Maarit Koivupalo

HEALTH AND SAFETY MANAGEMENT IN A GLOBAL STEEL COMPANY AND IN SHARED WORKPLACES

CASE DESCRIPTION AND DEVELOPMENT NEEDS
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Case description and development needs

Academic dissertation to be presented with the assent of the Doctoral Training Committee of Technology and Natural Sciences of the University of Oulu for public defence in the OP auditorium (L10), Linnanmaa, on 10 May 2019, at 12 noon

UNIVERSITY OF OULU, OULU 2019
Koivupalo, Maarit, Health and safety management in a global steel company and in shared workplaces. Case description and development needs
University of Oulu Graduate School; University of Oulu, Faculty of Technology
*Acta Univ. Oul. C* 701, 2019
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**Abstract**

Several companies work in shared workplaces and each company has different requirements for health (H), safety (S), environment (E) and quality (Q). Many globally operating companies have defined their own corporate requirements. Requirements in local national legislation and insurance policies are creating more challenges. The various requirements affect how HSEQ management is implemented in changing, complex, and heterogeneous working environments.

The aim of the thesis was to describe HSEQ management development in Northern Finnish process industry companies (N = 6) and their company network in the shared workplaces context during the past 20 years. The study also describes the current state of HS and partly EQ [HS(EQ)] management practices and tools in a global steel company. An important objective was to make recommendations on how to continuously improve and develop HS(EQ) issues. A mixed methods approach (interview, document study, questionnaire, benchmarking and -learning, SWOT analysis) were used in the case study.

HSEQ Assessment Procedure—a type of integrated management system tool—was developed to evaluate supplying companies’ HSEQ performance in shared workplaces. It was selected as the main method on one site of the global steel company. The global steel company’s HS management system was based on OHSAS 18001 with HS vision and principles, development plan, internal standards and performance indicators. Lost time injury frequency rate (LTIFR) and HSEQ AP performance showed positive trends.

Both corporate HS requirements and local HS(EQ) practices provided adequate tools for a safety culture and HS(EQ) performance development. Recommendations were made regarding HS(EQ) management tools, practices and indicators in shared workplaces operating globally. The focus should be on preventive actions, such as leading performance indicators and creating a uniform safety culture for shared workplaces with a sustainable foundation. The development should be supported by the commitment and participative development of every organisational level. Learning from internal good practices and external benchmarking are valuable methods for this purpose. HSEQ management, change management, internal and external standardisation and information technology systems should be exploited to support this goal.

**Keywords:** health and safety management, health and safety performance, integrated management system, management systems, organisational changes, safety culture, shared workplace
Koivupalo, Maarit, Työterveys- ja työturvallisuusjohtaminen globaalissa terästöissä ja yhteisillä työpaikoilla. Tapaustutkimuksen kuvaus ja kehityskohteet
Oulun yliopiston tutkijakoulu; Oulun yliopisto, Teknillinen tiedekunta
Acta Univ. Oul. C 701, 2019
Oulun yliopisto, PL 8000, 90014 Oulun yliopisto

Tiivistelmä

Yhteisellä työpaikalla työskentelee useita yrityksiä, jotka ovat määrittäneet omat vaatimukseensa työterveydelle (H), työturvallisuudelle (S), ympäristölle (E) ja laadulle (Q). Lisäksi kansainvälisillä yrityksillä, kansallisessa lainsäädännössä ja vakuutusyhtiöillä on omat vaatimukseensa, jotka luovat entistä haasteellisemman työympäristön. Monenlaiset vaatimukset vaikuttavat siihen, kuinka HSEQ-johtaminen on toteutettu muuttuvassa, monimutkaisessa ja epäyhtenäisessä työympäristössä.

Tutkimuksessa kuvattiin HSEQ-johtamisen kehittymistä pohjoissuomalaisissa prosessiteollisuuden yrityksissä (N=6) ja niiden yritysverkostossa, yhteisellä työpaikalla, viimeisen 20 vuoden aikana. Lisäksi kuvattiin HS ja osittain myös EQ [HS(EQ)]-johtamisen menetelmiä ja työkalujen nykytilaa kansainvälisessä terästöollisuuden yrityksessä, sekä kehitystarpeita tavoiteltessa HS(EQ)-johtamisen huippuosaamista. Tutkimus toteutettiin monimenetelmällisenä tapaus-tutkimuksena: haastattelu, dokumenttien tutkimus, kysely, esikuvaa-analyysi, SWOT-analyysi.


Asiakasnot: integroitu johtamisjärjestelmä, johtamisjärjestelmät, organisaatiomuutokset, turvallisuusjohtaminen, turvallisuuskulttuuri, turvallisuusmittarat, yhteinen työpaikka
Acknowledgements

My doctoral studies and the writing of the first article for this thesis originally started in the Department of Industrial Engineering and Management at the University of Oulu. Few years as a researcher encouraged me to explore topics more deeply. During my researcher years, I also learned the importance of thoroughness and theoretical background. The motivation to question, explore and define concepts has kept me going over the years. My work environment changed to the practical industrial field, but the core—a desire to develop safer and healthier workplaces—has been the same the whole time for me. Recent years in the steel industry have taught me what really happens to the research results when applied to the workplace. Above all, I have learned how important it is to research and to exploit the knowledge in practice and have time to implement and adopt the learnings. Time in the constantly changing working life is an irreplaceable value and sometimes too little appreciated. Time is sometimes required to deeply understand and develop the findings. This is valid in many ways, for example, my writing and learning process towards the doctoral degree and at the workplaces towards healthier and safer work environments.

First, I would like to express my great and warmest gratitude to my supervisor, Professor D.Sc. (Tech.) Seppo Väyrynen, for his support and guidance, especially for giving me the time I felt comfortable with to complete the studies. Even a couple of years break from my studies did not matter; I felt welcomed to come back. Whenever I needed support and encouragement, Seppo has given it.

My first ‘real job’ after being a summer trainee during my master’s degree studies was at the University of Oulu. In the beginning, it was difficult to start, but luckily, I had great colleagues who had more experience. I would like to acknowledge Docent D.Sc. (Tech.) Arto Reiman for his valuable advice and cooperation, especially during the final steps of my studies. B.Sc. Jukka Latva-Ranta, it was always nice and fun to work with you. D.Sc. (Tech.) Kari Kisko was the soul of the Work Science corridor and set an example of how to be innovative and open-minded. I could always count on the help from M.Sc. Henri Jounila.

My follow-up group Docent D.Sc. (Tech.) Kari Häkkinen and D.Sc. (Tech.) Mirja Viäänänen gave me much appreciated advice, encouragement and support during the writing process. I would like to acknowledge the pre-examiners, Docent D.Sc. (Tech.) Salla Lind-Kohvakka and D.Sc. (Tech.) Noora Nenonen for their careful review. Their valuable comments and suggestions guided me in finalising the thesis.
After my research years, I had the opportunity to learn what safety professionalism in the industrial context really is. Phil Rodrigo, gave me the possibility to start my doctoral studies again. Thank you for the support and for believing in me. I would not have been able to complete this thesis without you. The cooperation with Alastair McCubbin had a quick and interesting start. I’m sure our cooperation will continue straightforwardly. I appreciate the understanding and supporting the final stages of my studies. Dr Juha Ylimaunu gave careful comments regarding the thesis, and the comments were very valuable to me. I’m grateful for M.Sc. Marko Sulasalmi and M.Sc. Heidi Junno for their cooperation with the articles. Other colleagues in Outokumpu—Ari-Pekka Taipale, Pekka Ylijoutsijärvi, Susanna Saari and Arto Vilppola— I have learned so much from all of you about how to work hard and be a committed safety professional.

Financial support for this thesis was gratefully received from The Finnish Work Environment Fund. I would also like to say thank you for all the resources, such as the empirical material provided by Outokumpu and the University of Oulu.

My family has supported me on the path towards my doctoral studies. I want to express my gratitude to my mother Hilkka and sister Jaana, who know who I really am and how to support me. My father Pekka gave me a lot of support, valuable advice, guidance and was never tired of reading and commenting on my long texts during the writing process. You have taught me to be highly accurate. Without the patient support of my husband Keijo this would never have been possible. I know that this has not always been an easy path to travel, but you have always believed that I can reach ambitious goals. I really appreciate your understanding and encouragement. I have had the best assistant—Juuso—who has patiently listened to safety-related discussions and computer keyboard clacking since he was born. Tuisku ja Pyry, were the specialists in organising my papers and thoughts, helping with the typing and pushing me gently when I needed a warm clap on the shoulder.

March 18, 2019 Maarit Koivupalo
Abbreviations

CSR      Corporate Social Responsibility
E        Environment
EQ       Environment and quality
EU       European Union
EU-OSHA  European Agency for Safety and Health at Work
FOSC     Finnish Occupational Safety Card
GRI      Global Reporting Initiative
H        Health
HS       Health and safety
HSE      Health, safety, environment
HSEQ     Health, safety, environment, quality
HSEQ AP  Health, Safety, Environment and Quality Assessment Procedure
IOGP     International Association of Oil & Gas Producers
ILO      International Labour Organization
IMS      Integrated management systems
ISO      International Organization for Standardization
IT       Information technology
LTI      Lost time injury
LTIFR    Lost time injury frequency rate
OHS      Occupational health and safety
OHSAS    Occupational Health and Safety Assessment Series
OH&S     See OHS
OSH      See OHS
PDCA     Plan-do-check-act
Q        Quality
RA       Risk assessment
RQ       Research question
S        Safety
SBO      Safety Behavioural Observation
SFS      Finnish Standards Association
TRIFR    Total recordable injury frequency rate
WSA      World Steel Association
Key definitions

The following definitions are provided to clarify the meaning of the main terms used in this thesis.

**HS(EQ) management**: Occupational health and safety and partly environment and quality management, with a stronger focus on occupational health and safety.

**HSEQ Assessment Procedure (HSEQ AP)**: Assessment procedure used for evaluating supplying companies’ HSEQ performance in shared workplaces (hseq.fi, 2018).

**Health and safety management system** (or occupational health and safety management system): A management system or part of a management system used to achieve the OH&S policy (ISO, 2018).

**Health and safety performance** (or occupational health and safety performance): This is related to the effectiveness of the prevention of injury and ill health to workers and the provision of safe and healthy workplaces (ISO, 2018).

**Incident**: An occurrence arising out of, or in the course of, work that could or does result in injury and ill health (ISO, 2018).

**Near-miss**: An incident where no injury and ill health occurs but has the potential to do so (ISO, 2018).

**Occupational accident**: An unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work that results in one or more workers incurring a personal injury, disease or death (ILO, 1998).

**Occupational disease**: A case recognised by the national authorities responsible for recognition of occupational diseases. The data shall be collected for incident occupational diseases and deaths due to occupational disease (Commission Regulation 349/2011).

**Occupational injury**: Any personal injury, disease or death resulting from an occupational accident (ILO, 1998).

**Occupational safety and health**: See health and safety.

**Outsource**: An arrangement where an external organisation performs part of an organisation’s functions or processes (ISO, 2018).

**Principal company**: Single employer in a shared workplace who acts as the main authority (Act on Occupational Safety and Health Enforcement and Cooperation on Occupational Safety and Health at Workplaces, 44/2006).

**Process industry**: Describes industries that produce goods from raw materials using different physical and chemical process steps (Kotimaisten kielten keskus, 2018), e.g. steel, forest and chemical industries.
**Safety culture:** The safety culture of an organisation is the product of individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to and the style and proficiency of organisations’ health and safety programmes (EU-OSHA: Eeckelaert, Starren, van Scheppingen, Fox, & Brück, 2011, 13).

**Shared workplace:** A worksite where a single employer acts as the main authority and where more than one employer or self-employed worker operate simultaneously or successively in such a way that the work may affect other employees’ safety and health (Occupational Safety and Health Act 738/2002; Finnish Institute of Occupational Health, 2006).

**Supplier:** Also known as an external provider, defined as an organisation that provides products and services to customers (ISO, 2015). The supplying company operates at the principal company’s premises in a shared workplace (Väyrynen, Koivupalo, & Latva-Ranta, 2012).
Original publications

This thesis is based on the following publications, which are referred to throughout the text by their Roman numerals:


The author of this thesis was the primary author of all four original publications. In Article I, the author was the second writer due to the long history of the projects, in which the first author had participated throughout the process. The role of the author in the writing process of Article I was the same as in the other articles. The author formulated the research problems and questions, compiled the theoretical framework, summarised the results, analysed the empirical material and concluded the findings in each article. In Articles II and III, the material collection was done by the author. In Article I, the material collection was done by one co-author and numerous other researchers and in Article IV, it was done by one co-author. The role of the co-authors included reviewing and commenting on the article manuscripts. Articles I–III were journal articles, and Article IV was published as a peer-reviewed book article.
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1 Introduction

1.1 Background and research environment

While reading the news, I have often noticed that when a severe occupational accident occurs in a workplace, what is reported is the company’s premises where someone has been injured or even died. Nowadays, it is usual for a workplace to consist of workers from numerous companies, but when the worst happens, the principal company is in the news. If the financial benefits of accident prevention, and health and safety promotion are not strong enough reasons to implement health and safety measures, the loss of reputation and a decreasing number of customers will wake up even the most complacent organisation. However, many organisations have chosen to implement preventive measures and act before anything happens. Responsible organisations are concerned with the working environment, the well-being of their employees, the impact of operations on the local community, and the long-term effects of their products and activities (Väyrynen, 2017). These organisations have acknowledged the importance of proactive occupational health and safety management in shared workplaces, where a single employer acts as the main authority and where more than one employer or self-employed worker operate simultaneously (Occupational Safety and Health Act 738/2002; Finnish Institute of Occupational Health, 2006).

Traditionally, working environments in process industries, such as the steel, forest and chemical industries, have contained several risks for personnel, e.g. due to the use of mechanical equipment and energy intensive processes. Iron and steel production involves many hazards, such as noise, vibrations, high temperatures, radiation, chemicals, working at heights or in confined spaces, moving machinery, and heavy lifting (International Labour Organization [ILO], 2005). Due to the presence of hazards, the risks for severe injuries are generally higher in basic metal production compared to other manufacturing sectors (ILO, 2018a). Occupational accidents, occupational diseases and serious near-misses have occurred when accident prevention barriers have broken down. In contrast to the hot metal production environment, cold is a very common physical risk in circumpolar regions (Risikko, 2009), and it creates challenges for occupational health and safety (HS) management in companies that have operations in northern latitudes.

Although accident prevention strategies and actions have reduced the number of occupational accidents, metal production had the highest number of occupational
accidents in the manufacturing industry in 2017 in Finland (Finnish Workers’ Compensation Center, 2018b). Although, the frequency of occupational accidents has decreased in metal production over the past 13 years, it is still the highest among the manufacturing industries in Finland (Finnish Workers’ Compensation Center, 2018a). About one third of these accidents led to more than three days’ absence from work (Finnish Workers’ Compensation Center, 2018b). Fortunately, according to the Finnish Workers’ Compensation Center (2018b) the number of severe accidents has decreased, and the proportion of less severe accidents is higher than before in the Finnish manufacturing. Even though active accident prevention work has paid off and the severity is lower, there is still a significant amount of work to do to prevent all accidents. By economic activity, manufacturing, with, for example, the basic metal manufacturing industry as a part of it, had the highest number of non-fatal accidents at work, and the number of fatal accidents was the third highest in 2014 in the European Union (Eurostat, 2018). Preventive actions are obviously required to catch the less hazardous branches.

Twenty years ago, six process industry companies (N = 6) from Northern Finnish steel, forest and chemical industries decided that actions were required to ensure the health and safety of their personnel. Everyone must be able to return home without accidents or health problems after the working day and when they retire at the end of their career. This decision has led to the development projects and eventually to the development of the Health, Safety Environment and Quality Assessment Procedure (HSEQ AP), which is an assessment procedure used for evaluating supplying companies’ health, safety, environment and quality (HSEQ) performance in shared workplaces (hseq.fi, 2018). From the worker’s perspective, a healthy and safe workplace is certainly a desirable incentive. Other benefits arise from well-managed HS issues, and many of these were acknowledged 20 years ago when the active development started. In addition, for example a recent study from van den Heuvel et al. (2017) pointed out that well-managed HS contributes to labour productivity, promotes economic growth and reduces costs resulting from occupational accidents and work-related health problems, and enhances worker motivation. It also relieves pressure on public and private social protection, insurance and pension systems (van den Heuvel et al., 2017).

In the process industry context, there are often several companies working on one production site (shared workplace), and each company might have different requirements for HSEQ. The principal company in a shared workplace does not carry out all the activities by itself, and the individuals and companies within the network have their own roles and effects. One person might visit a production site
once to perform a short task and never come back again, while some companies and individuals may have been working on the site for years as external suppliers. A network cannot be managed like a single organisation since the partners are independent and have their own internal objectives and processes. In Finland, 38% of fatal accidents occurred in shared workplaces between 1.1.2005–1.1.2010 (Kekkonen & Rajala, 2017), and 80% of the victims were from supplying companies, according to Rantanen, Lappalainen, Mäkelä, Piispanen, and Sauni (2007). The research environment gets even more complicated if companies have global operations. Corporation sets their own requirements to manage HS (health and safety) and EQ (environment and quality), which might differ from the national requirements. In this study, a global company has production sites in different continents, and it has defined its own requirements for occupational HS. In addition, different requirements in national legislation and insurance company policies are creating even more fragmented environments.

Table 1 presents examples of current research topics in the field that are discussed in this thesis. These themes will be presented in detail in the theoretical part (Chapter 2). All the topics in the Table 1 have been studied widely. Even though the international HS standards OHSAS 18001 *Occupational health and safety management systems* (Finnish Standards Association [SFS], 2007), and the recently published ISO 45001 *Occupational health and safety management systems* (International Organization for Standardization [ISO], 2018), require strict change management, the management of change in the safety management context has not been studied extensively (Gerbee, 2017). This thesis aims to address this gap because changes in organisations and shared workplaces are common in the process industry. In addition, the different requirements from several internal and external parties increase the challenges in HS and EQ management, processes and performance.
Table 1. Examples of recent research by topic in the field of this thesis.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS management and safety culture in the steel industry</td>
<td>Brown, Willis, &amp; Prussia, 2000</td>
</tr>
<tr>
<td></td>
<td>Nordlöf, Wittavaara, Winblad, Wijck, &amp; Westerling, 2015</td>
</tr>
<tr>
<td></td>
<td>Simola, 2005</td>
</tr>
<tr>
<td></td>
<td>van Ginneken &amp; Hale, 2009</td>
</tr>
<tr>
<td>HS management in general</td>
<td>Fernández-Muñiz, Montes-Peón, &amp; Vázquez-Ordás, 2009</td>
</tr>
<tr>
<td></td>
<td>Forteza, Carretero-Gómez, &amp; Sesé, 2017</td>
</tr>
<tr>
<td>Sustainability and corporate social responsibility (CSR)</td>
<td>Montero, Araque, &amp; Rey, 2009</td>
</tr>
<tr>
<td></td>
<td>Zink, 2014</td>
</tr>
<tr>
<td>Integrated management systems (IMS)</td>
<td>Bernardo, Casadesus, Karapetrovic, &amp; Heras, 2009, 2012</td>
</tr>
<tr>
<td></td>
<td>Hamidi, Omidvari, &amp; Meftahi, 2012</td>
</tr>
<tr>
<td></td>
<td>Wilkinson &amp; Dale, 2007</td>
</tr>
<tr>
<td>Safety culture and behaviour</td>
<td>Morrow, Koves, &amp; Barnes, 2014</td>
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<td></td>
<td>Wachter &amp; Yorio, 2013</td>
</tr>
<tr>
<td></td>
<td>Zwetsloot et al., 2013</td>
</tr>
<tr>
<td>HS indicators</td>
<td>Hallowell, Hinze, Baud, &amp; Wehle, 2013</td>
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<tr>
<td></td>
<td>Hinze, Thuman, &amp; Wehle, 2013</td>
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<td></td>
<td>Kurppa, 2015</td>
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<td></td>
<td>Sinelnikov, Inouye, &amp; Kerper, 2015</td>
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<tr>
<td></td>
<td>van den Heuvel et al., 2017</td>
</tr>
<tr>
<td>HS management in shared workplaces</td>
<td>Milch &amp; Laumann, 2016</td>
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<tr>
<td></td>
<td>Nenonen, 2012</td>
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<td></td>
<td>Nygren, 2018</td>
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</tbody>
</table>

As mentioned, various requirements affect how the HS and EQ management is implemented. Special attention is needed to create a healthy, safe, sustainable and productive work environment. This is particularly the case when the working environment is actively and continuously changing (e.g. facing changes in personnel, the organisation, work tasks and processes), complex (including own personnel, contractors, subcontractors in the workplace), and heterogeneous (all the workplaces are unique with individuals from different organisations and nations). According to Zwetsloot et al. (2013), safety management in complex and dynamic situations is a challenge, and the planning is complemented by resilience and managing the unexpected. Resilience is the adaptive capacity of an organisation in a complex and changing environment (ISO, 2009). This study focuses on a situation where organisational changes occur frequently, and change is the constant situation. Effective HSEQ management practices, HS performance (ISO, 2018) and a safety culture (Eeckelaert, Starren, van Scheppingen, Fox, & Brück, 2011) all play important roles when striving towards excellence in HS and EQ management. The
The overall purpose of this research is to identify the actions required to achieve excellence in this field.

