd (2019) explained that the correct method of starting a chainsaw in the air was to hold the chainsaw firmly with one hand and have the other hand pulled the starter cord and they also recommended using electric chainsaws for aerial tree work which only requires a push of the start button to start the chainsaw, thus eliminating the need to pull a starter cord. The term "drop-start" could be defined differently among countries but the latter was unclear in this study because standards did not explicitly define the term; ANSI Z133 was the only standard which defined "drop-start" as "the act of pushing the saw down with one hand and pulling the starter cord with the other hand". Therefore, future studies can seek to clarify standardization of "drop-starting" among countries, clarify and understand the rationale behind countries which have allowed for exceptions to drop-start. The different views among professionals in different countries on drop-starting a chainsaw when working at

height, show that there is a need for global tree care professionals to come to a consensus on best safety practice in this aspect of arboricultural work, or whether more flexibility is required for arborist to operate a chainsaw at height.

4.2.4 TC

Among the TC subcategories that occurred in all standards, “arborist saddles,” “climbing lines,” “lanyards,” and “carabiners’ technical specifications” were related to basic tree climbing equipment that is essential for safe tree climbing. “Ladders” occurred in all standards because they are a common tool used to ascend and enter a tree (Ryan 1993, Bridge and Cowell 2009, Arborist Industry Safe Work Practices Committee 2011) and have risk or hazards associated with its use In the United States, TCIA (2019a) reported that injuries caused by falls or slips from ladders had the highest average cost of insurance claims of about $126,000 (USD) per occurrence and many arboriculture industries of ISA member countries also recognized the risk and high frequency of tree work with ladders (SafeWork Australia 2016b, SVLFG 2017, SAS 2017), therefore the risk associated with ladder use was possible reason for their common occurrence in standards. The remaining TC subcategories with 100% occurrence in standards from countries were related to tree climbing procedures, suggesting that the latter procedures were the safety practices most widely recognized by countries as essential to tree climbing operations.

“Ascenders, descenders and rope grabs” was the least common TC subcategory, possibly because of the infrequent (but increasing) use of stationary rope systems (SRS) and the rope walker technique (Tree Climbers International 2019). Both of these require ascenders, descenders, and rope grabs as mechanical climbing aids to facilitate movement up or down the climbing line (Jepson 1995, Bridge and

Cowell 2009, Ball and Walsh 2017) which reduces the strength needed by a climber to ascend the climbing line (WesSpur 2019a). Furthermore, tree climbing equipment and techniques are constantly developing (ITCC Rules Committee 2018), so standards may not have been updated to keep up with the trend of climbers using new tree climbing equipment, that includes ascenders, descender and rope grabs.

Despite the convenience of using ascenders, descenders, and rope grabs in tree climbing systems, such mechanical devices can become a safety hazard if not used appropriately or in compatibility with a climber's system. Arboriculture literature recommend safety practices like having a back-up system when using ascenders (Blair 1995, Tresset 2006, Bridge and Cowell 2009) and keeping the cam of ascenders (and rope grabs) free of debris and avoid dynamic loads of more than one person (Blair 1995). There were also product specification and technical literature for ascenders, descenders and rope grabs to comply with local or international safety standards (Anonymous 2006a, Anonymous 2006b), While there are available arboriculture literature and manufacturer's product manual on how to use ascenders, descender and rope grabs safely, including "ascenders, descenders, and rope grabs" as safety topics in standards would be important for the latter to be kept up to date with current use of these devices in tree climbing.

4.3 Similarities and differences among countries

Similarities and differences in safety topics among standards largely resulted from the types of standards in use. Because some countries used the same standard(s) they would naturally have similar subcategories, such as in Groups 1 and 3. Other groups (2 and 4) consisted of countries which used the same standard(s) but also used other (or their own) standards that included additional safety topics. For example,

Group 2 countries were all similar in GSR, PPE and CS but the slight difference in TC was because Spain had its own locally developed standard which included an additional subcategory ("select an anchor point that is structurally sound") as compared to Poland and Sweden.

Standards from countries could also be similar because of commonly recognized safety practices, such as in Group 5 countries. The latter group consisted countries from different regions in the world and they all used different types of standards. Yet, this group had the highest proportion of subcategories and overall high similarity index across categories, implying that their standards included many safety topics and shared views on safety practices.

I expected that countries which had 100% of subcategories' occurrences in one or more categories would have an overall high proportion of total subcategories present. The latter was true for Hong Kong, Canada, Singapore, Ireland and the United Kingdom but not for New Zealand, Austria and Australia. This result implied that compared to the former countries, which probably contained more safety topics in each category, standards from the latter countries might contain more safety topics only in certain categories or that these standards could be mentioning other work safety topics which were not included as subcategories in this study, since subcategories were mainly referenced from the ANSI Z133. For example, standards from New Zealand might have a lower proportion of TC subcategories compared to most countries, but they contained more SRS safety topics (such as having ascenders being backed up, climber's system shall remain at least 300mm below the top anchor point and to consider SRS work positioning system, equipment and configuration for lateral movement and non-vertical loading in SRS access and work positioning methods) than the SRS subcategories of this study. Because overall, standards from

New Zealand did not have a high proportion of subcategories and had high variations in CS and TC categories, New Zealand was distinctly different from other countries and placed in its own group (Group 6).

Although ANSI Z133 is an industry standard developed in the United States and adopted by ISA in its global professional credential programs (ISA 2019a), ANSI Z133 was not commonly used among countries. Instead, most countries used a locally developed standard or regional standard like the EAC's standards (EAC 2016, 2018). Most countries were less similar in safety topics to the ANSI Z133 and the latter had differences in the work safety topics in GSR, PPE, CS and TC, even though these were standard arboricultural operations. The implication of this finding was that, rather than adopting one country's standard as a reference material for international arboriculture industry, the ISA may consider developing an international standard through a collaborative effort among its member representatives to streamline work safety practices at a global level. This is best demonstrated in the findings from Hong Kong which had the highest proportion (99%) of all subcategories among countries. Although Hong Kong did not develop its own local standard but used many other standards because local arborists take professional credentials or certification programs that were based on the latter standards (S. Ma, personal communication, 8/9/19). Collective expertise from countries could develop a standard that covers a wider range of concerns among countries in arboricultural work safety issues. An international standard could also be useful as a reference for existing and new country members seeking to develop a standard in their country, since there are few countries which have yet to have a standard, or in future revisions of existing standards.

4.4 Conclusion

Compiling a database of each country's standard(s) identified the importance of having some form of regulation or guidance in addressing tree workers' safety. Knowing what types of safety standards exist in each member country would be useful for ISA as a lead organization to provide resources to help in increasing work standards for these countries, especially those without a standard, since the latter is important in providing best practices for arboricultural work safety to reduce the likelihood of injuries.

An article by Ball (2014) suggested that clauses in safety standards are probably written as a response to a fatal work incident and the findings of this study showed that the most common types of work safety practices among countries and these common types of work safety practices were related to most common types of injuries or causes of injuries related to the specific general work category. Ball (2014) also recommended that safety clauses in the ANSI Z133 safety standards should be written proactively to reduce work incidences rather than as a reactive response to any work incidences. Thus, analyzing the contents of standards is potentially a proactive way to determine real world problems of the arboriculture industry and this method can be an alternative to investigating injury statistics since there are few studies and inaccurate incident reporting on tree-related work injury statistics globally.

Standards had more shared topics in GSR and PPE as compared to TC and CS. The latter two categories are essential tree work technique that are hazardous, so the high variation among standards suggest that there should be more awareness for countries to review and revise work safety topics in tree climbing and chainsaw use. Alternatively, it is also possible that countries may vary in the types of trees,

demographics and culture, so the latter 3 factors (and perhaps others) may influence technical work practices in chainsaw use and tree climbing. For example, climbing palm trees requires a different technique from conventional tree climbing, so in countries like Malaysia, Singapore and even some states in the United States (Trent and Seymour 2010, Mostaan 2016, Wee and Rajathurai 2019) which have palm trees, safety topics in tree climbing might include climbing technique for palm trees so their standards could be different from other countries which do not have palm trees or that the latter are uncommon. However, whether (or to what extent) social or environmental factors of countries affect climbing techniques may require more studies of countries' arboriculture industries profiles which can include conducting surveys and interviews of local arborists to understand social or work cultures.