1.2 Scope and research problem

1.2.1 Scope of the study

The expression safety management is often used in the literature and especially in the daily spoken language of workplaces. The expression occupational health and safety management is used e.g. in ISO 45001 (2018) and is seen as a parallel topic in this study. Followed by ISO 45001 (ISO, 2018), OHS and OH&S have the same definition in this study. However, the abbreviation ‘HS’ is used without the ‘O’ as it is mentioned in the empirical part of this research in practice. In addition, the organisational structure in the global steel company discussed follows the definition excluding the ‘O’, as does the HSEQ AP too.

In this thesis, occupational health is only covered from the accident prevention perspective as ISO 45001 (ISO, 2018) and OHSAS 18001 (SFS, 2007) define it. Therefore, occupational disease statistics, for example, are in the scope of this study, but occupational health care as a wider theme is not. Likewise, risk management is covered from the HS risk perspective (accident prevention and HS management) but wider risk management issues, e.g. security risks, are excluded. The main scope of the study is in occupational HS management due to the role of the researcher (as a HS professional) and the organisation structure in the global steel company. Also, environmental (E) and quality (Q) management issues are included as closely related topics, and HSEQ issues were within the scope of Articles I and IV. Thus, the term used to describe the entity in this research is HS(EQ).

A company, a network or a self-employed party operating at the principal company’s premises in the shared workplace can be called a contractor (Nygren, 2018), or when proceeding one level further in the chain, a subcontractor (Oedevald & Gotcheva, 2015). A contractor is an external organisation that provides services to the organisation in accordance with agreed specifications, terms and conditions (ISO, 2018). Another definition for contractor is a person or an organisation providing services to an employer at the employer’s worksite in accordance with agreed specifications, terms and conditions (ILO, 2009). Other equivalent expressions for contractor found in the literature include supplying company (Väyrynen, 2017), service provider (Nenonen, 2012), supplier (Chen, Yeh, & Yang,
In this thesis, the terms *supplying company and supplier* (as an individual) and *principal company and (own) employee/personnel* are used when applicable. The selection reflects the terminology used in the global steel company and generally in Finland. The selection also reflects the view of ILO (2009), which considers both individuals and organisations.

The participants of this study are presented in Fig. 1 on the next page. The organisations involved are:

- Shared workplaces (N = 6), including:
  - Northern Finnish process industry companies (N = 6, N_{employees} = approximately 10,000), principal companies
  - Supplying companies (N = some hundreds, N_{employees} = some thousands) working at shared workplaces in the premises of principal companies
- Global steel company (N_{employees} = between 11,700 and 15,000 at the time of this research) and its sites (N = 8), will be referred to later as the *case company*.

The Northern Finnish companies are located mainly in the Oulu and Kemi-Tornio regions of Finland. The companies operate in the steel, forest and chemical industries, and are referred to as the *process industry* in this thesis. ILO (2018b) defines manufacturing as the whole manufacturing segment of the industrial sector, including processing (as in the chemical and metallurgical industries). In Finland, the process industry is a commonly used term to describe industry that produces goods from raw materials using different physical and chemical process steps (Kotimaisten kielten keskus, 2018). ILO (2018b) defines the iron and steel industry under the basic metalworking industry.
Process industry companies from Northern Finland had a large company network (supplying companies) on the sites. The sites in the case company studied in this research located in Europe, North and Central America, and Asia. Each site of the company had its own network of operators, including its own personnel, external supplying companies and self-employed individuals. Moreover, visitors visited the sites often.

The results presented in this thesis are the main findings in the scope of this thesis from the results in Articles I–IV. Therefore, some of the significant findings, which are not in the scope of this thesis, are only discussed in the articles.

### 1.2.2 Research problem and aim

The first aim of this thesis is to describe the main development steps of HSEQ management practices in Northern Finnish process industry companies and their company networks during the past 20 years. Also, HSEQ AP in the context of shared workplace was studied. This study is positioned in the field of process and steel industries. This history review part of the study helps to understand the development steps in the Northern Finnish process industry; thus, there might be other development steps in different contexts. Secondly, the study describes the current state of HS and partly EQ management in a global steel company. This
is described in the case company, which is one of the six process industry companies that participated in the history review part of this thesis.

The practical research problem concerned the lack of information on the overall stage of the HS(EQ) management in the process industry, and in the case company in particular. In addition, it was important to evaluate the HS(EQ) performance, in order to see the effects of the development actions taken. From the theoretical perspective, the problem was the lack of knowledge in the field of HS(EQ) management in the process industry and in the context of changing organisations and shared workplaces (cf. Table 1).

The third aim was to identify the development needs and make recommendations for HS(EQ) management practices in the process and steel industries. This was the most important aim and the main reason for the research. The overall goals were to further develop the HSEQ management and to work towards healthier, safer, and more sustainable and productive workplaces.

Five research questions (RQ) were formulated to gather the information required for this study:

RQ1. Over the past 20 years, what have been the main HSEQ management development steps in the Northern Finnish heavy process industries, such as the steel industry and its service delivery network, and how has their accident frequency changed?

RQ2. What kind of HS management practices and tools are used in a global steel company?

RQ3. Which HS performance indicators are used in a global steel company and how well does HS perform?

RQ4. How are supplying companies’ HSEQ issues managed with the HSEQ AP at a shared workplace in Finland and how has the HSEQ AP performance and accident frequency changed?

RQ5. What actions should be taken to improve the current situation and to achieve excellence in HS(EQ) management and performance?
The study design is described in Fig. 2. Articles I and IV answered RQ1 and RQ4. Article II answered RQ2 and Article III answered RQ3. RQ5 was combined from all four articles and the literature.

**Fig. 2. An overview of the study design.**

The study begins with a description of a broader picture (RQ1), and at the end, focuses on the details (RQ4). Thus, the study starts with a description of an example of HSEQ management development steps in the process industry, and then the focus turns to HSEQ management on one site in the case company (in the steel industry). The decision to focus on one company was made based on the researcher’s role and in-depth knowledge in the company. A comprehensive case study was conducted, and the HS(EQ) management was studied from three aspects: HS management practices and tools, HS performance indicators, and HSEQ management focusing on HSEQ AP. SWOT analysis (RQ5) was made to
demonstrate the big picture of the current state and to define the next steps within the field of HS(EQ) management. The company described in this case study is a global steel company (case company) and its industrial network.

1.3 Research approach

According to Lancaster (2005), the field of management is one of the latest areas of research. A characteristic of management research is that it raises both theoretical and practical problems. Attempts are made to apply some of the processes and methodologies in settings or situations, which are difficult or even impossible to control (Lancaster, 2005). To understand the process and nature in contemporary management research, it is essential to understand the theoretical antecedents at an adequate level.

Research philosophy describes how the research is positioned from epistemological and ontological points of view. Ontology concerns ideas about the existence of and relationship between people, society and the world, whereas epistemology defines how knowledge can be produced and argued (Eriksson & Kovalainen, 2008). Epistemology defines the criteria that are or should be regarded as acceptable knowledge in a discipline, according to Bryman and Bell (2015). Epistemology defines and gives structure to the kinds of scientific knowledge that are available, the limits for that knowledge and offers an answer to the question of what constitutes scientific practice and process (Eriksson & Kovalainen, 2008).

Epistemology can roughly be divided into positivism and interpretivism. Positivism is a natural science approach to research, and according to it, only phenomena and knowledge that are confirmed by the senses can be warranted as knowledge (Bryman & Bell, 2015). Positivists believe that phenomena are real and precise and, therefore, will adopt a research design that allows them to measure what they are investigating (Farquhar, 2012). Interpretivism aims to explain and understand human behaviour (Bryman & Bell, 2015). Farquhar (2012) stated that the researcher is not a detached observer, as suggested by positivism, but an active agent in the construction of the world through the specific ideas and themes incorporated in the relevant form of knowledge. This research is closer to interpretivism than positivism. The research reviews a field of HS(EQ) management, which is not standardised, and aims to increase the knowledge of how it is managed in the process industry. This research also aims to increase our understanding of how HS(EQ) is managed (and affected by human behaviour) in the context of changing work environments in shared workplaces.
Ontology can be roughly divided into objectivism and subjectivism. Objectivism is an ontological aspect, which suggests that research is based on facts, not subjective analysis (Bryman & Bell, 2015). Objectivists explain phenomena as independent of social actors, and a company or an organisation is seen as a machine-like entity that functions based on standards, guidelines, rules and legislation. People are operators and realise processes and values (Bryman & Bell, 2015). According to Eriksson and Kovalainen (2008), a subjective perception of reality is based upon perceptions and experiences that may be different for each person and change over time and context. The field of research in this study is seen as a sociotechnical system with interactions between people and technology in the workplace. Sociotechnical systems are becoming more complex (Carayon, 2006). The field of study includes technical artefacts as well as humans and the laws, rules and norms that cover their actions. This study is closer to subjectivism. The researcher’s perceptions and the knowledge of experienced HS professionals were used as empirical source material in this research. The researcher acted as an interviewer and participated profoundly in the empirical work.

According to Lancaster (2005), deductive research develops theories or hypotheses and then tests them out through empirical observation, and in inductive research, the researcher develops hypotheses and theories with a view to explain empirical observations in the real world. Most social research involves both inductive and deductive reasoning processes at some point in the same project (Eriksson & Kovalainen, 2008). This dissertation is closer to inductive in nature as the research started to develop from an idea about what the current state could be and describing it. Still, some deductive characteristics were involved.

Together, ontology, epistemology and methodology can be related to each other as a framework (Eriksson & Kovalainen, 2008). According to Johannesson and Perjons (2014), each research objective may need a different methodology, and despite the qualitative nature of case study used in this research, the data analysed can be quantitative or qualitative (Dul & Hak, 2008). According to Eriksson and Kovalainen (2008), many qualitative approaches are based on the ontological assumption in which reality is understood as subjective. Multi-strategy research combines qualitative and quantitative approaches to enhance confidence in the findings (Bryman, 2001). This research is mainly qualitative, but a quantitative approach was used in some parts. Multiple methodologies were chosen to improve accuracy and to broaden the picture in this study. Several sources were used in this research to provide descriptive results from different HS(EQ) management aspects. Quantitative data was used to support the overall description of HS(EQ)
management, and the quantitative part of the research is related to HS performance indicators and HSEQ AP results. The study aims to create an in-depth understanding of HS(EQ) management in the process industry, and more specifically, in the steel industry, and mainly qualitative methods were chosen to support that goal.

The case study was selected for the main research strategy (methodology) in this research. The main research strategy was selected based on the findings of previous research. Eriksson and Kovalainen (2008) claimed that case study research should be understood more as a research approach or research strategy than a method. The case study method makes it possible to utilise different techniques for data collection and has a strong empirical emphasis (e.g. Yin, 2003). Case study research aims to make room for diversity and complexity and avoids overly simplistic research designs (Eriksson & Kovalainen, 2008). Yin (2003) recommends using case study research when the researcher has little control over the events and when the focus is on a contemporary phenomenon within a real-life context. Dul and Hak (2008) defined case study with case(s) selected from a real-life context, and scores obtained from the case(s) were analysed in a qualitative manner. Case studies are usually considered more accurate, convincing, diverse and rich if they are based on several sources of empirical data (Eriksson & Kovalainen, 2008).

The case study is about a case company and its industrial network (supplying companies). From the case company, special attention was paid to one Northern Finnish site. This company was also involved in a wider group of process industry companies, which were part of the study as well, as described in Article I. The setting is presented in Fig. 3. This case study places special focus on the company’s HS(EQ) management practices and processes, as well as HS(EQ) performance in the context of the process and steel industries. All of the companies and the sites described are shared workplaces.
This research uses primary and secondary data. Primary data does not actually exist unless it is generated during the research process (Lancaster, 2005); thus, the empirical data is collected by the researchers themselves (Eriksson & Kovalainen, 2008). The primary data in this study are the descriptions of HS management practices, tools and indicators through interviews in the case company (Articles II and III). Furthermore, the descriptions, experiences and results of the HSEQ AP (Articles I and IV) and lost time injury frequency rate (LTIFR) data collection (Articles III and IV) use the primary data. Secondary data is information that already exists in some form or other, but which was not primarily collected (Lancaster, 2005), and this was used for LTIFR benchmarking and benchlearning. In addition, the path of projects (Article I) used secondary data by combining the results of previous projects.
2 Theoretical and practical framework

The theoretical and practical framework of this study with key concepts and their relations are presented in Fig. 4.

Fig. 4. Key concepts of this study.

This study focuses on HS(EQ) management practices and processes, and HS(EQ) performance in the process and steel industries, which have global operations. The organisations involved are complex and heterogeneous shared workplaces encountering continuous changes. The safety culture strongly defines how an organisation performs from the HS management’s perspective. HSEQ management
with integrated management system (IMS) -based tools in shared workplaces (HSEQ AP) is also within the scope of this study.

2.1 HS(EQ) management

2.1.1 HS management and corporate social responsibility

The objective of a safety management system is to manage the planning and implementation of a company’s safety policy (Oedewald & Reiman, 2006). An employer is accountable for and has the duty to organise occupational health and safety, and one approach to fulfil this is to implement an occupational safety and health (OSH) management system (ILO, 2009). ISO 45001 (ISO, 2018) defines an OH&S management system as a separate management system or part of a management system used to achieve the OH&S policy, which is consequently defined as intentions and direction of an organisation as formally expressed by its top management. The Appendix 1 presents the main elements of three common HS management systems.

HS management has extensive advantages. A good safety management system has a wide-ranging positive effect on company performance, including safety, competitiveness and economic-financial performance (Fernández-Muñiz et al., 2009). A long-term strategic commitment to OSH has a positive effect on a company’s economic performance, according to Reiman, Räisänen, Väyrynen, and Autio (2018). Employees in safe work environments are more motivated to work towards organisational goals, e.g. quality improvements (Das, Pagell, Behm, & Veltri, 2008). Good economic performance is also related to low accident rates and successful risk management, according to Forteza et al. (2017). Investment in HS systems can lead to a decreasing rate and severity of undesirable events and to improved productivity and quality (Shirali, Salehi, Savari, & Ahmadiangali, 2018).

HS is one of the high-profile topics in many industry sectors. Montero et al. (2009) claimed that socially responsible companies are aiming to exceed the demands set by law and to be successful in OHS and the environmental field. Furthermore, setting ambitious targets provides a reliable picture of a company that follows through with socially, environmentally and economically sustainable principles (Montero et al., 2009). One of the goals of the World Steel Association (WSA, 2018b) is to provide global leadership on all major strategic issues impacting the industry, with the focus on economic, environmental and social
sustainability. One goal defined by WSA (2018a) is to be an accident-free workplace. Also, the International Stainless Steel Forum (2018) has emphasised that the HS of the people is the first priority.

Sustainability and CSR cover several similar aspects and principles, such as HS, E and Q management and sustainable manufacturing (ISO, 2010). The ISO 26000 social responsibility standard provides guidance on how businesses and organisations can operate in a socially responsible way, including how to act in an ethical and transparent way, thereby contributing to the health and welfare of society (ISO, 2010). The Global Reporting Initiative (GRI, 2013) is a framework for reporting CSR issues and has included HS performance indicators in its social category. Zink (2014) concluded that there is a need for a different understanding of the overall performance of a company, which will generate new possibilities for human factors, including the three dimensions of sustainability: economic, ecological and social.

2.1.2 Standardisation and changing organisations

The trend to globalise business has increased, and almost all companies have some connection to international operations (Schneider & Hollister, 2008). Global companies have tried to tackle the challenge of managing HS, such as through internal HS standards, HS management systems and corporate responsibility activities (Morschett, Schramm-Klein, & Zentes, 2009). One option to manage HS(EQ) risks in a global working environment is standardisation. The ISO 45001 standard (ISO, 2018) was published to replace OHSAS 18001 (SFS, 2007). It enables organisations to provide safe and healthy workplaces by preventing work-related injuries and ill health (occupational diseases), and proactively improve its HS performance. One important aspect is that HS management should be integrated into the daily work, and it should not be a separate process. Comprehensive HS management that is combined with an organisation’s overall management and business, and which addresses regulatory, technical or engineering, organisational, and managerial aspects is critical to ensure HS excellence (European Agency for Safety and Health at Work [EU-OSHA], 2010).

Separate management systems that cover Q, E and HS issues have become too complex to manage effectively. For this reason, IMS became an interest to business and research (e.g. Bernardo et al., 2009; Salomone, 2008; Wilkinson & Dale, 2007; Zeng, Shi, & Lou, 2007). Hamidi et al. (2012) listed justifications to integrate separate management systems. The main reason was that there are many
similarities, and integration reduces duplication and costs. They concluded that IMS focuses on teamwork, and it can help to ensure that a company’s leadership is committed to getting on the continuous improvement journey towards sustainable development. According to Zutshi and Sohal (2005), the benefits are savings, better utilisation of resources and improved communication across the organisation.

However, problems have been observed in the integration process. Sui, Ding, and Wang (2018) found that it was difficult to integrate management departments on a large scale because of operational and organisational complexities. The integration process was complex, and the implementation required a high amount of human and financial resources (Nunhes, Motta Barbosa, & de Oliveira, 2017). Bernardo et al. (2012) summarised the findings from the literature in their research as follows: a lack of experience and resources in the organisation, a lack of support from certification bodies, differing perceptions of who the main stakeholders are, the risk of creating ranking systems, attitudes, the high cost of audits, the loss of power, the fear of job loss, inter-functional conflicts, the organisational culture, increased bureaucracy and difficulties in the implementation. According to Jørgensen, Remmen, and Mellado (2006), there is no specific way to integrate management systems, and the integration must be in line with the organisation’s operations. The latest ISO certificates—ISO 9001 for quality management, ISO 14001 for environmental management and ISO 45001 for HS management—follow the same generic management system approaches (ISO, 2018) to enable organisations to integrate them more easily into their business processes and form IMS.

Organisations frequently face diverse and intense changes. There can be hundreds of changes in an organisation on a site within a year, and thus, the plant or installation changes to something completely different from the initial design (Leovnik & Gerbec, 2018). Paton and McCalman (2000) stated that change is one of the constants of history. Redesigning processes, restructuring, mergers, acquisitions and total quality programmes can change organisations (Raineri, 2011). The changes often indicate major transitions for employees, such as new roles and tasks, new leaders and co-workers, losing colleagues, changed social status or job insecurity (Mathisen, Bronnick, Arntzen, & Vestly Bergh, 2017). Successful individuals, nations and enterprises have the ability to effectively manage and exploit change situations (Paton & McCalman, 2000).

The impact of change, including organisational change, was highlighted in the context of accident prevention, according to Le Coze (2011). In the process industry, changes are a daily reality, and potential implications for major accident hazards
must be properly managed (Gerbec, 2017). HS management systems such as OHSAS 18001 (SFS, 2007) and ISO 45001 (ISO, 2018) require processes and operations that have strict change controls. The more closely HS management becomes linked to an organisation’s core activities, the better HS performance will be during organisational change (EU-OSHA, 2010). The reason is that the HS issues are not usually the major concern of management during changes; rather, the focus is on economic problems, mergers, downsizing or rapid technological innovation (EU-OSHA, 2010). According to a report by EU-OSHA (2010), integrated management of changes, including technical and organisational aspects, in the process industry has only started and there is a lot of work to do.

2.2 HS performance indicators

The indicators to measure safety performance can be called, for example, safety indicators (Harms-Ringdahl, 2009; Reiman & Pietikäinen, 2012; Øien, Utne, & Herrera, 2011), key performance indicators (Gerbec, 2017) and safety performance indicators (Hale, 2009). HS management system performance measurements have been used to describe more widely how a management system performs, dividing it into interventions, organisational performance and worker performance (Haas & Yorio, 2016). Kongsvik, Almklov, and Fenstad (2010) divided organisational safety indicators into safety climate and to risk analyses tradition. All safety related indicators do not measure the same. Process safety indicator is a widely used term to measure process safety (Swuste, Theunissen, Schmitz, Reniers, & Blokland, 2016). A distinction between process and occupational or personal safety should be made because personal safety indicators do not reflect how well process safety is managed (Bellamy, 2009; Erikson, 2009; Hopkins, 2009). However, Bellamy (2015) concluded that there is a link between occupational and process safety and between fatal and non-fatal occupational accidents. That link is the hazard.

There is little consensus among researchers and practitioners regarding the terms used to categorise the types of performance indicators to assess the effectiveness of HS management system elements and practices (Haas & Yorio, 2016). In this study, HS performance indicator is used to describe an indicator that is used to measure HS performance in the occupational HS context. HS performance is defined in ISO 45001 as “performance related to the effectiveness of the prevention of injury and ill health to workers and the provision of safe and healthy workplaces” (ISO, 2018, p. 14). Based on the ISO 45001 (ISO, 2018) definition, performance is a measurable result. The role of the indicator is “to
provide information on safety, motivate people to work on safety and contribute to change towards increased safety” (Reiman & Pietikäinen, 2012, p. 1999). HS performance can relate either to quantitative or qualitative findings, and the results can be determined and evaluated by qualitative or quantitative methods (ISO, 2018). Furthermore, Zink (2014) concluded that HS performance can be linked to broader strategic management processes.

HS performance indicators are often divided into leading and lagging indicators. However, there is a lack of agreement on basic definitional issues concerning leading and lagging indicators (e.g. Harms-Ringdahl, 2009; Sinelnikov et al., 2015). The use of leading and lagging indicators is problematic because they are inter-related in complex ways (Lingard, Hallowell, Salas, & Pirzadeh, 2017), and the lagging indicators might also have the characteristics of a leading indicator in predicting another outcome or event (Dyreborg, 2009). However, Øien et al. (2011) argued that there is no need for a discussion about what is leading and what is lagging, but there is a need to develop and implement useful indicators that can provide early warnings about potential major accidents. Hopkins (2009) reached a similar conclusion, i.e. the consequence is not large if the indicator is described as leading or lagging. Yet, Dyreborg (2009) disagreed because there are causal relationships between leading and lagging indicators, and it is important to develop causal relationships between them, and for experiential feedback and organisational learning, the distinction is important. Although the debate is on-going regarding leading and lagging HS performance indicators among researchers, the terms are roughly used to categorise HS performance indicators in this thesis.

2.2.1 Leading indicators

A growing number of safety professionals have questioned the value of lagging indicators, e.g. accident statistics, arguing that they do not provide enough information or insight to effectively avoid future accidents (e.g. Grabowski, Ayyalasomayajula, Merrick, & McCafferty, 2007; Hinze et al., 2013; Mengolinim & Debarberis, 2008). Leading indicators are also referred to as pro-active, positive, predictive, upstream, heading, indirect, activity, drive or monitor indicators (Hinze et al., 2013; Janackovic, Stojiljkovic, & Grozdanovic, in press; Podgórska, 2015; Reiman & Pietikäinen, 2012). Leading indicators address the need to predict and act before an unwanted event (Hale, 2009; Hinze et al., 2013), and they are invaluable for enabling organisations to identify and correct deficiencies and for preventing or mitigating the
Several studies have characterised effective leading HS performance indicators. Good leading indicators are complete, consistent, effective, traceable, minimal, continually improving and unbiased, according to Leveson (2015). Another common criterion for indicator selection is SMART: specific, measurable, achievable, relevant and time-bound (Zwetsloot, 2013). A third list of criteria includes valid, reliable, sensitive, representative, openness to bias and cost-effectiveness (Hale, 2009). Hale (2009) points out that leading indicators should correlate with lagging indicators, thereby providing proof for managers that they are indeed valid.

Hinze et al. (2013) points out that several carefully selected leading indicators will probably provide the best predictive results. Øien et al. (2011) agrees, arguing that there is no such thing as a universal model or method for the development of HS performance indicators. They suggest that the use of several different methods would provide the best outcome. Sinelnikov et al. (2015) found that corporate performance is mostly measured with lagging indicators, but on the site level, the focus is more on leading metrics because leading indicators are very process-specific. Another reason was that organisations may find it difficult to roll up site-level leading indicators to the corporate level because sites differ in terms of size, location, operations, structure, culture, occupational HS procedures and many other characteristics, which make them difficult to normalise and sometimes impossible to compare. Sinelnikov et al. (2015) suggested that a standard index for leading indicators could be created and validated, and it could be used for benchmarking across organisations.

Marshall, Hirmas, and Singer (2018) concluded that Heinrich’s pyramid from 1932—one of the most familiar occupational safety management tools, describing the severity distribution of occupational accidents and incidents—is statistically invalid for different economic activities and geographic regions. However, the inconsistency is small, and the pyramid can be used for practical purposes as a descriptive and predictive tool. The safety pyramid has become a popular way to illustrate HS performance. For example, the International Association of Oil & Gas Producers (IOGP, 2016) uses pyramid illustration in their yearly safety performance data report; WSA (2017b) uses it in their definitions; and a study by Joulnia, Väyrynen, and Latva-Ranta (2015) applied it to a comparison of accidents versus near-misses and hazard observations, and the empirical material was partly from the companies studied in Article I in this thesis. Near-miss is defined in ISO (2018) as an incident where no injury and ill health occurs but has the potential to
do so. Hazard is a source with a potential to cause injury or ill health (ISO, 2018, 12).

Hallowell et al. (2013) investigated leading safety indicators at construction sites, where suppliers, vendors and the company’s own personnel worked together (this set up is roughly comparable to the shared workplace described in Chapter 2.4). They argued that although leading indicators as concepts are defined, no specific leading indicators were identified or specified. Sheehan et al. (2016) listed examples of themes in leading indicators: accountability for OHS, audits and workplace inspections, consultation and communication about OHS, empowerment and employee involvement, management commitment and leadership, positive feedback and recognition, prioritisation of OHS, risk management of OHS, OHS systems and the provision of OHS training.

According to Marshall et al. (2018), it is very important for companies to record minor incidents because they are relevant and effective measures and projections of the overall safety performance. Bellamy (2015) agrees with the importance of investigating the underlying causes of the more minor and more frequent incidents or deviations. Though, she highlights that a breakdown of accident causation and potential severity ratio at a barrier level are both important for risk management. Hazards and their barriers need independent and deeper scrutiny, and this does not merely entail looking at the more frequent incidents or using their decline as safety indicators. The importance of preventive safety actions and a reporting culture is emphasised in accident prevention strategies (Bellamy, Mud, Manuel, & Oh, 2013; Douglas, Cromie, Chiara Leva, & Balfe, 2014; Grabowski et al., 2007; Hinze et al., 2013). Active reporting of near-misses are indications of a good safety culture, where people are not afraid to talk and report their own failures (Häkkinen, 2015). According to Pedersen and Nielsen (2013), safety culture is a leading indicator, which is influenced by the context, and it can be used as a strategic management tool.

### 2.2.2 Lagging indicators

#### LTIFR and benchmarking

Accident rates are one of the most commonly used measures of safety performance (Morrow et al., 2014). In addition to preventive actions, reactive indicators, i.e. lagging HS performance indicators, should be monitored if good external practices
are considered, and a comparison is made between internal and external HS performance levels (Øien et al., 2011). **LTIFR** is a commonly used indicator for HS performance monitoring, and it is defined as the **number of lost time injuries per one million hours of work** excluding the day of the accident (e.g. IOGP, 2016; Kjellén, 2000; WSA, 2017b).

The WSA uses LTIFR as its main public HS performance indicator (WSA, 2018a). Also, IOGP (2016) uses LTIFR as one of its main HS performance indicators, but in addition, total recordable injury frequency rate (TRIFR) is used. TRIFR includes fatalities, lost workday cases (comparable to lost time injury [LTI]) and medical treatment cases (IOGP, 2016). WSA collects safety data yearly from its member companies. The number of fatalities, LTIs, medical treatment incidents, first aid incidents, near-misses and safety deviations are the indicators in the survey (WSA, 2017a). However, only LTIFR statistics were published on their website (WSA, 2018a). IOGP’s and WSA’s LTIFR data was used as a benchmark in this study.

**Critique on accident frequency**

Although actively used for benchmarking purposes, LTIFR has some deficiencies as an indicator, such as the following:

- It is insensitive to the severity of the injuries (Kjellén, 2000). It places equal weight on accidents with one day absence, 100 days absence or permanent impairment.
- It is possible to manipulate the registration and classification of injuries (Kjellén, 2000). Accidents are often self-reported, and the injured person might decide not to report. This defect is a common problem for accident reporting, not just for LTIFR statistics (more information related to underreporting and under coverage is provided later in this chapter).
- The use of alternative jobs, i.e. restricted work (Kjellén, 2000), for the injured person. An accident victim could end up with a long period of restricted work but no absence at all. Still, the accident harms the injured person for a long time.
- It is fluctuating and sensitive to changes in small companies (Kjellén, 2000). Working hours in small companies are small and only one accident can show a high increase in LTIFR.
Details in the equation might differ, e.g.:

- Frequencies can be defined in several ways, such as per 200,000 labour hours as in the United States (Bureau of Labor Statistics, 2018).
- European Statistics on Accidents at Work and ILO (Eurostat, 2013, 2018; ILO, 2018c) define separate incidence rates for fatal accidents and for accidents leading to more than three days of absence. Incidence rate is the number of accidents at work per 100,000 persons in employment.

There are more uncertainties related to occupational accident statistics in general. The current research widely reports on underreporting. Van den Heuvel et al. (2017, p. 26) defines underreporting as: “employees and/or employers decide not to report an occupational accident or illness for a variety of reasons, or do not know they are obliged to report it”. Underreporting of non-fatal accidents was a large problem for the European Statistics on Accidents at Work in the EU (van den Heuvel et al., 2017). Probst, Petitta, and Barbaranelli (2017) concluded that national surveillance statistics in the United States and Italy underrepresent the true occurrence of occupational accidents and injuries due to underreporting. Fagan and Hodgson (2017) had similar results from the United States with Occupational Safety and Health Administration recordkeeping violations in close to half of all facilities inspected. ILO (2012) reported that data regarding occupational injuries and illnesses was less available from developing countries, and where records exist, they are generally unreliable.

There are several reasons for underreporting. Moore, Cigularov, Sampson, Rosecrance, and Chen (2015) found, for example, the following: small injuries do not need to be reported, pain is a natural part of the job, home treatment is enough, uncertainty if the symptoms are related to work activity or not and a fear of negative consequences (such as losing one’s job or safety incentive, potential of not being hired again). Job insecurity, production pressure, safety compliance and safety reporting attitudes were reasons for underreporting, according to Probst et al. (2017). Also, van den Heuvel et al. (2017) listed the following reasons for underreporting: lack of knowledge about the obligation to report or how to report, time required to obtain and complete the accident report forms, fear of negative consequences in the case of a minor accident, fear of a negative influence on the reputation of the company, fear of consequences in general and cultural reasons.

Underreporting and low accident rates can be explained with little or no financial incentive at all for the victims (Eurostat, 2018). Usually insurance-based accident reporting systems offer substantial financial compensation for the victim.
when an accident is reported, but systems in which victims are covered by general social security systems do not distinguish between causes of the accident or disease (van den Heuvel et al., 2017). Eurostat reported that underreporting is more common in countries without an insurance-based reporting system (Eurostat, 2016). The Finnish Workers’ Compensation Center (2018a) concluded that occupational accident statistic data comparisons with Finnish statistics are easiest with those countries who have financial incentives related to the reporting, e.g. insurance compensation is made after the reporting. Examples of such countries are Germany, Portugal, Spain, France, Switzerland, Austria, Italy, Luxembourg and Belgium (Finnish Workers’ Compensation Center, 2018a). In this thesis, part of the sites had insurance-based systems, e.g. Finland and Germany, and part of them did not, e.g. Sweden and the United Kingdom (van den Heuvel et al., 2017).

Occupational accident data comparisons between countries is difficult due to the differences in legal and compensation criteria (Hämäläinen, Takala, & Kiat, 2017). Eurostat (2018) is aiming to harmonise statistics in the European Union (EU) and in the euro area. Differences occur based on the data source, which can be, for example, from authorities, insurance systems and interviews (Eurostat, 2018). Harmonisation and changes to statistical principles have been made and are required for the national statistics as well, but few examples from Finland demonstrate its development. Starting from 2005, it was a requirement to report occupational accidents with at least four absence days, and until 2004, the requirement was to report occupational accidents with at least three absence days (Tapaturmavakuutuslaitosten liitto, 2011). The Workers’ Compensation Act (2015) regarding occupational accidents and occupational diseases changed the definitions and practices.

Due to underreporting and under-coverage issues, instead of comparing occupational accident statistics, Kurppa (2015) suggests comparing the ratio between fatal and non-fatal accidents because in countries where no underreporting is expected, the ratio of fatal to non-fatal accidents is stable. Despite how complex and uncertain the situation is, Kurppa (2015) claims that it is useful to make crude comparisons, although it is known that there are differences and methodological uncertainties between data sources of different countries. He adds that international comparisons have the potential of being eye-openers and promoters for change. It is also important to look beyond the statistics. Effective, deep and long-term learning from incidents is critical for the safety of employees, the public and environmental protection (Margaryan, Littlejohn, & Stanton, 2017). Learning from incidents aims to communicate the changes in human behaviour and processes that
must be made to prevent future incidents, according to Margaryan et al. (2017), but the challenge is how to ensure that the actions have been effective.

**Differences in the definitions and details**

Even workplace accident, accident at work, occupational injury or occupational accident—to mention a few expressions—are defined differently between countries (Finnish Workers’ Compensation Center, 2018b). According to the ILO definition, an **occupational injury** is defined as any personal injury, disease or death resulting from an occupational accident, and an **occupational accident** is an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work that results in one or more workers incurring a personal injury, disease or death (ILO, 1998). This research follows the ILO (1998) definition. Another substantial factor that is argued is whether the symptoms are work-related or not. Even the existence of the incident can be questionable. The main criteria is that the occupational accident is defined as a work-related accident (e.g. Eurostat, 2018; ILO, 2018c; WSA, 2017b). Hämäläinen et al. (2017) stated that work-relatedness is a gradual component that may vary from obvious and commonly agreed to barely detectable.

More inconsistencies can be found in the details. The EU includes road traffic accidents during the journey between home and the workplace in accidents at work (Commission Regulation 349/2011). In Finland, road traffic accidents are included as well (Finnish Workers’ Compensation Center, 2018b), but in the United Kingdom, most injuries resulting from road traffic accidents are excluded if they occur on a public road (Health and Safety Executive, 2018). Commuting accidents are sometimes included (ILO, 2018c) and sometimes excluded (Eurostat, 2013) even in the global and multinational organisations’ definitions. Van den Heuvel et al. (2017) found that some countries do not record accidents experienced by part-time workers or short-term contractors in the EU; thus, the national statistics may suffer from under-coverage in relation to the overall workforce. Furthermore, some statistics only show the organisation’s own employee data, thereby excluding contractors. A benchmarking report from the New Zealand Business Leaders’ Health & Safety Forum (2017) concluded that 78 forum members participated in their study, and only 30 recorded contractors’ accidents, thus less than 40%. IOGP (2016) and WSA (2017b) include contractors in their reports and present them separately from own employees. IOGP (2016) reported that all companies reported both company and contractor data. It is obvious that the variations are remarkable.
With the number of supplying companies and external individuals at workplaces on the increase (see the next chapter), the follow-up for an entire network’s HS performance is even more important.

In the EU, the day of the accident was not always included in the counts of days absent, and in many countries, accidents causing up to three days of absence were not reported; only accidents at work causing more than three days of absence were reported (van den Heuvel et al., 2017). Eurostat (2018) data includes accidents with more than three calendar days of absence. In addition to the number of accidents, Eurostat (2018) uses incidence rates per persons employed. Based on the definitions, these numbers are not comparable to the LTIFR definition commonly used in companies and in the scope of this research, e.g. the case company and the companies in the Northern Finnish network, WSA member companies and IOGP member companies. Differences exist in how loss of working time is recorded, which has been acknowledged, e.g. by ILO. ILO (2002) defined loss of working time as lost days counted from and including the day following the day of the accident, which was measured in calendar days, weekdays, work shifts or working days. Calendar days were preferred for accident severity purposes, but if working days or weekdays were used, estimates in terms of calendar days were preferable (ILO, 2002).

**Occupational diseases**


However, counting of the number of occupational diseases was even more complicated than the number of occupational accidents. There is no suitable data available on occupational diseases in Europe, according to van den Heuvel et al. (2017). Kurppa (2015) found that the number of recognised occupational diseases did not reflect the overall burden of disease experienced in the EU. In addition, countries applied different lists of reportable occupational diseases (van den Heuvel et al., 2017). Compensation systems varied, and underreporting was discovered
Another major difficulty was that many diseases have multiple origins and proving work-relatedness can be difficult (Kurppa, 2015; van den Heuvel et al., 2017). Moreover, different statistical classification structures made the comparison complicated (Kieffer, 2015). In some surveys, respondents are asked if their illness is partly caused by their work, but it is questionable if persons can judge the link to work or not (van den Heuvel et al., 2017).

2.3 Safety culture

2.3.1 Definition

Continuous changes in workplaces create challenges to HS management. The safety culture and climate, commitment to safety and communication are essential when aiming for excellence. Organisational changes can have the features of psychosocial risks that may have negative impacts on risk management and workers’ engagement, well-being and health (Mathisen et al., 2017). According to Zwetsloot et al. (2013), the complexity of systems and organisations is growing, and it requires an approach to safety that goes beyond the simple rational analysis of technical systems, organisational patterns and procedures. Safety management must consider the dynamics of processes and actions that influence or are directly involved in safety. Thus, risk awareness and safety culture are essential complements to safety management systems (Zwetsloot et al., 2013).