Identifying common safety practices among countries will be useful in developing an international safety standard as a reference document or guideline for arboricultural associations around the world. At the time of this study, there were no international safety standards for arboricultural work operations and the database showed that countries either adopt another country or region's safety standard or developed their own standards locally through arboriculture associations, government, a collaboration of both or social insurance. As a lead organization for the global arboriculture community, ISA has the ISC, which can initiate development of an international safety standard for tree work operations, to standardize arboriculture work safety practices to facilitate communication and knowledge sharing internationally. While the latter is an advantage of an international standard, safety topics may still need to be applied situationally, when reasonable or practical: a "blanket rule" approach such as that of an international standard may still have to be adjusted accordingly to a country's types of trees, demographics and culture.

Future studies can assess worker's field compliance and safety performance to understand how safety standards affect work safety. Then, subsequent studies can investigate finer details of arboricultural work safety practices and expand the analysis of standards' contents to include the other aspects of arboriculture work operations such as working around electrical hazards, rigging, tree removals and using a chipper. Another potential area of study can also examine the effectiveness of standards in reducing the rate of tree related work incidences.

Tables and Figures

Table 1: List of countries that have a chapter or component in the International Society of Arboriculture (ISA), the type(s) of standards in use in each country, and whether a response was received from a representative of the chapter or component in each country. "NIL" indicates that it was unclear whether there were any standards for the country because no response was received, and no additional information could be found regarding the country's standards.

Countries	Abbreviation	Response	Standard	ANSI Z133	EAC Guidelines[1]	Local Standard	Industry Standard	Government Standard	Social Insurance
Australia	AU	Yes	Yes	No	No	Yes	Yes	Yes	No
Austria	AT	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Belgium	BE	No	Yes	No	Yes	No	Yes	No	No
Brazil[2]	BR	Yes	No	No	No	No	No	No	No
Canada	CN	Yes	Yes	No	No	Yes	Yes	Yes	No
Colombia	CO	Yes	Yes	Yes	No	No	Yes	No	No
Croatia	HR	No	Yes	No	Yes	No	Yes	No	No
Czech Republic	CZ	Yes	Yes	No	Yes	No	Yes	No	No
Denmark	DK	Yes	Yes	No	Yes	No	Yes	No	No
Estonia	EE	Yes	No	No	No	No	No	No	No
Finland	FI	Yes	Yes	No	Yes	No	Yes	No	No
France	FR	Yes	Yes	No	No	Yes	No	Yes	No
Germany	DE	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Hong Kong	HK	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Iceland	NIL	No	NIL	NIL	No	NIL	NIL	NIL	NIL
Ireland	IE	Yes	Yes	No	No	Yes	Yes	No	No
Italy	IT	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Japan	JP	Yes	Yes	Yes	No	No	Yes	No	No
Latvia	LV	Yes	Yes	No	Yes	No	Yes	No	No
Lithuania	LT	No	Yes	No	Yes	No	Yes	No	No
Malaysia[2]	MY	Yes	No	No	No	No	No	No	No

Mexico	MX	Yes	Yes	Yes	No	No	Yes	No	No
Netherlands	NL	Yes	Yes	No	Yes	No	Yes	No	No
New Zealand	NZ	Yes	Yes	No	No	Yes	Yes	Yes	No
Norway	NO	Yes	Yes	No	Yes	No	Yes	No	No
Poland	PL	Yes	Yes	Yes	Yes	No	Yes	No	No
Slovakia	SK	Yes	Yes	No	No	Yes	Yes	No	No
Singapore	SG	Yes	Yes	No	No	Yes	Yes	Yes	No
Spain	ES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Sweden	SE	Yes	Yes	Yes	Yes	No	Yes	No	No
Switzerland	CH	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Taiwan	TW	Yes	No	No	No	No	No	No	No
United Kingdom	UK	Yes	Yes	No	Yes	Yes	Yes	Yes	No
United States	US	Yes	Yes	Yes	No	Yes	Yes	No	No
Count of “Yes”		30	29	7	17	15	28	9	3
Percent of total (%)		88	85	20	50	44	82	26	9

[1]I assumed that members of the European Arboricultural Council (EAC) member countries used the EAC’s tree worker safety guidelines if another standard was not used in that country.

[2]At the time of this study, Brazil and Malaysia’s standards were still in draft and not published. The draft versions of standards were not released and could not be used for this study.

Table 2: Subcategories within each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)]. Numbers are for reference in Tables 3-7. Unless otherwise noted, all subcategories are from the ANSI Z133 (ANSI 2017).

No.	GSR	PPE	CS	TC
1	Adhere to manufacturers' instruction for equipment use	Appropriate use	Chainsaw protective clothing	Two workers
2	Emergency procedures and readiness	Employer's responsibility to provide PPE	Start chainsaw with chain brake on	Inspect climbing gear
3	Job briefing and work site set up	Head protection	Two hands	Line and at least one other secured means while aloft
4	Traffic control	Eye protection	Second tie in point when using chainsaw at height	Secured at all times during ascend
5	Establishing good communication between workers	Hearing protection	Chain brake on or engine shutoff when setting the chainsaw down	Ladder
6	Trained and competent workers	Clothing	Chain brake on when transporting the chainsaw in more than two steps	Allowed use of false crotch instead of natural crotch
7	Safety considerations when working under heat or extreme weather conditions[1]	Appropriate footwear	Chainsaw selection[8]	Inspect anchor point from the ground

8	Fire protection	Handling defective PPE[4]	Altering chainsaw safety devices	Tied in appropriately to prevent uncontrolled pendulum swing
9	Physical fitness[2]	Steel toed capped boots[5]	Hold chainsaw firmly to minimize movement when pulling the start cord	Compatibility between carabiners and terminated rope ends
10	Restrictions on employment of youths[3]	Hand protection	Shoulder level	Carabiners technical requirements (auto or three action locks, load on major axis, forces load)
11		Cut resistant pants (no spec) [6]	Stable body positioning when using chainsaw	Arborist saddles
12		Face protection	Stable body position before cutting	Climbing lines
13		Trained to use PPE	Safe way to carry chainsaw	Lanyard requirements
14		Cut resistant pants (ground)	No drop start	Secured at all times from start of work until the end
15		Respiratory protection	Kickback[9]	Preload anchor point with twice the weight of the climber before climbing
16		Cut resistant pants (aerial)[7]	Technical features of a chainsaw[10]	Termination knots at rope ends
17			Exceptions to drop start[11]	Hitches
18				Heat resistant
19				Secured at all times when using climbing spurs

20				Secured when repositioning
21				Preload after repositioning
22				Handsaw
23				Do not link carabiners and snap hooks
24				SRS techniques and procedures[12]
25				Ground crew responsibilities
26				Store climbing equipment properly to prevent damage
27				Tie in point can withstand loads from pruning or removals
28				Install climbing line or false crotch in main stem/leader/lateral limb
29				Splicing
30				Transport climbing equipment properly to prevent damage
31				Do not alter arborist saddles and lanyard
32				Select anchor point that prevents lateral movement of the climbing line
33				Three points of contact while climbing
34				Climbing spurs' gaff length requirements

35				Equipment to secure arborist cannot be used for anything else
36				Climbing line can be used to lower light weight tools
37				Snap hooks
38				Rope ends finished to prevent unravelling
39				Place false crotch or climbing line in a way that does not slide
40				Carabiners without captive eye must be load on major axis
41				Climbing lines requirement for SRT
42				Select an anchor point that is structurally sound[1]
43				No placement of climbing lines on stem without lateral limb unless it can be choked
44				Load-rated screw links
45				Never leave climbing line unattended in the tree
46				When line is damaged, secure with lanyard and replace the line
47				Pulleys[13]
48				Ascenders, descenders, rope grabs[14]

[1] From Australia, Italy, Canada and Singapore's standards.

[2] From Germany, Canada, New Zealand, Singapore and the United Kingdom's standards.

[3] From Austria, New Zealand, Germany and the United Kingdom's standards.

[4] From EAC, France, New Zealand, Canada and Singapore's standards

[5] From Australia, EAC, Germany, New Zealand, Canada and Singapore's standards.

[6, 7] Adapted from ANSI Z133's "cut resistant pants (ground) subcategory and modified accordingly.

[8] From Germany, United Kingdom, New Zealand, Canada and Singapore's standards.

[9] From Australia, United Kingdom, Italy, Canada and Singapore's standards.

[10] From Canada, Germany, United Kingdom, New Zealand and Singapore's standards.