Schein (2010, p. 17) defined the organisational culture:

“… a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.”

HS culture (or OHS culture) is a more general form of safety culture, and it is not used often in literature (Eeckelaert et al., 2011). Usually, safety culture or safety climate is used; therefore, it is the definition used in this thesis as well. Safety culture has several definitions, but often they are based on the definition by the Advisory Committee on the Safety of Nuclear Installations from 1993 as in EU-OSHA:
“... the safety culture of an organisation is the product of individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation’s health and safety programmes.” (Eeckelaert et al., 2011, p. 13)

2.3.2 The role of commitment

Participation, engagement and commitment to HS at every organisation level is essential. Also, ISO 45001 (ISO, 2018) emphasises the importance of worker participation. Safety participation includes acts such as helping co-workers with safety, seeking to promote the safety programme, making suggestions for change, participating in voluntary safety tasks or attending safety meetings (Curcuruto, Conchie, Mariani, & Violante, 2015; Martínez-Córcoles, Schöbel, Gracia, Tomás, & Peiró, 2012). Zwetsloot, Drupsteen, and de Vroome (2014) claimed that participative leadership is supported when safety and reliability are combined with job satisfaction. When leaders showed empowering behaviours, they facilitated collaborative learning processes that resulted in increased safety participation (Martínez-Córcoles et al., 2012). Waether and Yorio (2013) argued that the effectiveness of a safety management system and its practices depend on the levels of safety-focused cognitive and emotional worker engagement. According to their research, safety management systems can be designed and implemented to promote and enhance worker engagement. Safety motivation affects safety behaviour and change implementation. Pedersen and Kines (2011) argued that social motivation is more important for safety behaviour in large enterprises compared to medium-sized enterprises.

Zwetsloot, Kines, Ruotsala et al. (2017) investigated companies that are aiming for zero accidents. He stated that a common characteristic of all companies was the high commitment of both the managers and the workforce. This commitment, combined with other factors, is likely to be the main driver for long-term safety improvements. He found that companies aiming for zero accidents are serious in their strategies and practices to improve safety, and they understand that it will be a continuing effort. Although the tension between productivity and HS goals has been acknowledged (e.g. Han, Saba, Lee, Mohamed, & Peña-Mora, 2014; McLain & Jarrell, 2007), there is another aspect. Safety can be used as a spearhead for making wider changes in an organisation’s culture or at least in its climate, e.g. to change attitudes towards pride in work, performance and general productivity (van Ginneken & Hale, 2009).
Commitment from management, worker participation and engagement, and available resources (financial and personnel) supported the implementation of a good HS practice (van den Heuvel, Bakhuys Roozebom, Eekhout, & Venema, 2018). Management commitment was most strongly associated with accident prevention. An analysis report from EU-OSHA (Kaluza, Hauke, Starren, Drupsteen, & Bell, 2012) suggested five principles for good HS leadership:

1. Leaders must take seriously their responsibility for the establishment of a positive safety culture and safety climate.
2. Leaders should prioritise OSH policies above other corporate objectives and apply them consistently across the organisation and over time.
3. HS actions can deliver to their full potential if they have the unambiguous commitment of an organisation’s board and senior management. High-level management must be directly involved in implementing HS policies.
4. Good, regular, multi-level communication is vital to the delivery of improvements in HS. Leaders should encourage an open atmosphere in which all can express their experiences, views and ideas about HS, and which encourages collaboration between stakeholders, both internal and external, around delivery of a shared HS vision.
5. Leaders should show that they value their employees and promote active worker participation in the development and implementation of HS actions.

The importance of safety leadership throughout the organisation has been highlighted by several studies (e.g. Corrigan, Kay, Ryan, Ward, & Brazil, in press; Sheehan et al., 2016; Wu, Lin, & Shiau, 2010; Zwetsloot, Kines, Ruotsala et al., 2017). Martínez-Córcoles et al. (2012) concluded that empowering leaders promoted collaborative learning directly and by encouraging dialogue and open communication. According to Sheehan et al. (2016), there is a need for sustained safety leadership training programmes for managers at all levels to understand their roles and to learn how to be safety leaders. Increasing managers’ safety awareness, influencing managers’ safety attitudes, recognising managers’ safety commitment, emphasising managers’ safety responsibilities, developing adequate organisational safety procedures, superiors’ encouragement and support, benchmarking others’ safety activities, understanding the economic effects of safety, and safety improvements were the factors that promoted managers’ commitment to safety (Tapcura, Nenonen, & Kivistö-Rahnasto, 2017). Problem-solving, social competence and safety knowledge were relevant for senior managers’ engagement.
in behaviours that demonstrated their safety commitment (Fruhen, Mearns, Flin, & Kirwan, 2014).

If there is a good safety culture without a management system, safety can be organised inconsistently; it can be under-resourced and not seen as business driven (Corrigan et al., in press). In addition, if a company is seeking to improve its safety culture, defined safety indicators play an important role. Morrow et al. (2014) claimed that safety culture is correlated with concurrent measures of safety performance and may be related to future performance. Two elements are important contributors when improving workplace safety: positive safety communication and an error management climate (Cigularov, Chen, & Rosecrance, 2010). Moore et al. (2015) recommended the creation of a positive error management climate, which included, for example, sharing near-misses with supervisors and co-workers. Corrigan et al. (in press) characterise a positive safety culture as the way safety is perceived, valued and prioritised in an organisation. According to them, it reflects the commitment to safety at all levels in the organisation and should go through all aspects of the work environment. Ratilainen et al. (2016, p. 31) defined safety as a value, which was “a long-term commitment in having safety integrated as a positive value within all business operations and strategies”.

### 2.3.3 Safety culture and performance monitoring

Sutherland, Cox, and Makin (2000) suggested measuring safe and unsafe behaviour before an accident occurs rather than investigating what happened after the incident. They place one extra layer on the bottom of the Heinrich’s pyramid from 1932—that is, behaviour. Brown et al. (2000) studied safe employee behaviour in the steel industry. They concluded that encouraging employees’ safety is more than slogans and posters, which often served as substitutes for safety programmes in industrial settings. They found that safety hazards have more of an effect than only directly causing accidents. Indirectly, hazards influence employees’ perceptions of organisational factors, e.g. safety climate and pressure, and lead to unsafe behaviours (Brown et al., 2000).

Curcuruto et al. (2015) argued that when seeking to improve safety performance, benefits can be gained from distinguishing between prosocial, e.g. helping others, and proactive, e.g. seeking change, safety behaviours. Organisations can reduce the rate of minor injuries and property damage by increasing the help they extend to their employees and creating environments in which employees feel comfortable raising their suggestions and concerns about safety (Curcuruto et al.,
Brown et al. (2000) characterised a positive safety climate as one with an open-door policy for hazard and accident reporting, a sincere concern for employee well-being and fairness in accident investigations.

Some organisations have used safety climate assessments. Eeckelaert et al. (2011) saw safety climate as a superficial and momentary reflection of an organisation’s safety culture. Safety climate is both a leading and a lagging indicator, according to Payne, Bergman, Beus, Rodríguez, and Henning (2009). They explain that employees’ perceptions of the safety climate should be partly based on previous accidents/injuries (lagging), but the safety climate also sends messages to workers about appropriate and expected behaviours, and in that way, it influences accidents (leading). The safety climate can be regarded as a predictor of safety performance (Eeckelaert et al., 2011). Kvalheim, Antonsen, and Haugen (2016) summarised that the practical use of safety climate assessments should not be an indicator for safety performance but an indication of where to focus next.

Proactive HS management has led to significantly more positive safety climate perceptions as well as improved employee organisational commitment and job satisfaction (Haslam, O’Hara, Kazi, Twumasi, & Haslam, 2016). A research by Neal, Griffin, and Hart (2000) concluded that the general organisational climate can influence perceptions of the safety climate. They pointed out that these perceptions of safety climate influence safety performance through their effects on knowledge and motivation.

Nordlöf et al. (2015) investigated the safety culture at a large steel company in Sweden. They found that workers’ perceptions were that the risks present in their work environment must be accepted because they could not do anything about them. They experienced that safety performance at work is the responsibility of the individual, and that it is not possible to count on one’s colleagues or the manager. Also, the workers reported that there is a constant and ongoing trade-off between productivity and safety (Nordlöf et al., 2015).

### 2.4 Shared workplaces

#### 2.4.1 Definition of a shared workplace

Shared workplaces or worksites have become a common way to organise operations in the process industry. In Finland, a **shared workplace** is characterised by employees of several employing companies working at the same principal premises (Finnish
The legislation recognises shared workplaces in Finland (Act on Occupational Safety and Health Enforcement and Cooperation on Occupational Safety, Health at Workplaces 44/2006; Act on the Contractor’s Obligations and Liability when Work is Contracted Out 1233/2006; Occupational Safety and Health Act 738/2002). A formal safety management system is not mandatory, but an approach that is similar to a safety management system is required. The Finnish legislation (738/2002) defines the duties and responsibilities as follows: “. . . each for their part and together in adequate mutual cooperation and by information ensures that their activities do not endanger the employees’ safety and health”.


“Where several undertakings share a work place, the employers shall cooperate in implementing the safety, health and occupational hygiene provisions and, taking into account the nature of the activities, shall coordinate their actions in matters of the protection and prevention of occupational risks, and shall inform one another and their respective workers and/or workers’ representatives of these risks.”

EU-OSHA has decided to broaden the focus of OHS to more complex networks rather than just a single company, referring to HS within supply chains (Ustailieva et al., 2012). Outsourcing is the act of obtaining finished and semi-finished products or services from an outside company if these activities were traditionally performed internally (Dolgui & Proth, 2013). According to ISO (2018, p. 14) outsourcing is an arrangement where an external organisation performs part of an organisation’s functions or processes.

The terminology around shared workplaces and its different operators is not well established. A recent literature search from international databases by the Finnish Regional State Administrative Agency (Kekkonen & Rajala, 2017) discovered that the definition of shared workplace is not used as often, defined as precisely and studied that widely in Finland. Nenonen (2012) and Nygren (2018) used the term ‘multi-employer worksite’ to describe similar circumstances. Ustailieva et al. (2012) made a distinction between two main supply chain networks or the relationships between companies and the members of their supply chain: a primary network, i.e. a company and its suppliers of certain goods and materials, and a secondary network, i.e. a company and its contractors and subcontractors providing
specific services, such as maintenance, construction, cleaning or catering activities. The secondary network is closer to the shared workplace and multi-employer worksite. Heikkilä, Malmén, Nissilä, and Kortelainen (2010) used the term ‘industrial park’ to describe circumstances with multiple independent companies. In an industrial park, there might not be a single principal company but several equal companies. Still, the risks and advantages are relatively similar. Throughout this study, the term ‘shared workplace’ is used.

According to Singer and Donoso (2011), most commonly outsourced operations were supporting services, e.g. catering and cleaning, information technologies, human resources, telecommunications, e-commerce and logistics in the United States and Europe. Networking helps companies to manage changing business environments (Väyrynen et al., 2008). Outsourcing has many advantages, including cost savings and financial flexibility, strategic focus on core activities, access to advanced technology and skills, improved service levels, access to specialised expertise and organisational politics (Belcourt, 2006; Dolgui & Proth, 2013). From a safety perspective, outsourcing reduces overlapping procedures, uses resources more efficiently and helps to more easily achieve safety objectives (Nenonen, 2012).

2.4.2 Safety in shared workplaces

However, risks can occur when outsourcing operations, such as the transfer of expertise and insider knowledge to vendors (Belcourt, 2006), reduced work quality and productivity (Burke & Ng, 2006), migration of production and services to vendor’s country and reduced freedom of the buyer (Dolgui & Proth, 2013). Furthermore, inter-organisational communication flows present a challenge when the network is not managed by one company (Heikkilä et al., 2010). Milch and Lauman (2016) identified several risks: a lack of shared responsibility, safety versus production trade-offs, confusion of responsibility, breakdown in communication and information-sharing, complex safety management systems, employees’ lack of familiarity with the local work environment, a lack of industry-specific knowledge and experience, fragmented decision-making processes, and distrust and status differences.

Nenonen (2012) identified the negative impacts on safety management caused by outsourcing: the co-ordination of different activities and implementation of safety measures became difficult, staffing was cut, and qualified personnel was reduced, and service providers had a limited overview of the customer company’s
operations, performed work tasks, special features and safety regulations. Nygren (2018) concluded that dynamic changes in the relationships between the client and its contractors complicated the distribution of and adherence to legal responsibilities for safety management. In addition, service providers often operate on several principal companies’ sites, where working practices, cultures and habits are different (Nygren, 2018). Rantanen et al. (2007) pointed out that a strong safety attitude and in-depth safety knowledge are required when sending a worker to another employer’s workplace. For example, in maintenance work, sites and tasks can vary according to the customer environment, and there can be a wide variety of tasks that change (Lind, 2009).

Muzaffar, Cummings, Hobbs, Allison, and Kreiss (2013) claimed that compared to the operators (own personnel), the risk was 2.8 times higher for contractors to sustain a fatal accident than a non-fatal accident in the mining industry. Milch and Laumann (2016) found that issues due to outsourcing and inter-organisational complexity can hinder efficient safety management and, in that way, raise the risk of organisational accidents. Nygren (2018) agreed with the findings by concluding that a discrepancy exists between in-house workers and contract workers, and contract workers suffer more accidents and of a more severe nature.

Outsourcing has also led to complex sociotechnical systems involving multiple companies and work processes. This kind of setting requires collaboration between employees from different organisations and coordination across organisational boundaries (Milch & Laumann, 2016). Many safety issues have already gained great recognition in multiemployer workplaces, e.g. communication and hazard identification (Nenonen, 2012). Nevertheless, management of some other safety areas has received limited attention. Nenonen and Vasara (2013) recommended that parties at multiemployer worksites promote cooperation with the implementation of safety activities to avoid overlapping safety operations, efficiently allocate remote resources for safety, strengthen the commitment of all parties and ensure efficiency in safety. In addition, they found that companies on multiemployer worksites already cooperate in safety management regarding training, orientation and guidance, flow of information, risk analysis, audits and accident investigations.

In fast-changing environments, managing HS becomes a challenge at worksites and on a global level. A single principal company can not necessarily choose which employees enter the site (Heikkilä et al., 2010), posing challenges in safety risk management (Schubert & Dijkstra, 2009). In shared workplaces, many companies are inside the same area, and there are temporary and permanent workers consisting of both locals and foreigners. In addition, some of the operations are outsourced and some
of the operations are important core businesses for the principal company. Especially, different languages and cultures create a challenge when personnel from several countries work at the same premises, according to Wasilkiewicz, Albrechtsen, and Antonsen (2016). When developing a safety management system, it is important to consider the different needs of permanent and temporary employees (Luria & Yagil, 2009). In addition, company size matters, which creates more challenges in shared workplaces because the sizes of the various companies can vary greatly. It should be noted that the tasks and the risks associated with the tasks can be very different. For example, the principal company may be large with formal HS practices that suit the organisation’s structure. However, the principal company will also require its suppliers, which may be small companies or even individuals, to follow the same practices. Yorio and Wachter (2014) concluded that smaller organisations do not need such formal practices, and they do not have the same level of resources as big organisations do to adopt safety practices.

### 2.4.3 The importance of collaboration

Camarinha-Matos, Afsarmanesh, Galeano, and Molina (2009) emphasised participation in networks in the form of collaborative organisations. Although the variety of organisations and people were largely autonomous, i.e. geographically distributed and heterogeneous in terms of their operating environments, cultures, social capital and goals, the organisations and the people collaborated to achieve common or compatible goals, thus jointly generated value (Camarinha-Matos et al., 2009). They asserted that collaboration is a more demanding process than networking or cooperation, because risks, resources, responsibilities, losses and rewards were shared. According to Camarinha-Matos et al. (2009), collaboration gave outside observers the image of a joint identity, but it required mutual engagement from all participants, and it implied mutual trust, dedication, and the investment of time and effort.

Oedevald and Gotcheva (2015) concluded that in a large subcontractor network, activities and local practices are different, and their safety management systems and cultures cannot be homogenised. The whole network should develop safety management and a safety culture together and learn how to manage its activities towards safety. Hallikas et al. (2004) recommended that companies in networks share their views on risks because different viewpoints help to recognise and understand common opportunities and threats in a more holistic way. Besides the principal company’s own success in HS performance, overall success depends on the
performance of the entire network, including the supplying companies and any other external individuals in the shared workplace. Suppliers are often smaller in size than the principal companies, but their employees have a very important role in the value network (Väyrynen, 2017). Cantor (2008) suggested that if a company’s supply chain does not obey comprehensive workplace safety practices, it can cause negative consequences, e.g. fatal and serious accidents, higher insurance costs, financial and legal consequences, loss of corporate goodwill and difficulty attracting customers and recruiting employees. The entire supply chain must be considered when companies are aiming to act sustainably (Zink, 2016).

Because the number of shared workplaces has become common, collaborative work environments are forming and many employers with their employees are involved in the purchasing company’s value chain (Väyrynen, Jounila, Latva-Ranta, Piikarainen, & von Weissenberg, 2016). More research on how to manage HS and E issues most effectively in situations of shared ownership and responsibility, such as in the case of industrial parks, leasing, outsourcing and similar constructions, was required in a study conducted by Duijm, Fiévez, Gerbec, Hauptmanns, and Konstandinidou (2008). Their research revealed that especially small and medium-sized companies need guidance on how to manage HSE effectively. Ju, Rowlinson, and Ning (2018) studied how voluntary OHS programmes are perceived. They concluded that acceptance by contractors depends on the power of the organisers, the requirements of project clients and the head offices, the extent to which the programme was diffused, and the perceived effectiveness of the programme.

### 2.4.4 Tools to assess HSEQ performance in shared workplaces

There are solutions available to manage HSEQ in shared workplaces and in different industry sectors. A few that have been developed include safety performance evaluations for construction contractors (El-Mashaleh, Rababeh, & Hyari, 2010; Ng, Cheng, & Skitmore, 2005), safety (HSE) criteria for maintenance project contractor selection (Hadidi & Khater, 2015), methods to evaluate HS management systems, such as a resilience engineering perspective in the manufacturing industry (Costella, Saurin, & de Macedo Guimarães, 2009), a supplier quality performance rating system (Chen et al., 2004), and HSE assessment for contracting companies in the petrochemical industry (Gholami, Nassiri, Yarahmadi, Hamidi, & Mirkazemi, 2015; Nassiri et al., 2016).

One voluntary solution is the **HSEQ Assessment Procedure** (hseq.fi, 2018). The HSEQ AP is used for meeting business and regulatory needs, and it is an
assessment method that can be used for evaluating supplying companies’ HSEQ performance in shared workplaces. Ju et al. (2018) noted that when striving for continual improvements in HS performance, the practices implemented by large construction companies with superior safety performance are likely to be imitated by companies with less satisfactory safety performance. Learning from other companies’ good practices is the idea behind the HSEQ AP as well. According to Väyrynen (2017), HSEQ management in shared workplaces can be effectively arranged with proper participation by all employers, including the contractors and employees. Ju et al. (2018) agreed that, in most cases, the impact of voluntary OHS activities was increased when they were co-organised by multiple stakeholders. The Council Directive 89/391/EEC and legal requirements in Finland (738/2002, 44/2006, 1233/2006) identified similar actions needed in shared workplaces as the HSEQ AP seeks to solve, e.g. highlighting the importance of cooperation, communication and the prevention of occupational risks.

The objective of the HSEQ AP is to ensure that supplying companies in shared workplaces have enough knowledge and skills related to HSEQ requirements to operate on the sites of principal companies (hseq.fi, 2018). About 200 suppliers were assessed using the HSEQ AP, and 12 principal companies joined the HSEQ cluster (hseq.fi, 2018). The HSEQ AP cluster is a voluntary consortium for suppliers’ quality control using the HSEQ AP among the suppliers working inside factory areas in shared workplaces (Väyrynen et al., 2016). The main categories were based on the European federation for quality management (EFQM) excellence model, and from the HSEQ point of view, the elements were leadership, policy and strategy, people, partnerships and resources, processes, customer results, people results, society results and key performance results. The HSEQ AP is described in detail in Article IV.
3 Material and methods

3.1 Overview

The research strategy provides support on a higher level, but it needs to be complemented with research methods that guide the research in a more detailed way (Johannesson & Perjons, 2014). In multimethod research, two or more sources of data (or research methods) are used to investigate linked research questions (Lewis-Beck, Bryman, & Futing Liao, 2004). Sequential and concurrent methods were used in this study. Mixed methods research aims to tackle the limitations of a single research method by expanding the scope, deepening the insights and improving the analytic power of the study (Sandelowski, 2000).

Interviews and data collection from archives (document study) were the main material and data collection techniques. Interview was chosen because it is suitable for engaging with people who have access to privileged information, i.e. people possessing deep and unique information and knowledge about some domain (Johannesson & Perjons, 2014). Documents were analysed to fulfil the study material about HSEQ management and performance. Questionnaire was used to map the current situation of HSEQ management and the HSEQ AP. Benchmarking, including benchmarking and actions as described by Freytag and Hollensen (2001), was used in the data analysis and collection phase.

RQ5 was answered in the form of SWOT analysis, thereby analysing the internal (strengths and weaknesses) and external (opportunities and threats) factors. SWOT analysis is a crude and subjective tool, but it can be used to carry out a quick strategic review (Friend & Zehle, 2004). A SWOT analysis was performed by the author using the empirical data from the Articles I-IV. The analysis was done using the steps presented by Friend and Zehle (2004). First, the empirical material was analysed, which led to an all-inclusive list of strengths, weaknesses, opportunities and threats. In the next stage, the parallel factors were eliminated, some of the factors were combined and the most important factors were emphasised. Based on the interpretation, the most important factors were selected. According to Friend and Zehle (2004), a SWOT analysis should be short and simple, and it is important to avoid complexity and over-analysis.

Table 2 summarises the materials and methods used in this research.
Table 2. Summary of the materials and methods.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Materials</th>
<th>Method</th>
<th>Presented in Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1. Over the past 20 years, what have been the main HSEQ management development steps in the Northern Finnish heavy process industries, such as the steel industry and its service delivery network, and how has their accident frequency changed?</td>
<td>Project reports, and other documentation and notes during the projects (collaboration with the industry)</td>
<td>Document study Inquiry</td>
<td>I, IV</td>
</tr>
<tr>
<td>RQ2. What kind of HS management practices and tools are used in a global steel company?</td>
<td>Interview results and observations Internal HS standards and instructions Statistical data</td>
<td>Interview Document study</td>
<td>II</td>
</tr>
<tr>
<td>RQ3. Which HS performance indicators are used in a global steel company and how well does HS perform?</td>
<td>Interview and questionnaire results and observations Internal HS standards and instructions Statistical data</td>
<td>Interview Questionnaire Document study Benchmarking</td>
<td>III</td>
</tr>
<tr>
<td>RQ4. How are supplying companies’ HSEQ issues managed with the HSEQ AP at a shared workplace in Finland and how has the HSEQ AP performance and accident frequency changed?</td>
<td>Interview and questionnaire results and observations HSEQ AP related documentation Statistical data</td>
<td>Interview Questionnaire Document study</td>
<td>I, IV</td>
</tr>
<tr>
<td>RQ5. What actions should be taken to improve the current situation and to achieve excellence in HS(EQ) management and performance?</td>
<td>Project reports and other documentation Internal HS standards and notes during the projects (collaboration with the industry)</td>
<td>Document review SWOT analysis</td>
<td>I-IV</td>
</tr>
</tbody>
</table>

Material was selected for the articles as follows:

- Article I: Materials covering a period of 15 years were collected from Northern Finnish process industry companies that had participated in HSEQ management-related development research projects. These materials already existed when starting to write the article. At the time, the author was a researcher at the University of Oulu, which is the organisation behind the
research projects. The article writing process involved compiling the data and findings and combining the conclusions.

- Articles II and III: The material was available because the researcher worked in the case company. Themes were decided based on the researcher’s interest, job content and especially the current themes trending in HS management practices in the case company and in the general HS(EQ) management research.
- Article IV: The material was created for an internal report in the case company. During a practical HSEQ management practices mapping, it became apparent that the data and findings could be used for a scientific purpose as well. Additional research activities were conducted to complete the empirical material.

The material in the articles was collected between 1994 and 2015. If any gaps in the material were observed after the article was published, e.g. more yearly data was published to the time series, the data was completed in this thesis’ compilation part. In addition, information in the most recent reports and other relevant sources has been exploited to ensure full coverage of the research topic. Detailed material descriptions of each article are presented in the next chapters.

3.2 HSEQ management development in the Northern Finnish process industry

Article I includes materials from 1994 to 2010, which were created for the article based on a study of the documents. All the units (companies) studied in this research located in Northern Finland. A design science approach was used as a method in the original Article I, and typical of its nature, evaluation in various forms was used. Design science aims to build innovations, i.e. new constructions or improvements to existing designs, and assesses their usefulness (Järvinen, 2004). HSEQ AP can be seen as an innovation. Article IV (where the participant company was one of the principal companies in Article I and one of the sites in the case company in Articles II and III) also provided materials for the development of the path description to answer, together with Article I, RQ1.

Units of process industry companies (N = 6) and their service delivery network (N = some hundred supplying companies) comprised the field material for the chain of development projects between 1994 and 2008. The projects were starting points for HSEQ management and IMS-related development efforts in these companies. In total, approximately 10,000 employees were working in the principal
companies and some thousands in the supplying companies. This part was mainly
descriptive and inductive in nature. The path of the projects included a sequence of
improvements in HSEQ management and IMS. The last stages of the path of
projects was building a new assessment system for HSEQ management, the HSEQ
AP (for more information, see Article IV and hseq.fi, 2018). In reference to design
science’s principles (Järvinen, 2004), the HSEQ AP aims to be a method for
disclosing supplying companies’ assessed systems, achieved goals and how well
the goals were reached.

Both principal and supplying companies participated in the HSEQ AP
development together with the University of Oulu and The Institute for
Management and Technological Training, POHTO. The companies involved in the
HSEQ AP development work had strong participative roles by trialling and piloting
the actions and acting as early adopters. Important findings included opinions from
individuals and companies, and participatory development was applied.

Accident data was collected (inquiry) from 10 mills or independent companies
(units), and it is presented in the form of LTIFR. The participants were early
adopters of the Finnish Occupational Safety Card (FOSC; for more information,
see Väyrynen et al., 2008) and developers for the HSEQ AP. The time series was
from 1994 to 2010. The size of the units varied from small and medium-sized
enterprises to international corporations. Afterward, Article I was published in
2012, and the data for this thesis was complemented until the end of 2010.

3.3 HS management studies in the case company

Materials from the eight sites of the case company were collected in 2013 for
Article II and in 2015 for Article III. One Northern Finnish site of the case company
discussed in articles II and III participated in the path of projects (Article I) and for
Article IV.

The empirical part of this study focused on the HS management practices of a
global company producing stainless steel. At the Northern Finnish site,
ferrochrome was produced in addition to stainless steel. At the time of the study,
production facilities covered all continents and the sites were in Finland, Sweden,
Germany, the United Kingdom, Mexico, the United States and China, with a global
sales and service centre network. The case company had a long history, originating
from the 1910s (Outokumpu, 2018). During the research, the company experienced
numerous organisational changes. The organisation changed significantly at end of
2012 when several new sites joined the company. Some sites had previously been
part of larger organisations and had been so for decades, whereas other sites were relatively new to the industry, but all were experiencing on-going changes. There were additional large changes when some sites left the company in 2013 (Outokumpu, 2015). The organisation investigated in this case study was also constantly facing changes internally between organisations. A number of employees at individual sites and in the whole case company changed during the empirical work and, for example, the China unit was not part of the case company after writing the articles.

The data was collected using semi-structured interviews with HS(EQ) managers in different sites. In addition, human resource specialists and other HS specialists were interviewed. According to Eriksson and Kovalainen (2008), the advantage of using semi-structured interviews is the possibility to vary the wording and order of questions in each interview. In addition, the materials are quite systematic and comprehensive, although the tone of the interview is conversational and informal. That was an important advantage for this research, because especially in the Article II, the interviewees were not that familiar with the researcher, and the first connection was made during the interview. In semi-structured interviews, the respondents can formulate the answers in their own words (Johannesson & Perjons, 2014), which made the interviews more relaxed.

Interviewees were chosen by the researcher based on their experience, knowledge and position at the sites. The main criterion was that the interviewees should know all the HS management practices, tools and indicators used at their sites. The interviewed locations were the same in Articles II and III, except two additional sites participated in Article III. Table 3 summarises the investigated sites and the interviewees.

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Number of employees 2013</th>
<th>Number of employees 2015</th>
<th>Number of interviewees 2013</th>
<th>Number of interviewees 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Europe</td>
<td>3,300</td>
<td>2,850</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Europe</td>
<td>2,200</td>
<td>2,000</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Americas</td>
<td>800</td>
<td>930</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Europe</td>
<td>550</td>
<td>540</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>Europe</td>
<td>120</td>
<td>110</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>Asia</td>
<td>500</td>
<td>450</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>Europe</td>
<td>-</td>
<td>770</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>Americas</td>
<td>-</td>
<td>1,100</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Summary</td>
<td></td>
<td>7,470</td>
<td>8,750</td>
<td>8</td>
<td>14</td>
</tr>
</tbody>
</table>
The number of employees decreased in most of the sites between the years 2013 and 2015. In Article II, the total number of employees in the interviewed organisations was about 7,470, which represented approximately half of the whole company (the number of employees at the end of 2013 was about 15,000). In Article III, the total number of employees in the interviewed organisations was about 8,750, which represented approximately 75% of the whole company (the number of employees at the end of 2015 was about 11,700).

The interviews were conducted in English, except for one, which was done in Finnish. In that exceptional interview, written questions were presented in English. Language created a challenge for some of the interviews. It was possible that different expressions and words might be used in different locations. Due to this uncertainty, in one interview (Article II), there was an interpreter. In addition, although the main method in the articles was interview, in locations F and H (Article III), questionnaire was used. The questionnaire included the same questions as the interviews. To ensure the precise understanding, terminology was questioned and explained in detail several times during the interviews and together with the questionnaires.

Prior to the interviews, the questions were e-mailed to the interviewees. The request was that they should prepare for the interview by knowing what content to expect. In Article II, preliminary answers were requested and received. For Article III, it was known beforehand that the knowledge related to HS performance indicators was fragmented between departments. The interviewees were made aware of the possibility of inviting other internal experts to attend the interview if they did not have enough knowledge themselves. Conversations were recorded and transcribed for analysis. The interviews were carried out by using internal video conference equipment. The length of the interviews varied between one and four hours.

For Article II, the questions were structured based on the main elements of OHSAS 18001 (SFS, 2007). Emergency preparedness and legal and other requirements sections were excluded due to the different legal requirements in each country. For Article III, the questions comprised all leading and lagging HS performance indicators used at the time of the interview and their improvement needs. Internal corporate HS material was reviewed systematically for both articles. This documentation included HS standards and instructions, vision and principles (Article II) and HS performance indicators. For Article III, HS performance data was collected and analysed.
After the interview and document study, the data was organised based on the OHSAS 18001 (SFS, 2007) structure in Article II. For Article III, the results were analysed and classified systematically. The material was read through and different themes were sketched based on the RQs. In addition to the strict themes, areas needing improvement were identified. At the end, the material was categorised based on the themes.

Benchmarking material was collected from OHSAS 18001 (SFS, 2007), WSA (2018a) and IOGP (2016). WSA members represent approximately 85% of the world’s steel production (WSA, 2018b). WSA was chosen as the first benchmark because it represents the steel industry within which the case company operates. IOGP was chosen as a second benchmark because IOGP members represent the process industry, as does the case company. Furthermore, their data was easy to find and available on the internet, and their definitions were similar to the case company’s definitions.

3.4 HSEQ management development in a shared workplace

Articles I and IV provided the empirical materials for RQ4. The principal company in Article IV was one site of the case company (discussed in Articles II and III). Both the principal company and supplying companies located in Northern Finland. The principal company had about 2,300 employees in 2013. Article I provided the material related to the HSEQ AP description and development. The material in Article IV originated from a project that was implemented between 2012 and 2013. The empirical section was divided into five main parts, which reviewed suppliers’ HSEQ management practices from different aspects (Table 4).

<table>
<thead>
<tr>
<th>Purpose of the data collection (parts of the study)</th>
<th>Method</th>
<th>Number of respondents</th>
<th>Presented in Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Description of the HSEQ AP</td>
<td>Document study</td>
<td></td>
<td>I and IV</td>
</tr>
<tr>
<td>2) Supplier HSEQ management and the current situation in the case company</td>
<td>Questionnaire, document study</td>
<td>22</td>
<td>IV</td>
</tr>
<tr>
<td>3) Principal and supplying companies’ views related to the HSEQ AP</td>
<td>E-mail questionnaire</td>
<td>39</td>
<td>I</td>
</tr>
<tr>
<td>4) Supplying companies’ views related to HSEQ AP</td>
<td>Semi-structured interview</td>
<td>3</td>
<td>IV</td>
</tr>
<tr>
<td>5) LTIFR and HSEQ AP performance</td>
<td>Document study</td>
<td>-</td>
<td>IV</td>
</tr>
</tbody>
</table>
Part 1 was presented in two articles, and it described the HSEQ AP in detail based on published research reports, other documents related to research projects and the website (hseq.fi, 2018).

The questionnaire in part 2 was sent to 23 respondents and 22 were returned (response rate 96%). The respondents represented several departments from the principal company: procurement, production, maintenance and mill services, logistics, HSEQ, research centre and port operations. These respondents were individuals involved in with supplier’s safety, usage, selection or assessment.

In part 3, the experiences related to the HSEQ AP were collected using a questionnaire (N = 73), which was sent by e-mail, and 39 responses were received (response rate 53%). These respondents had participated in the HSEQ AP as an assessor or main assessor (principal companies) or as a representative of the supplying companies (e.g. managing director, production manager, or HS manager). From the respondents, 15 were from principal companies and 24 from supplying companies. The size of the supplying companies varied between 1 to 9, 10 to 39 and 40 to 239 employees. Each size category represented one third of the supplying companies that responded.

In part 4, the respondents were HSEQ managers responsible for HSEQ issues in the supplying companies (or a similar role). It was known in advance that they had the broadest knowledge about suppliers’ HSEQ management practices at the premises of the principal company. The supplying companies offered maintenance, repair and installation services, and the number of employees was about 40, 60 and 80.

HSEQ performance indicators were analysed in part 5, using LTIFR data from the principal company’s archives and the HSEQ AP results. A comparison of the HSEQ AP results was made based on the first and the second assessment (N = 11).
4 Results

4.1 HSEQ management development in shared workplaces in Northern Finland

Article I describes the history of HSEQ management-related research and development work in process industry companies and its service delivery network in the context of shared workplaces. Article I answers mainly to RQ1: Over the past 20 years, what have been the main HSEQ management development steps in the Northern Finnish heavy process industries, such as the steel industry and its service delivery network, and how has their accident frequency changed? The HSEQ AP development from Article IV was also used to answer RQ1.

Fig. 5 presents LTIFR from principal and supplying companies. Additionally, research projects completed by the University of Oulu are presented on the bottom of the graph. Two years and one research project (TUOLATU II) have been added to the data since the publication of Article I.

![Graph showing LTIFR development](image)

Fig. 5. Path of projects and LTIFR development in companies participating to the projects (modified from Article I).
Principal and supplying companies in the studied network showed positive long-term development in accident statistics in the form of LTIFR with its linear trendline. Especially supplying companies significantly improved their LTIFR. Principal companies’ LTIFR went down as well but not as dramatically. However, supplying companies’ starting point was higher. The lowest LTIFR values were in 2010 for principal companies (13.3) and in 2008 for supplying companies (27.8).

Table 5 presents the results of the development projects completed by the University of Oulu.

**Table 5. Development projects and results (modified from Article I).**

<table>
<thead>
<tr>
<th>Project</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCS</td>
<td>- Quality model of services and work conditions, measuring system</td>
</tr>
<tr>
<td></td>
<td>- Participative collaboration and communication at expert, management and</td>
</tr>
<tr>
<td></td>
<td>worker levels</td>
</tr>
<tr>
<td>TYTA</td>
<td>- Best in class based on walkthrough of good practices in individual</td>
</tr>
<tr>
<td></td>
<td>companies</td>
</tr>
<tr>
<td>TYKTA</td>
<td>- Continuous development towards the FOSC approach and system</td>
</tr>
<tr>
<td></td>
<td>- Piloting training material, first pilot courses for instructors and</td>
</tr>
<tr>
<td></td>
<td>employees</td>
</tr>
<tr>
<td>PORISHA</td>
<td>- Defining the strengths and weaknesses of managing risks in small and</td>
</tr>
<tr>
<td></td>
<td>medium-sized enterprises</td>
</tr>
<tr>
<td>TUTTO</td>
<td>- Approach for implementing a safety management system for small and</td>
</tr>
<tr>
<td></td>
<td>medium-sized enterprises (SMEs) for supplying services</td>
</tr>
<tr>
<td></td>
<td>- Best in class based on walkthrough of good practices in individual</td>
</tr>
<tr>
<td></td>
<td>companies</td>
</tr>
<tr>
<td>KEHYS</td>
<td>- Opinions on the FOSC system from individuals and companies</td>
</tr>
<tr>
<td></td>
<td>- Collecting time series of opinions and accident statistics</td>
</tr>
<tr>
<td>KEHYS II</td>
<td>- Continuing the above and tailoring the needs of the construction</td>
</tr>
<tr>
<td></td>
<td>branch, municipality workplaces and special view from SMEs</td>
</tr>
<tr>
<td>TALI</td>
<td>- Defining the basic requirements</td>
</tr>
<tr>
<td></td>
<td>- Unifying the terms of contracts concerning occupational safety</td>
</tr>
<tr>
<td></td>
<td>- Importance of reporting of accident/dangerous situations</td>
</tr>
<tr>
<td>HSEQ</td>
<td>- Piloting the HSEQ AP model</td>
</tr>
<tr>
<td></td>
<td>- Best in class based on walkthrough of good practices in individual</td>
</tr>
<tr>
<td></td>
<td>companies</td>
</tr>
<tr>
<td>TUOLATU</td>
<td>- HSEQ AP steering committee</td>
</tr>
<tr>
<td></td>
<td>- Opinions of the HSEQ AP from individuals and companies</td>
</tr>
<tr>
<td></td>
<td>- Further development for assessment tools and assessor training</td>
</tr>
<tr>
<td></td>
<td>- Collecting the time series of accident statistics</td>
</tr>
<tr>
<td></td>
<td>- Implementation of after-work assessment</td>
</tr>
<tr>
<td>TUOLATU II</td>
<td>- Evaluation for the procedure, results and experiences of HSEQ AP</td>
</tr>
<tr>
<td></td>
<td>- After-work assessment and simplified version of HSEQ AP</td>
</tr>
</tbody>
</table>
4.2 HS management practices and tools in the case company

In Article II, local HS management practices and tools were studied. The Article answers RQ2: What kind of HS management practices and tools are used in a global steel company?