[11] From Singapore's standard.

[12] From Australia, EAC, United Kingdom and New Zealand's standards.

[13, 14] From United Kingdom and Australia's standards.

Table 3: Presence (1) and absence (0) of main categories [General Safety Requirements (GSR), Personal Protective Equipment (PPE), Tree Climbing (TC), and Safe Chainsaw Use (CS)] expressed as counts and proportions of total countries (n=29) and categories (n=4).

Countries	GSR	PPE	TC	CS	Count	% of total
United States	1	1	1	1	4	100
Australia	1	1	1	1	4	100
Austria	1	1	1	1	4	100
Belgium	1	1	1	1	4	100
Canada	1	1	1	1	4	100
Colombia	1	1	1	1	4	100
Croatia	1	1	1	1	4	100
Czech Republic	1	1	1	1	4	100
Denmark	1	1	1	1	4	100
Finland	1	1	1	1	4	100
Germany	1	1	1	1	4	100
Hong Kong	1	1	1	1	4	100
Ireland	1	1	1	1	4	100
Japan	1	1	1	1	4	100
Italy	1	1	1	1	4	100
Latvia	1	1	1	1	4	100
Lithuania	1	1	1	1	4	100
Mexico	1	1	1	1	4	100
Netherlands	1	1	1	1	4	100
New Zealand	1	1	1	1	4	100
Norway	1	1	1	1	4	100
Poland	1	1	1	1	4	100
Slovakia	1	1	1	1	4	100
Singapore	1	1	1	1	4	100
Spain	1	1	1	1	4	100
Sweden	1	1	1	1	4	100
Switzerland	1	1	1	1	4	100
United Kingdom	1	1	1	1	4	100
France	1	1	1	0	3	75
Count	29	29	29	28		
% of total	100	100	100	96		

Table 4: Presence (1) and absence (0) of subcategories within the main category "General Safety Requirements" (GSR) expressed as counts and proportions of total countries (n = 29) and subcategories (n=10). Numbers in the first row correspond to each subcategory and are described in Table 2.

Country	1	2	3	4	5	6	7	8	9	10	Count	% of total
Austria	1	1	1	1	1	1	1	1	1	1	10	100
New Zealand	1	1	1	1	1	1	1	1	1	1	10	100
Australia	1	1	1	1	1	1	1	1	1	0	9	90
Canada	1	1	1	1	1	1	1	1	1	0	9	90
Germany	1	1	1	1	1	1	1	0	1	1	9	90
Hong Kong	1	1	1	1	1	1	1	1	1	0	9	90
Ireland	1	1	1	1	1	1	1	0	1	1	9	90
Singapore	1	1	1	1	1	1	1	1	1	0	9	90
United Kingdom	1	1	1	1	1	1	1	0	1	1	9	90
France	1	1	1	1	1	1	1	1	0	0	8	80
Italy	1	1	1	1	1	1	1	1	0	0	8	80
Poland	1	1	1	1	1	1	1	1	0	0	8	80
Spain	1	1	1	1	1	1	1	1	0	0	8	80
Sweden	1	1	1	1	1	1	1	1	0	0	8	80
United States	1	1	1	1	1	1	0	1	0	0	7	70
Belgium	1	1	1	1	1	1	1	0	0	0	7	70
Colombia	1	1	1	1	1	1	0	1	0	0	7	70
Croatia	1	1	1	1	1	1	1	0	0	0	7	70
Czech Republic	1	1	1	1	1	1	1	0	0	0	7	70
Denmark	1	1	1	1	1	1	1	0	0	0	7	70
Finland	1	1	1	1	1	1	1	0	0	0	7	70
Japan	1	1	1	1	1	1	0	1	0	0	7	70
Latvia	1	1	1	1	1	1	1	0	0	0	7	70
Lithuania	1	1	1	1	1	1	1	0	0	0	7	70
Mexico	1	1	1	1	1	1	0	1	0	0	7	70
Netherlands	1	1	1	1	1	1	1	0	0	0	7	70
Norway	1	1	1	1	1	1	1	0	0	0	7	70
Slovakia	1	1	1	1	1	1	1	0	0	0	7	70
Switzerland	1	1	1	1	1	1	1	0	0	0	7	70
Count	29	29	29	29	29	29	25	15	9	5		
% of total	100	100	100	100	100	100	86	51	31	17		

Table 5: Presence (1) and absence (0) of subcategories within the main category "Personal Protective Equipment" (PPE) expressed as counts and proportions of total countries (n = 29) and subcategories (n=16). Numbers in the first row correspond to each subcategory and are described in Table 2.

Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Count	% of total
Australia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
Hong Kong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
Ireland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
Singapore	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
United Kingdom	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
Canada	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	15	94
Poland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15	94
Spain	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15	94
Sweden	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15	94
Austria	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	12	75
Germany	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	12	75
Italy	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	12	75
New Zealand	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	12	75
United States	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	11	69
Belgium	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Colombia	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	11	69
Croatia	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Czech Republic	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Denmark	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Finland	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Japan	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	11	69
Latvia	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Lithuania	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Mexico	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	11	69
Netherlands	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Norway	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69

Slovakia	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
Switzerland	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11	69
France	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	6
Count	28	28	28	28	28	28	28	25	24	24	24	15	14	13	13	6		
% of total	97	97	97	97	97	97	97	86	82	82	82	52	48	45	45	21		

Table 6: Presence (1) and absence (0) of subcategories within the main category "Safe Chainsaw Use" (CS) expressed as counts and proportions of total countries (n = 29) and subcategories (n=17). Numbers in the first row correspond to each subcategory and are described in Table 2.

Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Count	% of total
Australia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	100
Canada	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	100
Hong Kong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	100
Singapore	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	100
New Zealand	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	16	94
Ireland	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	14	82
Poland	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	14	82
Spain	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	14	82
Sweden	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	14	82
United Kingdom	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	14	82
United States	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	13	76
Austria	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	0	13	76
Colombia	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	13	76
Japan	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	13	76
Mexico	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	13	76
Germany	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	9	53
Italy	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	8	47
Belgium	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Croatia	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Czech Republic	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Denmark	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Finland	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Latvia	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Lithuania	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Netherlands	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41

Norway	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Slovakia	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
Switzerland	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	7	41
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Count	29	28	28	28	28	28	24	15	15	15	14	14	13	12	10	9	4		
% of total	97	97	97	97	97	97	83	52	52	52	48	48	45	41	34	31	14		

Table 7: Presence (1) and absence (0) of numbered subcategories (first column—descriptions are in Table 2) within the main category "Tree Climbing" (TC) expressed as counts and proportions of total countries (n = 29). Country abbreviations are in Table 1.

Subcategory	HK	ES	PL	SE	US	CO	JP	MX	SG	CN	IE	UK	AU	FR	NZ	AT	DE	IT	CH	BE	HR	CZ	DK	FI	LV	LT	NL	NO	SK	Count	% of total
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	29	100
14	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	97
15	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	97
16	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	97
17	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	97
18	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	28	97
19	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	93
20	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	93
21	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	93
22	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	26	90
23	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	26	90
24	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23	79
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	17	59
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	17	59
27	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	16	55
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	52
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	52
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	15	52
31	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	48
32	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	45
33	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	41
34	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	41
35	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	41
36	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	41
37	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	38
38	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	38
39	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	34
40	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	34
41	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	34
42	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	28
43	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	31
44	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	31

45	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	31
46	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	28
47	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	24
48	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	21
Count	48	47	45	45	44	44	44	44	44	36	36	36	31	31	30	28	28	25	25	24	24	24	24	24	24	24	24	24		
% of total	100	98	94	94	92	92	92	92	92	75	75	75	65	65	63	58	58	52	52	50	50	50	50	50	50	50	50	50		

Table 8: Proportion of all subcategories (n=91) included in the standard(s) in each country listed in (a) descending and (b) alphabetical order.