All six sites had OHSAS 18001-based HS management systems, but it was not officially certified in each location. Although the local practices and tools varied greatly, they had similar frameworks. The local sites followed HS standards adequately (basic level fulfilled with some unconformities), but development was needed to proceed to the next level and to achieve more uniform and ambitious HS practices. HS tools, i.e. information technology (IT) tools that support HS management, included systems, applications, forms and software in the study. The number of used systems was remarkably high. The most desired characteristics for HS tools were user-friendliness, multipurpose usage, manageability, and time and cost effectiveness. The HS tools in use did not cover all the requirements that were set for HS management in corporate requirements. The main weaknesses were related to HS reporting and risk management tools and the high number of separate tools, which were not compatible with each other. HS management elements and the main findings are summarised in Table 6.
Table 6. The main elements of HS management in the case company and the substantial findings from the sites.

<table>
<thead>
<tr>
<th>Element</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk management</td>
<td>o Risks assessed at least at a basic level at each site</td>
</tr>
<tr>
<td></td>
<td>o Many risk assessment (RA) methods used</td>
</tr>
<tr>
<td></td>
<td>o Usually the responsibility of RA was in the production organisation</td>
</tr>
<tr>
<td></td>
<td>o Blue collar employees participated in the RAs</td>
</tr>
<tr>
<td></td>
<td>o Usually, the sites required contractors’ RAs</td>
</tr>
<tr>
<td></td>
<td>o RAs stored in different systems in different formats</td>
</tr>
<tr>
<td>Competence</td>
<td>o Many different HS trainings at the sites</td>
</tr>
<tr>
<td></td>
<td>o Usually trainings arranged by human resources or HS professionals</td>
</tr>
<tr>
<td></td>
<td>o Different training record databases on each site, mostly separate</td>
</tr>
<tr>
<td></td>
<td>record database for contractors</td>
</tr>
<tr>
<td></td>
<td>o Short introduction to HS required from contractors, more precise</td>
</tr>
<tr>
<td></td>
<td>from own personnel</td>
</tr>
<tr>
<td></td>
<td>o Safety and work instructions available for everyone, different</td>
</tr>
<tr>
<td></td>
<td>system on each site</td>
</tr>
<tr>
<td>Communication</td>
<td>o Intranet used for safety communications</td>
</tr>
<tr>
<td></td>
<td>o Many different additional tools for HS communications</td>
</tr>
<tr>
<td>HS performance</td>
<td>o Monthly HS reporting required</td>
</tr>
<tr>
<td></td>
<td>o Real-time follow-up for some HS performance indicators</td>
</tr>
<tr>
<td></td>
<td>o Spreadsheet follow-up on each site</td>
</tr>
<tr>
<td></td>
<td>o Target set for LTIFR on each site</td>
</tr>
<tr>
<td></td>
<td>o Additional local targets (leading and lagging indicators)</td>
</tr>
<tr>
<td>Reporting and</td>
<td>o Corporate-wide real-time LTI reporting</td>
</tr>
<tr>
<td>investigation</td>
<td>o Significant variations in local systems</td>
</tr>
<tr>
<td></td>
<td>o Accident investigation followed corporate standard workflow (reporting,</td>
</tr>
<tr>
<td></td>
<td>investigation, root cause analysis, actions, follow-up,</td>
</tr>
<tr>
<td></td>
<td>communication, learning), but the quality was not high</td>
</tr>
<tr>
<td></td>
<td>o Hazard/near-miss investigations varied greatly</td>
</tr>
<tr>
<td>Audits</td>
<td>o Audit procedures varied, many audit types used</td>
</tr>
<tr>
<td></td>
<td>o Reports stored in different systems</td>
</tr>
<tr>
<td>Meetings and</td>
<td>o Various meetings and reviews, including HS topics</td>
</tr>
<tr>
<td>reviews</td>
<td>o Documents, e.g. agendas, memos, stored in different systems</td>
</tr>
</tbody>
</table>

Corporate HS management roughly followed OHSAS 18001 requirements, similarly as on the sites. Corporate HS management was based on HS vision and principles. The vision was based on the idea that all accidents are preventable. The principles emphasised the individual’s own responsibility and possibility to be involved in HS. The leader’s example was in important role. Safety was the priority,
and if needed, took precedence over production (safety principle I). Thinking before acting, risk assessments and learning from mistakes were the other safety principles. The safety development plan focused on safety systems and processes, employee ownership and safety leadership. HS performance indicators for monthly follow-ups were defined and targets for LTIFR were set. HS standards defined the framework and gave guidance more widely. The following standards were launched at the time of publication of Article II:

- Incident investigation for accidents, near-misses and hazards
- Definitions for reporting
- Risk assessment
- Working at heights
- Manual handling
- Confined spaces
- Contractor safety
- Safety behavioural observations.

In addition, four standards were under development: HS communication, isolation of equipment, training and competence, and HS audits. Compared to the OHSAS 18001 elements, the main weaknesses were competence, communication, HS audits, control of documents, management review, operational control and change management. There were no procedures to manage these areas, or the procedures were insufficient or inconsistent.

### 4.3 HS performance indicators in the case company

Article III reviewed HS performance indicators in the case company, answering RQ3: Which HS performance indicators are used in a global steel company and how well does HS perform? The case company reported monthly leading and lagging HS performance indicators from each site, and the requirements were defined in the internal corporate HS standards and instructions (see the exact definitions from the Appendix 2). Both own personnel and contractors were included in the data.

Required lagging indicators were the number of fatalities, lost-time incidents, non–lost-time incidents, occupational diseases, total sick leave hours and sick leave hours due to injuries. Leading indicators were the number of near-misses, hazards, safety behavioural observations (SBOs were reported only by own personnel, not by contractors), other preventive safety actions and safety training hours. One
addition since the publication of Article III is that the case company often used a safety pyramid illustration in the internal HS performance statistics and reports.

Most of the indicators were covered at least adequately in the reporting. The most precise and unanimously understood indicators were fatal accidents, LTIs, total sick leave hours, sick leave hours due to injuries and SBOs. Confusion between the definitions of accidents without absence (non-LTI), near-misses versus hazards and other safety training indicators were observed. Reporting of occupational diseases was highly dependable on the local legislation, and comparable data with the same definition was difficult to receive. Safety training hours were not received from all sites. Length of absence was highly dependable on the country, and a similar type of accident could result in a different absence length in another country.

The case company’s LTIFR was compared to the corresponding data from WSA and IOGP. In 2005, it was significantly weaker (LTIFR 19.4), but in 2016, the frequency approached the benchmarks (LTIFR 2.24). The latest LTIFR in WSA was 1.01 and in IOGP 0.27. Fig. 6 presents the LTIFR from the case company and the benchmarks. One additional year has been added to this data compared to the original Article III.

![Fig. 6. LTIFR comparison (reprinted by permission from Article III © 2017 Authors).](image)

Detailed recommendations based on the literature and the interviewees’ experiences were given in Article III. There were two major issues. First, the corporate HS standards were not specific enough and compatible with the local instructions. Different national, international and corporate requirements caused
misinterpretations. Second, some of the indicator definitions needed to be more precise.

4.4 HSEQ management and performance in a shared workplace in Northern Finland

Article IV mapped the methods for supplying companies’ HSEQ management on one site of the case company. RQ4 (How are supplying companies’ HSEQ issues managed with the HSEQ AP at a shared workplace in Finland and how has the HSEQ AP performance and accident frequency changed?) is covered mainly in Article IV, but some results related to the description and experiences of the HSEQ AP were also presented in the Article I.

The HSEQ AP was developed for shared workplaces, keeping in mind that it should be suitable for small companies as well. Resources, time and money were saved, because one assessment made by a few representatives from different principal companies was valid for the whole group of principal companies who had joined the HSEQ AP network. The HSEQ AP covered health, safety, environment and quality aspects. The group of principal companies set the basic requirements, and supplying companies were evaluated against them. An assessor group from the principal companies included professionals from different areas, such as HSEQ, purchasing and maintenance. Each assessment had to include representatives (assessors) from at least from two principal companies. The HSEQ AP included self-assessments made by supplying companies and assessors’ assessments made by principal companies’ representatives. The assessments usually took from four to six hours, and after that, the supplying companies had the opportunity to define the actions for the revealed development focuses and deviations (if any). Corrective actions were followed-up and re-assessments were made when needed.

The supplying companies’ HSEQ management was fragmented with multiple different assessment methods on one site of the case company, and the supplier’s HSEQ performance level was not followed systematically enough. The HSEQ AP was chosen as one of the main methods to be used for supplying companies’ evaluations. The challenge at the time of the project was that the benefits of the HSEQ AP were seen in the principal company, but the usage was not extensive. Negative comments were related to the cost for the supplying companies and the agility of the method. One inspiration for a change was that it was known that supplying companies had higher LTIFR compared to the sites’ own personnel, and the ambition was to get them to the same level.
Article I revealed experiences related to the HSEQ AP at an early stage of its usage from principal and supplying companies’ perspectives. Based on the results, the HSEQ AP was functioning well, and both principal and supplying companies appreciated it. The representatives from the supplying companies appreciated it even more than the representatives from the principal companies (assessors). The supplying companies thought the HSEQ AP was useful and suitable for their branch. However, some of the questions and alternatives were not clear enough in their opinion. The assessors from the principal companies identified the same weakness. The assessors were satisfied with the suitability of the HSEQ AP for their branch. Additionally, they thought the instructions were adequate to complete the assessment.

Three years passed and in Article IV, the experiences were investigated again from the supplying companies’ perspective. One fundamental difference in the assessment procedure was that the main assessor’s role changed from principal companies to a third party (specialised for certification). The experiences related to the HSEQ AP were encouraging again, but further development was required. Advice from the assessors was appreciated, and in terms of good practices, the best value to be gained from the HSEQ AP was the development of HSEQ skills and management. Each interviewee thought that the requirements and results were realistic. All interviewees hoped that the HSEQ AP would be more transparent, which supports the other observation: how well-known is the HSEQ AP? All representatives thought that in Northern Finland it is known, but only in big companies. All interviewees agreed that cooperation with the principal company had improved after they participated in the HSEQ AP, but the significance of the results was not clear. The interviewees questioned how they would benefit by participating in the HSEQ AP.

The LTIFR and HSEQ AP results showed a positive trend, but it was unclear how much the HSEQ AP had affected this positive development. Still, all representatives from the supplying companies thought that the HSEQ AP had some positive effect on HSEQ performance and practices. The scores of the HSEQ AP were higher in the second assessment round compared to the first assessment, and the average increase was 44% from 292 to 422. Fig. 7 presents LTIFR development in the shared workplace.
The trend with all supplying companies in the shared workplace was decreasing, and each supplier that participated in this part of the study improved their LTIFR during the 2008–2013 period. It was remarkable that the higher the supplying company’s LTIFR was in 2008, the faster the decrease was over the next six years. Both parties at the shared workplace improved their LTIFR from 25 to below 5 (principal company) and around 12 (supplying companies), and the combined LTIFR in the shared workplace was 6.2 in 2013.

4.5 Recommendations for further development in HS(EQ) management

SWOT analysis (Table 7) was conducted based on the empirical results from Articles I-IV and the literature review aiming to answer to RQ5 (What actions should be taken to improve the current situation and to achieve excellence in HS(EQ) management and performance?). The analysis aims to provide a description of the current situation and how to continuously improve HS(EQ) management practices, tools and indicators in the changing global working environment and in the shared workplace.
Table 7. SWOT analysis – HS(EQ) management in the case company and in the shared workplaces.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>Participative development</td>
<td>Fragmented and complicated HS management, IT,</td>
</tr>
<tr>
<td>Long-term commitment</td>
<td>reporting systems and audit practices</td>
</tr>
<tr>
<td>Leadership commitment</td>
<td>Not fulfilling all the requirements set by internal HS</td>
</tr>
<tr>
<td>Good performance development (LTIFR, HSEQ AP)</td>
<td>standards, limited compatibility with local instructions</td>
</tr>
<tr>
<td>Basic level in HS management achieved (OHSAS 18001 based)</td>
<td>Narrow quantitative targets</td>
</tr>
<tr>
<td>Internal HS standards applied adequately</td>
<td>Focus on lagging HS performance indicators</td>
</tr>
<tr>
<td>Contractors included in HS performance indicators and HSEQ management requirements</td>
<td>Occupational diseases not reported adequately</td>
</tr>
<tr>
<td>Development needs acknowledged regarding HSEQ management in shared workplaces</td>
<td>Not standardised HS competence and training, change management, company-wide HS management review, and HS documentation control practices</td>
</tr>
<tr>
<td></td>
<td>Multiple tools for supplying companies’ HSEQ management</td>
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<tr>
<td></td>
<td>High LTIFR in supplying companies</td>
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<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
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<tbody>
<tr>
<td>Learning from good practices inside the company</td>
<td>Focus on numbers instead of ‘big picture’</td>
</tr>
<tr>
<td>Ensuring the applicability and development of the existing standards, developing the missing standards</td>
<td>Focus on lagging indicators</td>
</tr>
<tr>
<td>Leading indicators and qualitative methods</td>
<td>Fragmented and not genuinely preventive safety culture</td>
</tr>
<tr>
<td>Benchmarking with wider set of indicators</td>
<td>Safety climate measurement HSEQ management not supported by IT systems</td>
</tr>
<tr>
<td>Safety climate measurement</td>
<td>Incompatible IT systems between the sites</td>
</tr>
<tr>
<td>Focus on attitudes and behaviour</td>
<td>Standardised requirements for HS competence and training, change management, HS communication, Settling for an adequate level</td>
</tr>
<tr>
<td></td>
<td>Incident investigation, company-wide HS leaders do not understand their roles and management review, HS documentation control responsibilities related to safety</td>
</tr>
<tr>
<td></td>
<td>Complete PDCA cycle and continuous improvement</td>
</tr>
<tr>
<td></td>
<td>Fragmented field of HSEQ management practices</td>
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<tr>
<td>HSEQ performance</td>
<td>The HSEQ AP not developed further</td>
</tr>
<tr>
<td>Development and implementation of IMS</td>
<td></td>
</tr>
<tr>
<td>Expanding the usage of the HSEQ AP</td>
<td></td>
</tr>
<tr>
<td>Developing HSEQ in shared workplaces</td>
<td></td>
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<tr>
<td>Treating internal and external personnel similarly</td>
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</table>

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Based on the recommendations made in this thesis, HS(EQ) management practices could be developed further, but the threats must be regarded when considering the next steps. Threats can realise if there is insufficient motivation to attempt the development attempt or if there is a lack of resources and ambition. The main threats are related to the reactive and performance focused ideology and culture (lagging indicators). The importance of supportive IT systems was acknowledged, and it was seen as a big threat if they are not sufficient. Confusion about the roles and responsibilities as well as the fragmented HSEQ management practices reflect the same: the work environment is changing, becoming more complex and heterogenous, and in such an environment the practices and tools must be effective.

Weaknesses can become opportunities if the resources are allocated properly. The most powerful tools can be learning from others (internally) and benchmarking other organisations. The safety culture, including the attitudes and behaviour, is an essential part of the success and continuous improvement in an organisation. However, the foundation and basic requirements must be in place to be able to develop further. The benefits of IMS and HSEQ management principles should be used to support the basis of HSEQ management.
5 Discussion

5.1 HS(EQ) management, standardisation and cultural issues

HS(EQ) management practices in shared workplaces are developing rapidly. Companies from different branches, research organisations and international associations are aiming for better workplaces, but sometimes the direction is different to some extent. Terminology has created challenges even between the articles in this thesis, and even when the participants were from quite narrow business branches. Standardisation from several perspectives is clearly required.

HS and safety, e.g. in the context of HS management/culture and safety management/culture, were used as similar expressions in the case company and in the literature. Often, the weighting was undoubtedly on safety in the case company. Standardisation (ISO, 2018; SFS, 2007) had the same emphasis as did the scope in this research. It should be highlighted that occupational health from an occupational health care aspect was not usually a part of HS issues. Occupational disease-related terminology was also a variable. Occupational disease was used the most (e.g. case company; Commission Regulation 349/2011; GRI, 2013), but work-related or occupational illness (WSA, 2017b) and illness (OGP, 216) were also used.

In addition, ‘O’ for occupational was both included, e.g. in HS management systems (ISO, 2018; SFS, 2007), and excluded, e.g. in the context of safety indicators (e.g. Hale, 2009; Harms-Ringdahl, 2009; Reiman & Pietikäinen, 2012; Øien et al., 2011), shared workplace (e.g. Milch & Laumann, 2016; Nenonen, 2012) and safety culture (e.g. Corrigan et al., in press; Eeckelaert et al., 2011; Morrow et al., 2014). If E and Q were included, O was excluded in the case company and in the shared workplace (HSEQ AP). A similar trend was observed in the literature (Duijm et al., 2008; Gholami et al., 2015), although IMS was often used to describe the entity aiming for one system (e.g. Bernardo et al., 2009; Salomone, 2008; Wilkinson & Dale, 2007; Zeng et al., 2007).

Global terms in the case company (Articles II and III) related to shared workplace were “own personnel and contractors”, and the terms in Northern Finland (Articles I and IV) were “principal company and supplying company”. The latest trend can be seen in ISO 45001 (ISO, 2018), which uses contractor. Contractor should be considered for use in the shared workplace context as well. In addition, lost time injury (e.g. IOGP, 2016; Kjellén, 2000; WSA, 2017b) and lost time incident (in the case company, Articles II and III) were used as parallel terms.
To concur with the mainstream, it is recommended that lost time injury be used in the case company as well.

The fragmented terminology reflects the actively developing field of HS(EQ) management research. In addition, the terminology related to the local languages and translations created challenges in the global company, the case company. There might not be a word for all the terms in all languages and explanations were often required. Misunderstandings and complications are obvious risks.

Advantages of HS management (Shirali et al., 2018) and the wider advantages, e.g. to company performance (Fernández-Muñiz et al., 2009; Forteza at al., 2017), motivation (Das et al., 2008) and social responsibility (Montero et al., 2009; Väyrynen, 2017), have attracted a great deal of attention in academic research and the business world (e.g. WSA, 2018a). The findings from the Northern Finnish process industry and from the case company support this increasing significance. It is essential that the basis of HS(EQ) management is built up on a sustainable foundation. If the framework is not stable, the advanced layers will fail to provide the advantages. Previously, OHSAS 18001 (SFS, 2007), and presumably from now on ISO 45001 (ISO, 2018), can form the basic structure and fundamental elements for HS management supported with E and Q management systems, such as ISO 14001 and ISO 9001. The latest development in ISO standards (HS, E and Q) are following the same generic management system approaches (ISO, 2018). Based on the common structure and the strong tradition in Q management, it is easier for organisations to integrate separate management systems into their business processes and form IMS.

Complex sociotechnical systems created challenges for the whole research environment. Management systems, internal standardisation and corporate responsibility activities are aimed at managing HS risks in the global environment (Morschett et al., 2009). Supporting and complementing common management system standards, such as OHSAS 18001 (SFS, 2007), the case company’s global HS vision and principles, internal HS standards, HS performance indicators and HS development plan (Articles II and III) were aiming for similar benefits (cf. Morschett et al., 2009), but like the global environment, it was actively and continuously changing, complex, and heterogeneous. These tools are required in order to form the desired uniform safety culture. Differences in HS(EQ) management between the sites in the case company were observed and the shared workplace created its own special features. Internal corporate HS standards should be based on a higher level of definitions and standards following the principles of the business branch (WSA, 2017b), general HS management standards (ISO, 2018;
SFS, 2007) and global guidelines (ILO, 2009). As external definitions differ, it is important to standardise requirements inside the company, between the operators in the shared workplaces, and wider in the global field. Once standardised HS management practices have been defined, it is important to ensure that the standards are applied and developed further at every level.

Standardisation aims to respond to the local differences in the case company e.g. with HS definitions, which Kurppa (2015) also noticed in the form of national accident statistics. The corporate HS definition standard was perceived as not specific enough, and it was not always compatible with the local instructions. This result supports previous research findings with various practices in LTIFR and accident statistics (Kurppa, 2015). Another weakness in the case company’s internal HS standards was competence (Article II). This is a congruent result with the conclusion in Article III, with training one of the weakest HS performance indicators reported. Competence and HS training practices should be standardised inside the case company due to the requirement in ISO 45001 (ISO, 2018). Sheehan et al. (2016) suggested that the provision of OHS training could be one of the leading HS performance indicators, which could develop HS management in the case company in a more preventive direction.

As Paton and McCalman (2000) stated, change is one of the constants, and that has been obvious in the case company especially from the organisational change’s perspective. After one change, there was another coming. The initial setting has changed to something completely different, and the new situation must be acknowledged (cf. Levovnik & Gerbec, 2018) and reviewed. The working environment was continuously changing. Thus, the ability to manage unexpected situations became a prerequisite for excellence. Changes have a wide effect on an organisation, as Mathisen et al. (2017) described. This can also be seen from the LTIFR development in the case company. LTIFR increased after a large organisational change, and after that, it has settled down. As Le Coze (2011) pointed out, the impact of change on accident prevention was (and should be) highlighted. Globalisation is visible in the case company as it was in the studies by Gerbec (2017), and Schneider and Hollister (2008). In the case company, it was observed that change management from the HS management perspective required more effort. As EU-OSHA (2010) summarised, the more closely HS management becomes linked to the core activities, the better HS performance will be during organisational change. The importance of managing change is supported in ISO 45001 (ISO, 2018) as well. This study supports the findings emphasising the importance of change management in HS(EQ) management. Exploiting the process
of change management has only started within the organisations that are the subject of this research.

Learning from accidents is a fundamental goal in accident prevention and in HS management. All accidents must be preventable, but if an accident occurs, the focus should be on learning from the accident and treating it with the required seriousness. The effectiveness of the defined actions during an incident investigation was one challenge in the case company, similar to the conclusion reached by Margaryan et al. (2017). The investigation process was created, but the quality needed assurance (Article II). Regarding occupational accidents, one must be idealistic and aim for zero accidents, as Zwetsloot, Kines, Ruotsala et al. (2017) described. It must be understood that the aim is not to reach the goal immediately and there is more than one aim. However, the main aim is to make the journey towards zero accidents supported by the preventive actions. There are milestones during the journey (e.g. yearly LTIFR and TRIFR targets, which can be more than zero). Through these milestones, the organisation accepts that it is not perfect and idealistic but is aiming for something and learns from any mistakes that occur (accidents and near misses).

The ‘safety first’ ideology has a similar aim in the case company (Article II) than the Zero Accident Vision (Zwetsloot, Kines, Ruotsala et al., 2017). Both WSA (2018a) and the International Stainless Steel Forum (2018) supported the vision in their principles. Zwetsloot, Kines, Ruotsala et al. (2017) argued that if business analysts who see ‘innovation for zero’ as a mega trend for the coming decade are right, the Zero Accident Vision has the potential to become a very significant trend in safety leadership. Companies aiming for zero accidents are committed and serious in their strategies and practices to improve safety, and they understand that it will be a continuing effort (Zwetsloot, Kines, Ruotsala et al., 2017).

The Zero Accident Vision has similar characteristics as the positive safety culture (Corrigan et al., in press). When developing safety culture further, there are a few principles that should be exploited. As Schein (2010) defined, organisational culture is a product of learning from the group; thus, it is important for the group to learn together, share their values and be genuinely committed to the goal (safety). A thriving safety culture depends on trust and transparency, and it is important to consider the possibility of the ownership of safety. In addition, an open climate plays a significant role, together with encouraging dialogue (Martínez-Córcoles et al., 2012). An environment where employees feel comfortable voicing their suggestions and concerns about safety (Curcuruto et al, 2015), an open-door policy for hazard and accident reporting, a sincere concern for employee well-being,
fairness in accident investigations (Brown et al., 2000), together with a positive safety communication and error management climate (Cigularov et al., 2010; Moore et al. 2015) are the essential success factors in HS(EQ) management. Good HS leadership principles, as described by Kaluza et al. (2012), were observed, although not directly investigated, in the case company. For example, the commitment of the organisation’s board and senior management, serious attitudes from leaders towards a positive safety culture and safety climate, and high-level management’s direct involvement in implementing HS policies were observed characteristics of good HS leadership principles. It is crucial for leaders to understand their roles and to learn how to be safety leaders (Sheehan et al., 2016), and this must be emphasised in the case company.

Developing HSEQ management systems and processes are the first step, but commitment, engagement and participation will define the ultimate success (cf. Martínez-Córcoles et al., 2012; Wachter & Yorio, 2013; Zwetsloot et al., 2013; Zwetsloot et al., 2014) of a uniform and preventive safety culture in the case company and in Northern Finnish shared workplaces. It will show how safety is perceived as a value (cf. Ratilainen et al., 2016).

5.2 HS indicators and performance

HS performance has recently gained a lot of interest in HS management research. Performance measurements are required in order to achieve the desired results in terms of healthier and safer workplaces. The determined HS indicators define the levels to compare and the desired outcomes. The distinction between leading and lagging indicators and the use of accident statistics as an indicator is a highly controversial research topic (Dyreborg, 2009; Harms-Ringdahl, 2009; Hopkins, 2009; Lingard et al., 2017; Sinelnikov et al., 2015; Øien et al., 2011). A similar trend was observed in the case company (Articles II and III). For example, a near-miss has the characteristics of both leading and lagging indicators. In the case company, a near-miss was leading indicator due to its potential to prevent accidents through investigation and corrective actions. However, after the empirical study, it was changed to a lagging indicator, since something has already happened (no injuries, but for instance, property damage), and the focus was placed on more preventive indicators, such as hazards and SBOs. As a lagging indicator had the characteristics of a leading indicator in predicting another outcome or event, the conclusion supports Dyreborg’s (2009) findings.
Supporting also the research of Øien et al. (2011), it is essential to develop and implement useful indicators that can provide early warnings about potential major accidents, and the discussion between leading and lagging indicators is a secondary issue. The findings in this research support the previous studies, with the focus of HS management and accident prevention on preventive indicators and actions (Bellamy et al., 2013; Douglas et al., 2014; Grabowski et al., 2007; Hinze et al., 2013). The use of qualitative methods, as ISO 45001 (ISO, 2018) suggests, is one alternative for developing HS performance indicators in the case company, because many leading indicators are qualitative (cf. Sheehan et al., 2016).

Similarly, as Sinelnikov et al. (2015) concluded, corporate HS performance was measured and especially communicated in the case company often with lagging indicators, but on the site level, the focus was more on leading indicators. There was a standard index in the case company for leading indicators (cf. Sinelnikov et al., 2015), and it was used for benchmarking internally at some level. However, the communication with leading HS performance indicators was inadequate. The importance of HS communication was acknowledged in the literature (ISO, 2018; Kaluza et al., 2012; Martínez-Córcoles et al., 2012; Sheehan et al., 2016), and it requires development in the case company (Article II).

The currently used leading indicators in the case company were quite an adequate type of measurable indicator, but they were not exploited well enough (Article III). The essential role of the indicators was not highlighted, and the usage was not ambitious. There were several indicators, as also Hinze et al. (2013) and Øien et al. (2011) suggested, but the individual indicators needed to be more specific and consistent (cf. Leveson, 2015; Zwetsloot, 2013). Also, the communication with them should be more visible to achieve the characteristics of a good indicator, as previous research has described (Hale, 2009; Leveson, 2015; Zwetsloot, 2013). The correlation between leading and lagging indicators should be highlighted in the case company, so that the managers understand their validity, as Hale (2009) points out. The relevance, representativeness and effectiveness (cf. Leveson, 2015; Zwetsloot, 2013) of the indicators should be evaluated as well. There was not a target for leading indicators in the case company at the company-level, and the creation of achievable and unbiased targets should be considered to facilitate development in a more proactive direction. The findings in this research are aligned with previous studies (Bellamy et al., 2013; Douglas et al., 2014; Hale, 2009; Leveson, 2015; Zwetsloot, 2013).

The safety pyramid illustration is used in the case company as it is used within its benchmarks (IOGP, 2016; WSA, 2017b). Although it is statistically invalid for
different economic activities and geographic regions, the inconsistency is small, and the pyramid is useful for practical purposes as a descriptive and predictive tool. The result supports the previous findings made by Marshall et al. (2018). The importance of reporting a minor incident is acknowledged in the literature (Bellamy, 2015; Marshall et al., 2018) in the same way as it is in the case company. Placing an extra layer (behaviour) on the bottom of Heinrich’s pyramid, as suggested by Sutherland et al. (2000), could be one way to illustrate how behaviour is emphasised among leading indicators. SBO was an indicator, which is used in the case company for this purpose.

LTIFR statistics were compared in this thesis despite the critique it has gained as an HS performance indicator. The justification for that is that it is commonly used with quite reliable data available (if the exact definition is provided), and it is the only widely available HS performance indicator used for benchmarking. Uncertainties, such as underreporting (Eurostat, 2016; Eurostat, 2018; Moore et al., 2015; Probst et al., 2017; van den Heuvel et al., 2017) and differences in legal and compensation criteria (Hämäläinen et al., 2017), behind the accident statistics should be acknowledged, and the numbers should be critically reviewed. In addition, several inconsistencies in accident statistics’ details as described in Section 2.2.2 increase the uncertainty. Even inside the EU, differences are inevitable, and when dealing with the global data, the differences are even more substantial (cf. ILO, 2002; van den Heuvel et al., 2017). If the definition of LTIFR is available in the source, it is possible to make rough comparisons. However, the comparator must know the background and the content of the data, and the results must be communicated carefully to avoid misinterpretation. Critique towards occupational accident statistics should not be taken lightly.

Despite the uncertainty, comparisons and benchmarking are a good way to learn and proceed with the HS excellence pursuit. The results of this research support Kurppa’s (2015) findings that it is useful to make crude comparisons as the benchmarking reveals development targets and good practices. One alternative could be comparisons between fatal and non-fatal accidents, as Kurppa (2015) suggested. However, that requires a large amount of data, and at the company level where there are, for example, one or none fatal accident per year, it is not a practical measure. Nevertheless, at the country or regional levels, it could be used. In addition, IOGP (2016) uses the severity of lost workday cases (the number of days lost for each lost workday case) and the severity of restricted workday cases (the number of days of restricted work per restricted workday case) as indicators, which describes the severity better than just the number of accidents. However, it was
observed in Article III that the length of absence is not necessarily a valid indicator to compare the seriousness of accidents globally due to the local differences in legal and compensation criteria. Therefore, it is more usable for narrow internal comparisons.

The fast development of HS performance indicators is noticeable in the literature and in the case company (Articles II and III). For example, in the case company, commuting accidents was not a separate accident category when the empirical data was collected, but later it was changed to one. Also, WSA (2017b) has included it in its latest definitions. This result supports the previous studies claiming that commuting accidents are categorised in variable ways (ILO, 2018c; Eurostat, 2013). In addition, the focus from LTIFR has changed to TRIFR (to include restricted work and medically treated incidents in addition to lost time injuries) in the case company after the empirical data was collected. That development follows the example of IOGP (2016) and WSA (2017b), taking accidents with less severe injuries into consideration. This is a good example supporting the conclusion of Kurppa (2015), which was that benchmarking reveals development targets and good practices. The definitions and the main indicators develop, and precision continuously increases. Clearly, academic research and practitioners have both noticed the same.

Accident statistics, and more specifically, LTIFR comparisons (with the exact definition) should be used together with other HS performance indicators, highlighting the importance of leading indicators. In the case company, there are other HS performance indicators as well; thus, they are not leaning towards LTIFR only. Despite the critique, accident statistics are a measure that tells how many individuals have been injured. Even one accident is too much. Ultimately, the aim and vision must be to prevent all accidents and not to focus on a certain number of them. Socially responsible organisations aim for well-being at work, and a healthy and safe workplace (ISO, 2010; ISO, 2018; Montero et al., 2009; WSA, 2018a; Zink, 2014). The accident rate indicator is not a perfect HS performance indicator, far from it, but it is still usable for limited purposes if its weaknesses are kept in mind. Inside one organisation, a trend is inevitable, and the rate of accidents has decreased in all groups in this study. It is clear message that the rate of accidents is decreasing.

The number of occupational diseases, as Kurppa (2015) claimed, was even more difficult to measure than the occupational accidents. The findings in this study support his conclusion; thus, the comparable data and systematic evaluation with the indicator even inside the case company did not exist (Article III). The number
is often presented in sustainability reports (GRI, 2013; Koskela, 2014) as it was in the case company. It should be considered how occupational disease prevention (considering also exposures and occupational hygiene) as a wider theme could be included in the corporate HS standards as EU Council Directive 89/391/EEC (1989) requires, even though a comparison between the number of occupational diseases would not be the focus.

5.3 HSEQ management in shared workplaces

Reflecting the diverse definition of shared workplaces (Chen et al., 2004; Dolgui & Proth, 2013; Lamare et al., 2015; Nenonen, 2012; Nygren, 2018; Oedevald & Gotcheva, 2015; Occupational Safety and Health Administration in Finland, 2017; Ustailieva et al., 2012; Väyrynen, 2017), their HSEQ management practices and tools started to form and develop strongly in the 2000s. As Nenonen (2012) concluded, many safety issues have gained recognition in multiemployer workplaces, but there are still many issues left to be developed (Luria & Yagil, 2009; Nenonen & Vasara, 2013; Wasilkiewicz et al., 2016; Yorio & Wachter, 2014). EU-OSHA (Ustailieva et al., 2012), the Finnish legislation (738/2002, 44/2006, 1233/2006), ISO 45001 (ISO, 2018), the Northern Finnish process industry and the case company have recognised that the traditional way to organise work has changed.

As Zink (2016) argued, the entire supply chain must be considered when companies are aiming to act sustainably. The results from the case company (Articles II and III) show that overall performance was measured. The same principle has been applied in the research and development of the HSEQ AP. A standardised selection of common leading indicators specified for shared workplaces was not observed, and it supports the findings made by Hallowell et al. (2013). There were some HS performance indicators, especially lagging, which were used widely, but leading HS performance indicators were not exploited. The interest was strongly in LTIFR performance. As Haslam et al. (2016) reported, proactive HS management could be a way to increase positive safety climate perceptions, leading to improved employee organisational commitment and job satisfaction. The HSEQ AP could be used as a leading indicator in shared workplaces. Nonetheless, it is a key tool for developing partnerships and mutual excellence within a business network.

In order to reduce the negative consequences of outsourcing and increase the positive value and success of HSEQ management, collaboration and participation
(Camarinha-Matos et al., 2009; Directive 89/391/EEC; Ju et al., 2018; Väyrynen, 2017; Väyrynen et al., 2016) are key elements to succeed at the intra- and inter-organisational levels in complex socio-technical systems (Milch & Laumann, 2016). The development of the HSEQ AP successfully applied participatory development and collaboration principles. The group of people and organisations participated in the projects and were committed to the goal, which they knew was going to be a long path. The HSEQ AP was selected as the main assessment method in the case company’s one site (Article IV), which increases its importance for suppliers to participate in it. In HSEQ AP development work, many active pioneering supplying companies were involved. Determined and engaged HSEQ AP-related research and development work has paid off, and the LTIFR decreased in the shared workplaces. At the same time, the scores in HSEQ AP increased based on a small sampling. Within the same group of companies and a review of the long-term trend, the results show positive development in HSEQ management. However, the HSEQ AP could help more to confirm suppliers’ adequate HSEQ performance. If that is made in a wider extent, suppliers will see more value for participating in it.

Collaborative and participatory methods should be applied in safety culture development (Hallikas et al., 2004; Oedevald & Gotcheva, 2015). The safety culture is under development every day because the people and organisations present in shared workplaces are changing constantly. The HSEQ AP is one approach to collaborate in a multilevel network but requires commitment from all sides. The contractor companies that are aiming to work in a safety-critical environment should take the initiative to be competent and equal partners in the business network, as Oedevald and Gotcheva (2015) claimed. The HSEQ AP acknowledges the versatile group of supplying companies and aims to understand them (Väyrynen, 2017). The motivation strategy to safety depends on the company size (cf. Pedersen & Kines, 2011), and it should be considered in a heterogeneous group of supplying companies. As Oedevald and Gotcheva (2015) concluded, safety management systems cannot be homogenised in large subcontractor networks. Large companies with more resources can act as an example, which is applied to the HSEQ AP development. Assessors from principal companies have advised on how to develop HSEQ issues in the supplying companies, which has been one of the main benefits. Supporting the results of Ju et al. (2018), large companies are acting as role models.

Northern Finnish HSEQ management development follows a comparable path as IMS development (Wilkinson & Dale, 2007) and HS integration with a broader
strategic management process (Zink, 2014). The HSEQ AP has similar benefits in supplying companies’ HSEQ management as IMS in general, such as reducing duplication and costs due to similarities, supporting sustainable development and improving communication (Hamidi et al., 2012; Zutshi & Sohal, 2005). The results in Article I supported the IMS approach throughout HSEQ with other studies (e.g. Wilkinson & Dale, 2007; Zeng et al., 2007). However, the reality was different on a broader scale. In the case company, the management systems were separated at the corporate level. One reason could be the critique towards IMS as the studies revealed (Bernardo et al., 2012; Nunhes et al., 2017; Sui et al., 2018). IMS could be exploited more efficiently to avoid the overlapping of multiple management systems. According to Wilkinson and Dale (2007), there is little or no difference between Q management and excellence. The identified goal in the case company is to strive towards excellence in HS management; thus, it can be seen as similar to HS and Q management. As Article I concluded, the principal companies’ IMS-like systems and supplying companies’ management systems are becoming more similar. The same trend is seen in the case company. Some of the sites had integrated systems and some (not all) of the sites were aiming for that. In addition, one site was striving to enhance the usage of HSEQ AP. The future will show if wider IMS implementation will be made and if it is successful.

Väyrynen (2017) stated that the HSEQ AP is an effective tool, but the research and development must be continued, and this thesis supports that conclusion. A recent development is promising for the future of the HSEQ AP: a national standardisation body in Finland has published a standard based on it (PSK 8404, 2015), which should increase its popularity. Latva-Ranta, Väyrynen, and Koivupalo (2012) discovered that the HSEQ AP’s self-assessment results were similar to the actual assessment, and the results in Article IV supported that observation. Also, good agreement was observed between the experts and the actual audit results (Jounila, Cajander, Reiman, Latva-Ranta, & Väyrynen, 2017). However, various criteria in the tool and the scales related to those criteria should be improved (Jounila et al., 2017). Jounila et al. (2018) analysed HSEQ audits and suggested areas for improvement among supplier companies. Development needs from principal and supplying companies were observed in Articles I and IV as well. Recent research activity supports the efforts to expand the usage and develop the assessment procedure (e.g. Jounila et al., 2017, 2018; Article IV; Laine, 2018; Article I). As Väyrynen et al. (2016) suggested, the network utilising the HSEQ AP can be called at best a cluster of safety culture and sustainability.
Although outsourcing and globalisation in the business environment is a trend, safety cannot be outsourced for external companies or for corporate HS(EQ) organisations. Safety must be a value and a characteristic inside the organisation. To be able to succeed, safety must be understood similarly within the heterogeneous group of all the operators no matter what organisation they represent. The desire to work safely must come from inside the organisation to be able develop a safety culture.