	Country	Proportion
(a)	Hong Kong	99%
	Singapore	95%
	Spain	92%
	Poland	90%
	Sweden	90%
	Canada	85%
	Colombia	82%
	Ireland	82%
	Japan	82%
	Mexico	82%
	United Kingdom	82%
	United States	82%
	Australia	80%
	New Zealand	75%
	Austria	69%
	Germany	64%
	Italy	58%
	Switzerland	55%
	Belgium	54%
	Croatia	54%
	Czech Republic	54%
	Denmark	54%
	Finland	54%
	Latvia	54%
	Lithuania	54%
	Netherlands	54%
	Norway	54%
	Slovakia	54%
	France	44%

	Country	Proportion
(b)	Australia	80%
	Austria	69%
	Belgium	54%
	Canada	85%
	Colombia	82%
	Croatia	54%
	Czech Republic	54%
	Denmark	54%
	Finland	54%
	France	44%
	Germany	64%
	Hong Kong	99%
	Ireland	82%
	Japan	82%
	Italy	58%
	Latvia	54%
	Lithuania	54%
	Mexico	82%
	Netherlands	54%
	New Zealand	75%
	Norway	54%
	Poland	90%
	Singapore	95%
	Slovakia	54%
	Spain	92%
	Sweden	90%
	Switzerland	55%
	United Kingdom	82%
	United States	82%

Table 9: Similarity matrix of all subcategories (n=91) and countries (N=29); abbreviations of country names are in Table 1. Cell values indicate similarity between the standards in a pair of countries, expressed as a percentage. A value of 100 indicates that the pair of standards includes and excludes exactly the same subcategories; a value of 0 indicates that the pair of standards includes and excludes none of the same subcategories. "—" indicates a country's comparison to itself.

	HK	SG	ES	PL	SE	CN	US	CO	IE	JP	MX	UK	AU	NZ	AT	DE	IT	CH	BE	HZ	CZ	DK	FI	LT	LI	NL	NO	SK	FR
HK	—																												
SG	96	—																											
ES	93	89	—																										
PL	91	87	98	—																									
SE	91	87	98	100	—																								
CN	86	88	79	77	77	—																							
US	84	81	90	92	92	71	—																						
CO	84	81	90	92	92	71	100	—																					
IE	81	84	77	75	75	80	67	67	—																				
JP	84	81	90	92	92	71	100	100	67	—																			
MX	84	81	90	92	92	71	100	100	67	100	—																		
UK	81	84	77	75	75	80	67	67	100	67	67	—																	
AU	81	84	75	73	73	82	65	65	82	65	65	82	—																
NZ	74	76	74	76	76	68	68	68	79	68	68	79	75	—															
AT	68	70	68	70	70	69	63	63	76	63	63	76	71	84	—														
DE	63	65	63	65	65	66	57	57	81	57	57	81	68	78	88	—													
IT	59	62	64	66	66	60	58	58	74	58	58	74	65	79	85	90	—												
CH	56	58	63	65	65	59	57	57	73	57	57	73	62	74	84	91	95	—											
BE	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	—										
HZ	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	—									
CZ	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	—								
DK	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	—							
FI	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	—						
LT	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	100	—					
LI	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	100	100	—				
NL	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	100	100	100	—			
NO	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	100	100	100	100	—		
SK	55	57	62	64	64	58	56	56	71	56	56	71	60	75	85	90	96	99	100	100	100	100	100	100	100	100	100	—	
FR	45	45	52	52	52	46	53	53	53	53	53	53	48	54	53	60	62	63	62	62	62	62	62	62	62	62	62	62	—

Table 10: Numbered subcategories within each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] arranged in descending order of inclusion within standards in all countries (n=29). Lines under rows indicate the third quartile (97%), median (86%) and first quartile (41%).

Main Category	Subcategory Number	Proportion of Countries
GSR	1	100
GSR	2	100
GSR	3	100
GSR	4	100
GSR	5	100
GSR	6	100
TC	9	100
TC	10	100
TC	11	100
TC	12	100
TC	1	100
TC	2	100
TC	3	100
TC	4	100
TC	5	100
TC	6	100
TC	7	100
TC	8	100
CS	1	97
CS	2	97
CS	3	97
CS	4	97
CS	5	97
CS	6	97
PPE	1	97
PPE	2	97
PPE	3	97
PPE	4	97
PPE	5	97
PPE	6	97
PPE	7	97
TC	13	97
TC	14	97
TC	15	97
TC	16	97
TC	17	97
TC	18	93
TC	19	93
TC	20	93

TC	21	93
TC	22	90
TC	23	90
GSR	7	86
PPE	8	86
PPE	9	86
PPE	10	86
PPE	11	86
CS	7	83
TC	24	79
TC	25	59
TC	26	59
TC	27	55
CS	10	52
CS	8	52
CS	9	52
PPE	12	52
TC	28	52
TC	29	52
TC	30	52
GSR	8	51
CS	11	48
CS	12	48
TC	31	46
CS	13	45
PPE	14	45
PPE	15	45
PPE	13	41
CS	14	41
TC	33	41
TC	34	41
TC	35	41
TC	36	41
TC	38	38
TC	37	36
TC	38	36
CS	15	34
TC	39	34
TC	40	34
TC	41	34
CS	16	31
GSR	9	31
TC	43	31
TC	44	31
TC	45	31
TC	42	28
TC	46	28
TC	47	24

PPE	16	21
TC	48	21
GSR	10	17
CS	17	14

Table 11: Similarity matrix comparing the standard(s) in each country (n=29) to the ANSI Z133 used in the United States. Within each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and for all subcategories (n=91), values indicate the proportion of subcategories included in the ANSI Z133 that are also included in the standard(s) used in each country.

	United States (Z133)				
Country	**GSR**	**PPE**	**CS**	**TC**	**Overall**
Colombia	100	100	100	100	100
Japan	100	100	100	100	100
Mexico	100	100	100	100	100
Poland	90	75	94	98	92
Sweden	90	75	94	98	92
Spain	90	75	94	94	90
Canada	80	63	76	71	88
Hong Kong	80	69	76	92	84
Singapore	80	69	76	88	81
New Zealand	70	56	82	67	68
Ireland	60	69	71	67	67
United Kingdom	60	69	71	67	67
Australia	80	69	76	56	65
Austria	70	56	65	63	63
Italy	90	56	47	56	58
Switzerland	80	50	53	56	57
Germany	60	56	41	63	57
Belgium	80	50	53	54	56
Croatia	80	50	53	54	56
Czech Republic	80	50	53	54	56
Denmark	80	50	53	54	56
Finland	80	50	53	54	56
Latvia	80	50	53	54	56
Lithuania	80	50	53	54	56
Netherlands	80	50	53	54	56
Norway	80	50	53	54	56
Slovakia	80	50	53	54	56
France	90	25	24	65	53
Mean	80	60	66	68	68
StDev	10	17	20	18	16
First quartile	80	50	53	54	56
Median	80	56	59	63	61
Third Quartile	90	69	78	89	85

Table 12: Groups of most similar countries. Group numbers were arbitrary and labelled for references.

Group	Countries
1	United States
	Colombia
	Japan
	Mexico
2	Spain
	Poland
	Sweden
3	Ireland
	United Kingdom
4	Belgium
	Croatia
	Czech Republic
	Denmark
	Finland
	Latvia
	Lithuania
	Netherlands
	Norway
	Slovakia
	Switzerland
	Germany
	Austria
	Italy
5	Hong Kong
	Singapore
	Australia
	Canada
6	New Zealand
7	France

Table 13: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Spain (ES), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with ES	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
PL, SE	100%	100%	100%	94%	3%	98%
HK	90%	94%	82%	98%	7%	93%
CO, JP, MX, US	90%	75%	94%	92%	9%	90%
SG	90%	94%	82%	92%	5%	89%
CN	90%	88%	82%	75%	7%	79%
IE, UK	70%	94%	76%	75%	11%	77%
AU	90%	94%	82%	65%	13%	75%
NZ	80%	81%	88%	63%	11%	74%
AT	80%	81%	71%	58%	11%	68%
IT	100%	81%	53%	52%	23%	64%
DE	70%	81%	47%	58%	15%	63%
CH	90%	75%	59%	52%	17%	63%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	90%	75%	59%	50%	18%	62%
FR	100%	13%	18%	65%	41%	52%

Table 14: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Ireland (IE) and the United Kingdom (UK), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with IE and UK	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
SG	80%	100%	82%	79%	10%	84%
AU	80%	100%	82%	77%	10%	82%
DE	100%	75%	71%	83%	13%	81%
HK	80%	100%	82%	75%	11%	81%
CN	80%	94%	82%	75%	8%	80%
NZ	90%	69%	88%	75%	10%	79%
ES	70%	94%	76%	73%	11%	77%
AT	90%	75%	82%	71%	8%	76%
PL, SE	70%	94%	76%	69%	12%	75%
IT	70%	75%	65%	77%	5%	74%
CH	80%	69%	59%	77%	9%	73%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	80%	69%	59%	75%	9%	71%
CO, JP, MX, US	60%	69%	71%	67%	5%	67%
FR	70%	6%	18%	77%	36%	53%

Table 15: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Belgium (BE), Czech Republic (CZ), Denmark (DK), Finland (FI), Croatia (HZ), Lithuania (LT), Latvia (LV), Netherlands (NL), Norway (NO) and Slovakia (SK), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
CH	100%	100%	100%	98%	1%	99%
IT	90%	94%	94%	98%	3%	96%
DE	80%	94%	88%	92%	6%	90%
AT	70%	94%	65%	92%	15%	85%
NZ	70%	94%	47%	79%	20%	75%
IE, UK	80%	69%	59%	75%	9%	71%
PL, SE	90%	75%	59%	56%	16%	64%
ES	90%	75%	59%	52%	17%	62%
FR	90%	38%	59%	65%	21%	62%
AU	80%	69%	41%	60%	17%	60%
CN	80%	75%	41%	54%	18%	58%
SG	80%	69%	41%	54%	17%	57%
CO, JP MX, US	80%	50%	53%	54%	14%	56%
HK	80%	69%	41%	50%	18%	55%

Table 16: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Germany (DE), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with DE	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
CH	80%	94%	88%	94%	7%	91%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	80%	94%	88%	92%	6%	90%
IT	70%	88%	94%	94%	11%	90%
AT	90%	100%	76%	88%	10%	88%
IE, UK	100%	75%	71%	83%	13%	81%
NZ	90%	88%	59%	79%	14%	78%
AU	80%	75%	53%	69%	12%	68%
CN	80%	81%	53%	63%	14%	66%

PL, SE	70%	81%	47%	65%	14%	65%
SG	80%	75%	53%	63%	12%	65%
ES	70%	81%	47%	60%	14%	63%
HK	80%	75%	53%	58%	13%	63%
FR	70%	31%	47%	73%	20%	60%
CO, JP, MX, US	60%	56%	41%	63%	10%	57%

Table 17: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Austria (AT), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with AT	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
DE	90%	100%	76%	88%	10%	88%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	70%	94%	65%	92%	15%	85%
IT	80%	88%	71%	90%	9%	85%
CH	70%	94%	65%	90%	14%	84%
NZ	100%	88%	82%	79%	9%	84%
IE, UK	90%	75%	82%	71%	8%	76%
AU	90%	75%	76%	65%	10%	71%
PL, SE	80%	81%	71%	65%	8%	70%
SG	90%	75%	76%	63%	11%	70%
CN	90%	81%	76%	58%	13%	69%
ES	80%	81%	71%	60%	10%	68%
HK	90%	75%	76%	58%	13%	68%
CO, JP, MX, US	70%	56%	65%	63%	6%	63%
FR	80%	31%	24%	65%	27%	53%

Table 18: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Italy (IT), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with IT	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
DE	70%	88%	94%	94%	11%	90%
AT	80%	88%	71%	90%	9%	85%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	90%	94%	94%	98%	3%	85%
CH	90%	94%	94%	96%	3%	84%

NZ	80%	100%	53%	81%	19%	79%
IE, UK	70%	75%	65%	77%	5%	74%
PL, SE	100%	81%	53%	58%	22%	66%
AU	90%	75%	47%	63%	18%	65%
ES	100%	81%	53%	54%	23%	64%
SG	90%	75%	47%	56%	19%	62%
CN	90%	69%	47%	56%	19%	60%
HK	90%	75%	47%	52%	20%	59%
CO, JP, MX, US	90%	56%	47%	56%	19%	58%
FR	100%	31%	53%	67%	29%	53%

Table 19: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Australia (AU), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with AU	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
SG	100%	100%	100%	69%	16%	84%
CN	100%	94%	100%	69%	15%	82%
IE, UK	80%	100%	82%	77%	10%	82%
HK	100%	100%	100%	65%	18%	81%
ES	90%	94%	82%	63%	14%	75%
NZ	90%	75%	94%	65%	13%	75%
PL, SE	90%	94%	82%	58%	16%	73%
AT	90%	75%	76%	65%	10%	71%
DE	80%	75%	53%	69%	12%	68%
CO, JP, MX, US	80%	69%	76%	56%	11%	65%
IT	90%	75%	47%	63%	18%	65%
CH	80%	69%	41%	63%	16%	62%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	80%	69%	41%	60%	17%	60%
FR	90%	6%	0%	71%	45%	48%

Table 20: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in Canada (CN), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with CN	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
SG	100%	94%	100%	79%	10%	88%
HK	100%	94%	100%	75%	12%	86%
AU	100%	94%	100%	69%	15%	82%
IE, UK	80%	94%	82%	75%	8%	80%

ES	90%	94%	82%	73%	9%	79%
PL, SE	90%	94%	82%	69%	11%	77%
CO, JP, MX, US	80%	69%	76%	71%	5%	71%
AT	90%	75%	76%	58%	13%	69%
NZ	90%	75%	94%	54%	18%	68%
DE	80%	75%	53%	63%	12%	66%
IT	90%	75%	47%	56%	19%	60%
CH	80%	69%	41%	56%	17%	59%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	80%	69%	41%	54%	17%	58%
FR	90%	6%	0%	65%	44%	46%

Table 21: Similarity index for each main category [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] and overall to compare the standard used in New Zealand (NZ), to standards in other countries. The standard deviation (ST DEV) was calculated for the main categories.

Compare with NZ	Main Category					
Country	GSR	PPE	CS	TC	ST DEV	Overall
AT	100%	88%	82%	79%	9%	84%
IT	80%	100%	53%	81%	19%	79%
IE, UK	90%	75%	88%	75%	8%	79%
DE	90%	88%	59%	79%	14%	78%
PL, SE	80%	81%	88%	69%	8%	76%
SG	90%	75%	94%	67%	13%	76%
BE, CZ, DK, FI, HZ, LT, LV, NL, NO, SK	70%	94%	47%	79%	20%	75%
AU	90%	75%	94%	65%	13%	75%
CH	70%	94%	47%	77%	19%	74%
ES	80%	81%	88%	65%	10%	74%
HK	90%	75%	94%	63%	14%	74%
CN	90%	69%	94%	54%	19%	68%
CO, JP, MX, US	70%	56%	82%	67%	11%	68%
FR	80%	31%	6%	73%	35%	54%

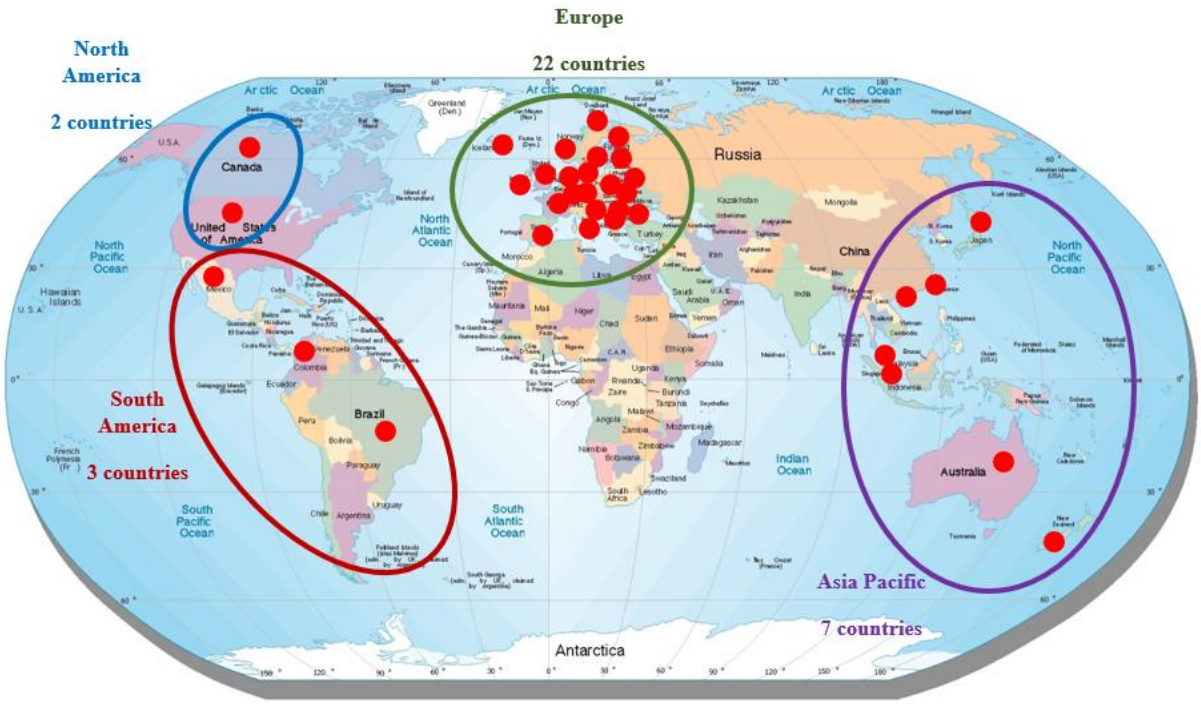

Figure 1: World map of the 34 registered members of International Society of Arboriculture countries. They are grouped according to their continents, shown in the various colors.

Figure 2: Word cloud which shows the most frequently occurring words when various arboriculture safety standards from the study population was analyzed with NVivo software. The larger the words, the more frequent those words are. For example, “Safety” is the most common word among arboriculture safety standards in different countries.

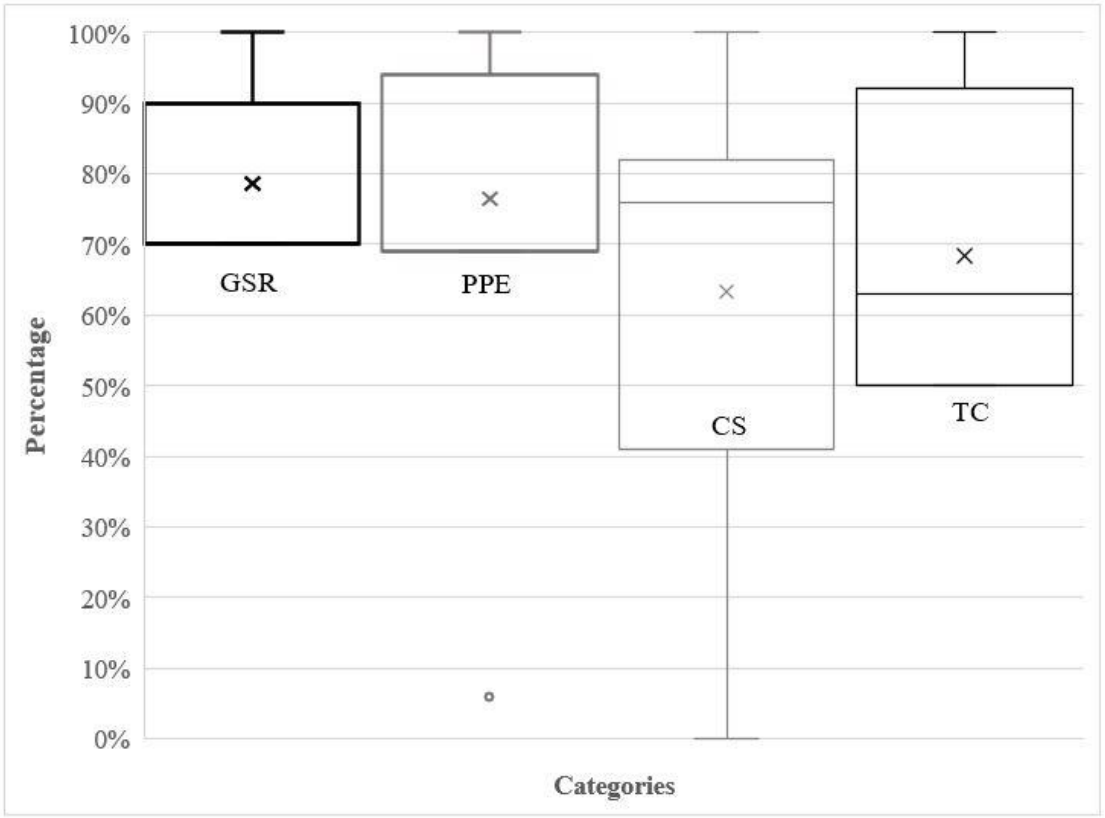

Figure 3: Box and whisker plots illustrating the proportion of all subcategories present in each main category [general safety requirements (GSR, n=10), personal protective equipment (PPE, n=16), chainsaw (CS, n=17), and tree climbing (TC, n=-48)]. In each plot, × represents the mean; the line within each box represents the median; upper and lower bounds of the box represent the first and third quartiles, respectively; whiskers represent the local minimum and maximum, respectively; and circles represent outliers, defined as values 1.5 times greater or less than the interquartile range, as measured from the third or first quartile, respectively.

APPENDIX A

ADDITIONAL INFORMATION OF STANDARDS

Table A1: Database of all the relevant standards and their associated descriptive information from various countries. NIL indicates no information was available.

No.	Geographic name	Geographic region that the standard covers	Title	Document type	Organization	Publication year (Newest)	Publication year (Oldest)	Revisions	Language	Age
1	Australia	Country	Guide to managing risk in tree trimming and removal work	Government	WorkSafe Australia	2016	NIL	NIL	English	3
2	Australia	Country	AS 2726.2 - 2004. Chainsaws - Safety requirements. Part 2: Chainsaws for tree service	Government	Australian Standard	2004	1995	2	English	24
3	Austria	Country	Work on trees M520	Social insurance	Allgemeine Unfallversicherungsanstalt (Austrian Workers' Compensation Board)	NIL	NIL	NIL	NIL	NIL
4	Austria	Country	Tree Work	Social insurance	Social insurance for farmers, foresters and landscapers (SVLFG)	2017	NIL	NIL	NIL	2
5	Europe[1]	Regional	A Guide to Safe Work Practice (Third Edition)	Industry	European Arboriculture Council (EAC)	2008	NIL	3	English	11

6	Europe[1]	Regional	European Tree Worker	Industry	European Arboriculture Council (EAC)	2016	2000	8	English	19
7	France	Country	Implementation of the Regulations on the prevention of falls-related risks to work done in trees by means of ropes	Government	Ministry of Agriculture and Fisheries	2007	NIL	NIL	French	12
8	Germany	Country	Accident prevention Regulations	Social insurance	Social insurance for farmers, foresters and landscapers (SVLFG)	2017	2000	NIL	German	8
9	Italy	Country	Instruction to work on trees safely using ropes	Government	National Institute for Insurance Against Work (INAIL)	2016	NIL	NIL	Italian	3
10	New South Wales	State	Amenity Tree Industry Code of Practice	Government	WorkCover New South Wales	2008	2008	NIL	English	11
11	New Zealand	Country	ACoP Part 1: Approved Code of Practice for Safety and Health in Arboriculture	Government	Ministry of Business, Innovation and Employment	2012	NIL	NIL	English	7
12	New Zealand	Country	Good Practice Guideline for Safety Requirements in Arboriculture Operations	Industry	The New Zealand Arboriculture Association	2017	1994	2	English	25
13	Ontario	Province	Arborist Industry Safe Work Practice	Industry	Arborist Safe Work Committee	2011	NIL	3	English	8
14	Quebec	Province	Practice of work safe pruning	Government	Committee on Standards, Equity, Health and Safety (CNESST)	2017	NIL	0	French	2

15	Singapore	Country	Best Practice Guidelines (2017) For Safety and Health in Tree Work	Industry	Singapore Arboriculture Society	2017	2017	0	English	2
16	Singapore	Country	Landscape Horticulture Management	Government	Workplace Safety and Health Council	2018	2008	1	English	11
17	Spain	Country	Justification of the climbing technique in works on trees	Industry	Association Española de Arboriculture	2015	2015	NIL	Spanish	4
18	Spain	Country	Safety in tree pruning work (I): Safe working practices for tree-climbing operations	Government	National Institute of Security, Health and well-being at work (INSSBT)	2018	NIL	NIL	Spanish	1
19	Spain	Country	Safety in tree pruning work (II): Safe working practices for tree-climbing operations (II): Basic and Rescue Techniques	Government	National Institute of Security, Health and well-being at work (INSSBT)	2018	NIL	NIL	Spanish	1
20	United Kingdom	Country	AFAG (Arboriculture and Forestry Advisory Group) 401 - Tree Climbing Operations	Government	Health and Safety Executive (HSE)	2013	NIL	2	English	6
21	United Kingdom	Country	AFAG 308 - Top-handled Chainsaws	Government	Health and Safety Executive (HSE)	2013	NIL	2	English	6
22	United Kingdom	Country	INDG317 - Chainsaws at work	Government	Health and Safety Executive (HSE)	2012	NIL	2	English	7
23	United Kingdom	Country	Industry Code of Practice for Arboriculture	Industry	Arboricultural Association	2015	2015	1	English	4
24	United Kingdom	Country	BS 3998: Recommendations for Tree Work	Industry	BSI Standards Publication	2010	1966	3	English	53

25	United Kingdom	Country	A guide to good climbing practice	Industry	Arboricultural Association	2016	2005	4	English	14
26	United States	Country	Z133 American National Standard for Arboricultural Operations - Safety Requirements	Industry	International Society of Arboriculture (ISA)	2017	1972	8	English	47
27	Victoria	State	Working safely with trees: recommended practices for the amenity tree industry	Government	WorkSafe Victoria	2001	NIL	NIL	English	18

[1]See Table 1 for countries which use EAC guidelines.

Table A2: Continuation of Table A1. List of obtained standards the source of their documents.

Geographic name	Title	Document type	Document format	Source
Australia	Guide to managing risk in tree trimming and removal work	Guide	Electronic copy	https://www.safeworkaustralia.gov.au/doc/guide-managing-risks-tree-trimming-removal
Australia	AS 2726.2 - 2004. Chainsaws - Safety requirements. Part 2: Chainsaws for tree service	Standard	Book	https://infostore.saiglobal.com/en-us/Standards/AS-2726-2-2004-123876_SAIG_AS_AS_260395/
Austria	Work on trees M520	Guide	Electronic copy	Michael Bazant, secretary of ISA Austria. Contact information: bazant@vlasitzundzodl.at
Austria	Tree Work	Guide	Electronic copy	Michael Kleine. Contact information: michael.kleine@anrica.org. http://www.svlfg.de/30-praevention/prv051_fachinfos_a_z/b/02_baumpflege/
Europe[1]	A Guide to Safe Work Practice (Third Edition)	Guide	Electronic copy	https://www.eac-arboriculture.com/eac_guides.aspx
Europe[1]	European Tree Worker Handbook	Guide	Book	https://shop.freeworker.com/european-tree-worker.html
France	Implementation of the Regulations on the prevention of falls-related risks to work done in trees by means of ropes	Standard	Electronic copy	Jeremie Thomas of ArboriCulture. Contact information: jeremoi@gmail.com
Germany	Accident prevention Regulations	Standard	Electronic copy	http://www.svlfg.de/30-praevention/prv1400-gesetze-und-vorschriften/prv0301-vorschriften-fuer-sicherheit-und-gesundheitsschutz/16_vsg42.pdf
Italy	Instruction to work on trees safely using ropes	Standard	Electronic copy	Rene Comin. Contact information: Renato.comin@promo.it
New South Wales	Amenity Tree Industry Code of Practice	Guide	Electronic copy	https://www.safework.nsw.gov.au/__data/assets/pdf_file/0009/52866/Amenity-Tree-Industry-Code-of-Practice.pdf

New Zealand	ACoP Part 1: Approved Code of Practice for Safety and Health in Arboriculture	Standard	Electronic copy	https://worksafe.govt.nz/topic-and-industry/forestry/health-and-safety-in-the-arboriculture-industry/safety-and-health-in-arboriculture/
New Zealand	Good Practice Guideline for Safety Requirements in Arboriculture Operations	Standard	Electronic copy	https://www.nzarb.org.nz/Safety++Compliance/Guides/Good+Practice+Guide.html
Ontario	Arborist Industry Safe Work Practice	Guide	Electronic copy	http://www.wsps.ca/WSPS/media/Site/Resources/Downloads/arborist_manual_3rd_edition_final2.pdf
Quebec	Practice of work safe pruning	Guide	Electronic copy	https://www.cnesst.gouv.qc.ca/Publications/300/Documents/DC300-434web.pdf
Singapore	Best Practice Guidelines (2017) For Safety and Health in Tree Work	Guide	Electronic copy	Rick Thomas of ArborCulture Pte Ltd. Contact information: rick@arborsingapore.com
Singapore	Workplace Safety and Health Guidelines: Landscape Horticulture Management	Guide	Electronic copy	https://www.wshc.sg/files/wshc/upload/infostop/attachments/2018/IS20181102000000431/WSH%20Guidelines%20on%20Landscape%20and%20Horticulture%20Management.pdf
Spain	Justification of the climbing technique in works on trees	Guide	Electronic copy	https://aearboricultura.org/Downloads/2015/Justificacion%20Trabajos%20Trepa.pdf
Spain	Safety in tree pruning work (I): Safe working practices for tree-climbing operations	Guide	Electronic copy	http://www.inssbt.es/InshtWeb/Contenidos/Documentacion/MIGRAR%20VARIAS/MIGRAR%20NTP/NTP/1113a1124/ntp_1119.pdf
Spain	Safety in tree pruning work (II): Safe working practices for tree-climbing operations (II): Basic and Rescue Techniques	Guide	Electronic copy	http://www.insht.es/InshtWeb/Contenidos/Documentacion/MIGRAR%20VARIAS/MIGRAR%20NTP/NTP/Ficheros/1113a1124/ntp-1120.pdf
United Kingdom	AFAG (Arboriculture and Forestry Advisory Group) 401 - Tree Climbing Operations	Guide	Electronic copy	http://www.hse.gov.uk/pubns/afag401.htm
United Kingdom	AFAG 308 - Top-handled Chainsaws	Guide	Electronic copy	http://www.hse.gov.uk/pubns/afag308.htm
United Kingdom	INDG317 - Chainsaws at work	Guide	Electronic copy	http://www.hse.gov.uk/pubns/indg317.htm

United Kingdom	Industry Code of Practice for Arboriculture	Guide	Electronic copy	https://www.trees.org.uk/Trees.org.uk/files/aa/aaa89992-0539-4615-9af4-32b0582a13f4.pdf
United Kingdom	BS 3998: Recommendations for Tree Work	Standard	Book	https://shop.bsigroup.com/ProductDetail/?pid=000000000030089960
United Kingdom	A guide to good climbing practice	Guide	Book	https://www.trees.org.uk/Book-Shop/Products/A-Guide-to-Good-Climbing-Practice
United States	Z133 American National Standard for Arboricultural Operations - Safety Requirements	Standard	Book	https://wwv.isa-arbor.com/store/product/122/
Victoria	Working safely with trees: recommended practices for the amenity tree industry	Guide	Book	The University of Massachusetts Library or the University of Melbourne Library

[1]See Table 1 for countries which use EAC guidelines.

APPENDIX B

SIMILARITY MATRICES OF CATEGORIES

Table B1: Similarity matrix of all main categories [general safety requirements (GSR), personal protective equipment (PPE), safe chainsaw use (CS) and tree climbing (TC)] among all countries (abbreviations of country names are described in Table 1). Similarity values were obtained by dividing the total number of shared main categories by the total number of main categories (n=4). "–" indicated a country's comparison to itself.

	US	**AU**	**AT**	**BE**	**CN**	**CO**	**HR**	**CZ**	**DK**	**FI**	**DE**	**HK**	**IE**	**IT**	**LV**	**LT**	**MX**	**NL**	**NZ**	**NO**	**PL**	**SK**	**SG**	**ES**	**SE**	**CH**	**UK**
US	–																										
AU	100	–																									
AT	100	100	–																								
BE	100	100	100	–																							
CN	100	100	100	100	–																						
CO	100	100	100	100	100	–																					
HR	100	100	100	100	100	100	–																				
CZ	100	100	100	100	100	100	100	–																			
DK	100	100	100	100	100	100	100	100	–																		
FI	100	100	100	100	100	100	100	100	100	–																	
DE	100	100	100	100	100	100	100	100	100	100	–																
HK	100	100	100	100	100	100	100	100	100	100	100	–															
IE	100	100	100	100	100	100	100	100	100	100	100	100	–														
IT	100	100	100	100	100	100	100	100	100	100	100	100	100	–													
LV	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–												
LT	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–											

MX	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–														
NL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–													
NZ	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–												
NO	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–											
PL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–										
SK	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–									
SG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–								
ES	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–							
SE	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–						
CH	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–					
UK	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	–				
FR	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75			

Table B2: Similarity matrix of GSR category among all countries (abbreviations of country names are described in Table 1). Similarity values were obtained by dividing the total number of shared subcategories by the total number of subcategories (n=10). "–" indicated a country's comparison to itself.

	AT	NZ	AU	CN	DE	HK	IE	SG	UK	FR	IT	PL	ES	SE	US	BE	CO	HZ	CZ	DK	FI	LV	LT	JP	MX	NL	NO	SK	CH
AT	–																												
NZ	100	–																											
AU	90	90	–																										
CN	90	90	100	–																									
DE	90	90	80	80	–																								
HK	90	90	100	100	80	–																							
IE	90	90	80	80	100	80	–																						
SG	90	90	100	100	80	100	80	–																					
UK	90	90	80	80	100	80	100	80	–																				
FR	80	80	90	90	70	90	70	90	70	–																			
IT	80	80	90	90	70	90	70	90	70	100	–																		
PL	80	80	90	90	70	90	70	90	70	100	100	–																	
ES	80	80	90	90	70	90	70	90	70	100	100	100	–																
SE	80	80	90	90	70	90	70	90	70	100	100	100	100	–															
US	70	70	80	80	60	80	60	80	60	90	90	90	90	90	–														
BE	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	–													
CO	70	70	80	80	60	80	60	80	60	90	90	90	90	90	100	80	–												
HZ	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	–											
CZ	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	–										
DK	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	–									
FI	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	–								
LV	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	–							
LT	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	100	–						
JP	70	70	80	80	60	80	60	80	60	90	90	90	90	90	100	80	100	100	80	80	80	80	80	–					
MX	70	70	80	80	60	80	60	80	60	90	90	90	90	90	100	80	100	80	80	80	80	80	80	100	–				
NL	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	100	100	80	80	–			
NO	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	100	100	80	80	100	–		
SK	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	100	100	80	80	100	100	–	
CH	70	70	80	80	80	80	80	80	80	90	90	90	90	90	80	100	80	100	100	100	100	100	100	80	80	100	100	100	–

Table B3: Similarity matrix of PPE category among all countries (abbreviations of country names are described in Table 1). Similarity values were obtained by dividing the total number of shared subcategories by the total number of subcategories (n=16). "–" indicated a country's comparison to itself.

	AU	HK	IE	SG	UK	CN	PL	ES	SE	AT	DE	IT	NZ	US	BE	CO	HZ	CZ	DK	FI	LV	LT	JP	MX	NL	NO	SK	CH	FR
AU	–																												
HK	100	–																											
IE	100	100	–																										
SG	100	100	100	–																									
UK	100	100	100	100	–																								
CN	94	94	94	94	94	–																							
PL	94	94	94	94	94	88	–																						
ES	94	94	94	94	94	88	100	–																					
SE	94	94	94	94	94	88	100	100	–																				
AT	75	75	75	75	75	81	81	81	81	–																			
DE	75	75	75	75	75	81	81	81	81	100	–																		
IT	75	75	75	75	75	69	81	81	81	88	88	–																	
NZ	75	75	75	75	75	69	81	81	81	88	88	100	–																
US	69	69	69	69	69	63	75	75	75	56	56	56	56	–															
BE	69	69	69	69	69	75	75	75	75	94	94	94	94	50	–														
CO	69	69	69	69	69	63	75	75	75	56	56	56	56	100	50	–													
HZ	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	–												
CZ	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	–											
DK	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	–										
FI	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	–									
LV	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	–								
LT	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	100	–							
JP	69	69	69	69	69	63	75	75	75	56	56	56	56	100	50	100	50	50	50	50	50	50	–						
MX	69	69	69	69	69	63	75	75	75	56	56	56	56	100	50	100	50	50	50	50	50	50	100	–					
NL	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	100	100	50	50	–				
NO	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	100	100	50	50	100	–			
SK	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	100	100	50	50	100	100	–		

CH	69	69	69	69	69	75	75	75	75	94	94	94	94	50	100	50	100	100	100	100	100	100	50	50	100	100	100	–		
FR	6	6	6	6	6	13	13	13	13	31	31	31	31	25	38	25	38	38	38	38	38	38	25	25	38	38	38	38	–	

Table B4: Similarity matrix of CS category among all countries (abbreviations of country names are described in Table 1). Similarity values were obtained by dividing the total number of shared subcategories by the total number of subcategories (n=17). "–" indicated a country's comparison to itself.

	AU	**CN**	**HK**	**SG**	**NZ**	**IE**	**PL**	**ES**	**SE**	**UK**	**US**	**AT**	**CO**	**JP**	**MX**	**DE**	**IT**	**BE**	**HZ**	**CZ**	**DK**	**FI**	**LV**	**LT**	**NL**	**NO**	**SK**	**CH**	**FR**
AU	–																												
CN	100	–																											
HK	100	100	–																										
SG	100	100	100	–																									
NZ	94	94	94	94	–																								
IE	82	82	82	82	88	–																							
PL	82	82	82	82	88	76	–																						
ES	82	82	82	82	88	76	100	–																					
SE	82	82	82	82	88	76	100	100	–																				
UK	82	82	82	82	88	100	76	76	76	–																			
US	76	76	76	76	82	71	94	94	94	71	–																		
AT	76	76	76	76	82	82	71	71	71	82	65	–																	
CO	76	76	76	76	82	71	94	94	94	71	100	65	–																
JP	76	76	76	76	82	71	94	94	94	71	100	65	100	–															
MX	76	76	76	76	82	71	94	94	94	71	100	65	100	100	–														
DE	53	53	53	53	59	71	47	47	47	71	41	76	41	41	41	–													
IT	47	47	47	47	53	65	53	53	53	65	47	71	47	47	47	94	–												
BE	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	–											
HZ	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	–										
CZ	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	–									
DK	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	–								
FI	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	–							
LV	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	–						

LT	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	100	–						
NL	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	100	100	–					
NO	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	100	100	100	–				
SK	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	100	100	100	100	–			
CH	41	41	41	41	47	59	59	59	59	59	53	65	53	53	53	88	94	100	100	100	100	100	100	100	100	100	100	–		
FR	0	0	0	0	6	18	18	18	18	18	24	24	24	24	24	47	53	59	59	59	59	59	59	59	59	59	59	59	–	

Table B5: Similarity matrix of TC category among all countries (abbreviations of country names are described in Table 1). Similarity values were obtained by dividing the total number of shared subcategories by the total number of subcategories (n=48). "–" indicated a country's comparison to itself.

	HK	**ES**	**PL**	**SE**	**US**	**CO**	**JP**	**MX**	**SG**	**CN**	**IE**	**UK**	**AU**	**FR**	**NZ**	**AT**	**DE**	**IT**	**CH**	**BE**	**HZ**	**CZ**	**DK**	**FI**	**LV**	**LT**	**NL**	**NO**	**SK**
HK	–																												
ES	98	–																											
PL	94	96	–																										
SE	94	96	100	–																									
US	92	94	98	98	–																								
CO	92	94	98	98	100	–																							
JP	92	94	98	98	100	100	–																						
MX	92	94	98	98	100	100	100	–																					
SG	92	90	85	85	88	88	88	88	–																				
CN	75	73	69	69	71	71	71	71	79	–																			
IE	75	73	69	69	67	67	67	67	79	75	–																		
UK	75	73	69	69	67	67	67	67	79	75	100	–																	
AU	65	63	58	58	56	56	56	56	69	69	77	77	–																
FR	65	67	67	67	65	65	65	65	65	65	77	77	71	–															
NZ	63	65	69	69	67	67	67	67	67	54	75	75	65	73	–														
AT	58	60	65	65	63	63	63	63	63	58	71	71	65	65	79	–													
DE	58	60	65	65	63	63	63	63	63	63	83	83	69	73	79	88	–												
IT	52	54	58	58	56	56	56	56	56	56	77	77	63	67	81	90	94	–											

CH	52	54	58	58	56	56	56	56	56	56	77	77	63	67	77	90	94	96	–													
BE	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	–												
HZ	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	–											
CZ	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	–										
DK	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	–									
FI	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	–								
LV	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	100	–							
LT	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	100	100	–						
NL	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	100	100	100	–					
NO	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	100	100	100	100	–				
SK	50	52	56	56	54	54	54	54	54	54	75	75	60	65	79	92	92	98	98	100	100	100	100	100	100	100	100	100	–			

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