5.4 Contribution of the study

The first aim of this thesis was to describe the main development steps of HSEQ management practices in Northern Finnish process industry companies and their company networks (shared workplaces) over the past 20 years. The HSEQ AP in the context of shared workplace was also studied. Furthermore, the study describes the current state of HS and partly EQ management in a global steel company, the case company. The third and the most important aim was to identify the development needs and make recommendations for improving HS(EQ) management practices in the process and steel industries.

This research contributes to the scientific community by adding knowledge about HS(EQ) management in the Northern Finnish process industry and global steel industry companies. New information was acquired from the HSEQ management development steps towards IMS and the usage of HSEQ AP in shared workplaces. In addition, new information was acquired from LTIFR development in the global company and in shared workplaces. From the global company’s perspective, new information also came from HS(EQ) management practices and tools, as well as HS performance indicators and benchmarking. The specific findings were:

- Terminology and definitions related to HSEQ management are fragmented and not well established internally in this case study and externally between organisations, e.g. national authorities, insurance companies, standardisation organisations, other global organisations, researchers, industry branches and companies.
- LTIFR is an adequate indicator for benchmarking purposes. Positive results were seen for the LTIFR development in the context of this study.
The importance of HS(EQ) management for all the operators in the shared workplaces was acknowledged in the Northern Finnish process industry and in the case company, global steel company.

HSEQ AP utilises an IMS-like system as a supplier’s assessment and management tool, and performance has been improving among the supplying companies. However, further development in HSEQ AP is needed.

The variety of HS(EQ) management practices, processes, tools and indicators is high in this global organisation, which was facing continuous changes.

The case company’s HS management system is based on OHSAS 18001 with HS vision and principles, development plan, internal standards and performance indicators.

Diverse internal and external requirements in HSEQ management increase the importance of standardisation.

A uniform safety culture, preventive actions, leading indicators, commitment and participation at every organisational level have a significant role in shared workplaces and in global organisations aiming for excellence in HS(EQ) management and performance.

Learning from internal good practices and benchmarking from external organisations are valuable methods for developing HS(EQ) management, processes and tools.

This research provides useful results for the process and steel industry organisations, which can be (and have been) used in planning, decision making, target setting and when aiming for excellence in HS(EQ) management and performance. Other organisations can use the results for benchmarking purposes. The given recommendations have high value for the case company and for other organisations aiming for excellence in HSEQ management and performance. Results related to HSEQ AP can be (and have been) used to develop the assessment procedure further.

5.5 Reliability and validity

This thesis investigated HS(EQ) management practices in a global steel company and in the Northern Finnish process industry. The study sought an in-depth understanding of how the practices have developed during the past 20 years, what the current situation is and how to develop it further. A qualitative research method was justified, since the empirical practitioner’s experiences and perceptions increase knowledge. A combined pragmatic and scientific research approach made
it possible to investigate the topic from in-depth aspects in practice. The case study method was chosen, because it could provide a broad view of the phenomena. According to Eriksson and Kovalainen (2008) a good case study is significant in one way or another, e.g. unusual, unique, or of general interest, relevant, or studies interesting issues theoretically or practically. In this case, HS(EQ) management was studied from an exceptionally wide perspective (in the process and steel industries, from local to global, and from details to wider issues), which is interesting for researchers and practitioners both theoretically and practically.

Validity is defined as the extent to which the data collection method or research method describes or measures what it is supposed to describe or measure (Lancaster, 2005). Construct validity refers to the extent to which the study investigates what it claims to investigate (Farquhar, 2012). Internal validity aims to persuade the reader that the research findings are based on a critical investigation of the data, which can be demonstrated by providing details on how the data was analysed, e.g. coding and within-case and cross-case analysis, including an explanation of how the data was triangulated (Farquhar, 2012).

The case study must be complete, which means that explicit attention has been given to the definition of the case and its context, and that all relevant evidence has been investigated (Eriksson & Kovalainen, 2008). To gain completeness, both the supporting and the challenging evidence were presented widely in this study. A definition of the case and its context has been made with accuracy because it was a prerequisite, due to the fragmented and reasonably vague research environment. The detailed description of the methodology aimed to increase internal validity.

A good case study considers alternative perspectives, which involves the examination of evidence from different perspectives, e.g. by triangulation (Eriksson & Kovalainen, 2008). Farquhar (2012) argues that triangulation alone as a means of supporting construct validity is probably inadequate, and a clear chain of research from RQs to conclusions should be presented. The methodology and the complete chain of research were described in detail. Triangulation involves varieties of data, investigator, theory and methodology, according to Denzin (1989). Triangulation with multiple methodologies (quantitative and qualitative) and mixed methods (interviews, document study, questionnaire, benchmarking, SWOT analysis) in material and data collection and analysing were used in this study. More than one researcher were involved, and several people were interviewed.

Semi-structured interviews were used to enable flexible interactions between the researcher and interviewees. It also allowed interviewees to explain the issues as they felt comfortable using their own words. Although the main elements were
covered, it is possible that some answers did not cover the topic’s small sub-parts completely, and some information is still hidden behind the interviewees due to the wide topic. Several sites and companies (organisations) were selected for this study to be able to create a more comprehensive description of the situation. The number of interviewees was adequate for the purposes of this study, but in the case of the supplying companies’ HSEQ AP results (Article IV), more material should be reviewed due to the small sample size.

**Reliability** outlines the extent to which a data collection approach will yield the same results on different occasions (Lancaster, 2005). Repeatability can be evaluated as Yin (2009) suggests: can another researcher repeat the research logic using the same data and end up with the same conclusion? In this study, it is unlikely that another researcher would be able to obtain the same research setting later; thus, the repeatability is limited. The organisations have changed, and the interviewees no longer work in the same organisation. In addition, the HS(EQ) management practices have developed further (which is good from the viewpoint of continuous improvement). Thus, the research described the current moment with the aim of improving HS(EQ) issues. The same questions could be asked with a new organisational setting, but the results would reflect another situation. For example, in Articles II and III, the study was made from the corporate perspective, and the local perspective would reveal new interesting characteristics. However, if the same research setting and the current level of HS(EQ) management (time dependable) could be achieved, then similar results could be achieved by another researcher. The collected data was recorded, transcribed and stored, so the evidence can be retrieved if required. From the corporate perspective (Articles II and III), the material was written and there was no risk for interpreting the material differently.

Criticism to interpretivism is related to producing subjective results and that the results are dependent on the individual researcher (Johannessen & Perjons, 2014). In addition, qualitative research has subjective connotations (Yin, 2009). Several researchers collected the data for this study to reduce single researcher bias. The data analysis was mainly made by one researcher (except partly in Article IV), so it is dependent on the researcher and the interpretation of the phenomena. However, the direction of the analysis would probably be quite similar with another researcher. The researcher has both an academic and a practical background with wide experience from both branches, which allows for investigating the topic from several perspectives. According to Yin (2009), transparency can be demonstrated
through careful documentation and references to the case study research database, supporting the construct validity at the same time.

**Generalisability** is another dimension of validity quality in data and relates to the extent to which the results from the data can be generalised to other situations (Lancaster, 2005). The studied HS(EQ) management procedures and tools are relevant from small companies to global organisations at least in an industrial context. Multiple aspects for the case were studied to tackle the challenge of generalisable results, which is common for case study methodology (Yin, 2009). Furthermore, multiple aspects supported the achievement of results from a heterogeneous and fragmented research environment. The aim of this study was to expand and generalise existing theories related to HS(EQ) management by describing it in its current industrial context in practice. Also, the recently developed HSEQ AP was described and tested. This study provides descriptions and models that can be used in other organisations, e.g. for benchmarking and learning purposes. Other organisations can benefit from the results by applying the recommendations and the descriptions to their organisation’s context. However, it is important to understand that the needs in each organisation are different, and the situation and development requirements must be analysed individually in each case.

### 5.6 Recommendations for future research

#### 5.6.1 HSEQ management and safety culture

The benefits of IMS, as described e.g. in Hamidi et al. (2012), have not yet been widely exploited, and there are some synergy benefits with E and Q management, which would reduce overlapping practices in the case company. Usage of the HSEQ AP could be increased in the case company, because the benefits seem to be extensive. As van Ginneken and Hale (2009) claimed, safety can be used as a spearhead for making wider changes to an organisation’s culture, e.g. performance and general productivity, which also supports integration (IMS). Wider integration that includes security issues (Tervonen, 2010) and ergonomics (Nouri, Azadeh, Mohammad, & Azam Azadeh, 2007) could be investigated as well. A review could be conducted between the HSEQ AP and Amalnick and Zarrin’s (2017) approach—HSEQ integration with ergonomics and the European federation for quality management (EFQM) excellence model. Also, an investigation could be
made to determine if there are benefits to using the HSEQ AP or a similar supplier evaluation globally in the case company.

The repeatability of this research is limited to this case study due to organisational changes and development in HS(EQ) management practices. However, this limitation creates interesting possibilities for repeating the research in the case company after some time to see how much the situation in HS(EQ) management and performance has developed.

A profound safety climate and safety culture assessment could be one method to proceed in the field of continuous improvement. It predicts and effects safety performance (Eeckelaert et al., 2011; Neal et al., 2000), and it is an indication of where to focus next (Kvalheim et al., 2016). In the Northern Finnish process industry and in the case company, systematic and wide safety climate research has not yet been done. It could reveal interesting research and development targets. Safety climate assessments should be exploited. Taking a wider scope, an examination of the safety culture in a global company and the differences between the sites and countries would reveal interesting details. According to Nordlöf et al. (2015), workers’ perceived risks present in their work environment must be accepted, because they cannot affect it and they can only make the best of the situation. This study revealed that according to HS managers, safety is the priority, but blue-collar workers’ views were not investigated, as Nordlöf et al. (2015) did. That is another reason why safety climate assessments should be made.

Evidence was not investigated nor revealed in this study in relation to leader’s valuation of their employees and promotion of active worker participation, prioritisation of HS policies above other corporate objectives, and encouraging an open atmosphere to encourage collaboration (principles for a good HS leadership as described in Kaluza et al., 2012). All these topics would be interesting for further research.

The case company added a behaviour layer (SBO) to the safety pyramid, but there was not yet any systematic evidence of its effectiveness. Zohar (2010) integrates the safety climate and safety pyramid models, and the idea of integration could be used to develop an integrated model for safety leadership and safety climate. The topic is especially relevant when considering that safety climate perceptions are linked to employees’ levels of job satisfaction, engagement and the objective turnover rate (Huang et al., 2016). Articles II and III were written from a corporate perspective. Another perspective could be local, including looking at the employees’ perceptions of the safety leadership and climate in their company.
HS-related communication was one of the weaknesses in the case company. After the process is systematic and described, it would be interesting to see the required actions needed and the benefits achieved. After all, the new ISO 45001 (ISO, 2018) requires a well-determined process for both internal and external communication. More widely, the recent publication of ISO 45001 (ISO, 2018) creates many possibilities for future research topics. In particular, the requirements in change management could be a challenge for many organisations. On the other hand, ISO 45001 (ISO, 2018) has emphasised the impact of very important issues that arise due to continuous changes e.g. in the organisation, personnel, work tasks and working environment (process safety perspective) in many workplaces.

5.6.2 HS performance

Accident prevention is one of the main themes in HS management (cf. ISO, 2018). Based on the observations made by the researcher in the workplaces, many individuals have not had any occupational accidents during their careers. However, Pietilä, Räsänen, Reiman, Ratilainen, and Helander (2018) found that approximately 15% of employees had at least two compensated occupational accidents in Finland between 2005 and 2015. It would be interesting to research if the percentage is similar in the case company and in the shared workplaces.

Benchmarking with leading HS performance indicators across organisations, as discussed in the EU-OSHA report (Callen & Wilson, 2015), Shea, De Cieri, Donohue, Cooper, and Sheehan (2016) and Sheehan et al. (2016), would be an interesting research topic. In addition, leading HS performance indicators for shared workplaces should be investigated further. The application could be, for example, the ability to use HSEQ AP actively as a goal-oriented leading HS performance indicator in shared workplaces. Hallowell et al. (2013) and Shea et al. (2016) identified proactive and leading HS performance indicators in their studies, and these could be reviewed when considering adjustments to the leading indicators. An in-depth analysis of leading indicators could be made; e.g. a company-wide indicator for housekeeping and systematic positive feedback were missing from the case company.

The number of hazard, near-miss and SBO reports was getting higher and the amount of data was increasing rapidly. Artificial intelligence and how to manage and analyse the existing and generating data could be one future topic. In addition, mobile computing has advantages for a similar setting, e.g. information sufficiency, fast communication and advantageous visualisation (Kim, Park, Lim, & Kim,
One interesting future research could be how to use artificial intelligence and mobile technology more widely to support the HS reporting, monitoring, analysing and communication process.

Knowledge about incident, e.g. near-miss, and accident reporting has increased and the threshold to report accidents is probably lower than before. This could be one topic for further study, i.e. whether it is easy to report incidents and accidents (from both the system and individual perspectives) and what kind of differences exist between countries. Regional differences could be investigated also from the contractor’s perspective.

Koskela (2014) reviewed CSR reporting and found that the companies mainly reported on occupational safety, whereas well-being at work was seldom reported. Well-being at work integrated with HS issues in the case company’s corporate standards and practices could be one future research and development topic, especially now when exposure to psychosocial risks has increased (van den Heuvel et al., 2018). This increasing importance is reflected, for example, in the Vision Zero campaign by the International Social Security Association (2018).

5.6.3 New perspectives

A wider perspective of accidents in the workplace should be taken because the absence period is lost working time no matter what the reason. For example, one study considered accidents at home, sports and other leisure-time injuries, and traffic accidents in addition to workplace accidents (Haikonen et al., 2017). The prevention of commuting, home and leisure accidents (Yrjämä-Huikuri & Väyrynen, 2015) could be applied to reduce total sickness absence. After all, the attitude towards safety is the key feature that is important in accident prevention. This attitude should be with us at all times wherever we are, whether at work, on the way to work, at home or during hobbies.

Hollnagel (2014) introduced a new mindset for safety. Traditionally, the purpose of safety management has been to ensure that the number of accidents and incidents is as low as possible or as low as is reasonably practicable (Safety I). According to Hollnagel (2014), a new way of seeing safety is Safety II, which is the ability to succeed under varying conditions, with the intended and acceptable outcomes as high as possible. The Safety II way of thinking measures the number of cases where things go right, focusing on the positive and preventive aspect of safety. The Zero Accident Vision presented in Zwetsloot, Kines, Wybo et al. (2017) has elements, i.e. commitment, way of doing business, innovation, prevention
culture, ethics and CSR, networking and cooperation that go deeper compared to traditional safety management and accident prevention approaches. Although some Zero Accident Vision principles were observed during this study, it would be interesting to investigate the topic more deeply and determine the areas to develop next in the case company.

Only a part of the future research recommendations is presented here. Many details were not mentioned because of the vastly developing diverse field of HS(EQ) management. There are many possibilities and directions for future development, and the organisation should decide what its desired outcome is.
6 Conclusions

The shared workplaces in this study were unique working environments, which were changing all the time. When several companies work in the same area, each company might have different requirements for HS(EQ) management. In addition, companies have global operations, and they have defined their own corporate requirements for HS(EQ) management. Different requirements in national legislation and insurance company policies create an even more fragmented environment. Due to this changing, complex, and heterogeneous working environment, it is important to manage HS(EQ) issues. This research contributed new information to the development of HSEQ management in Northern Finnish process industry companies (N = 6) and their company network in a shared workplace context during the past 20 years. The study also described the current state of HS(EQ) management practices and tools in the case company, and more specifically, on its one site and its development needs when aiming for excellence in HS(EQ) management and performance. One important objective was to make recommendations on how to continuously improve and develop HS(EQ) issues.

During the past 20 years, HSEQ management development efforts in the Northern Finnish process industry and its service delivery network have applied collaboration and participatory development principles. The development started from individual performance assurance (FOSC) and continued towards organisational performance assurance (HSEQ AP). The years included long-term committed work with pioneering research and development activities. Special attention was given to HSEQ management and IMS development in shared workplaces. The historical review clearly shows positive developments in HSEQ management and the development in LTIFR support this conclusion.

From the group of process industry companies that participated in the historical review, the focus was concentrated on one company—the case company. The case company’s HS management system was based on OHSAS 18001 (SFS, 2007). The core elements included risk management, competence, communication, HS performance, incident reporting and investigation, audits, and meetings and reviews. (Emergency preparedness and legal and other requirements were not in the scope of this research.) Corporate HS management was based on an HS vision and principles, development plan and internal HS standards. Corporate had defined the global requirements for the sites, and the sites had additional local HS tools and practices, such as instructions, trainings and indicators. IT tools, including systems, applications, forms and software, were used to support HS management locally and
globally. However, the number of used IT tools was remarkably high, and rather than supporting HS management practices, it complicated them.

Leading and lagging HS performance indicators were exploited and defined in internal HS standards and instructions in the case company. Both the company’s own personnel and contractors were included in the HS performance data. Some of the indicators were defined precisely, but some required specification. LTIFR and, more generally, occupational accident statistics have gained a lot of critique among researchers, e.g. due to the underreporting issue. Reliable, clear and specific definitions should be available when using accident statistics for performance evaluations. Accident statistics can be useful for benchmarking and learning purposes, but the weaknesses must be acknowledged. Based on LTIFR comparisons between the case company, WSA (2018a) and IOGP (2016), the case company was approaching the benchmarks. In 2005, LTIFR was significantly weaker in the case company, almost 20, but in 2016, the frequency was getting closer to the benchmarks at 2.24. For comparison, the latest LTIFR in WSA was 1.01 and 0.27 in IOGP. It is important to use both leading and lagging indicators to avoid shortcomings in accident rate indicators when aiming to prevent all accidents. Although both leading and lagging HS indicators were used in the case company, e.g. safety behaviour and safety climate, related indicators could inject new energy into safety culture development.

On one site of the case company, HSEQ management was fragmented with multiple different assessment methods, and the HSEQ AP was chosen as one of the main methods. Experiences and development ideas were collected regarding HSEQ AP, and the results were encouraging. Diverse research and development actions are required and on-going. Shared workplaces are becoming more common; thus, cooperation and collaboration in HS(EQ) management play a significant role. LTIFR and the HSEQ AP performance results showed positive results in the shared workplace. The HSEQ AP scores improved 44% between the first and second assessments. In 2004, LTIFR was approximately 25 and nine years later it was approximately six. However, it was unclear how much the HSEQ AP had affected the positive development. It is not possible to conclude if the companies improved LTIFR and the HSEQ AP results more than other companies or what the reasons were for the improvements. Yet, the companies took HSEQ issues very seriously and invested in the development efforts in HSEQ management.

Many local and global actions have been employed to develop and manage HS(EQ) issues in the case company and in shared workplaces. Both corporate HS requirements and the local HS practices and tools adequately determined how each
site could develop their safety culture and HS performance. Supported by those efforts, the HS performance has improved from an accident statistics’ perspective. Still, various development needs were observed to develop HS(EQ) management further. The recommendations in this study were made based on academic and applied science. The recommendations concerned HS(EQ) management tools, practices and indicators in shared workplaces that have global operations. The focus should be on preventive actions, such as leading indicators and in creating a uniform safety culture for shared workplaces with sustainable foundation. The development should be supported by commitment and participative development from every organisational level. Learning from internal good practices and external benchmarking are valuable methods for this purpose. Due to the increasing changes in workplaces, change management plays an important role. HSEQ management practices, internal and external standardisation, communication and IT systems should be exploited to support the goal. To develop uniform safety culture in shared workplaces, safety must be understood as a value that resides inside the organisation. Therefore, safety must be understood similarly within the heterogeneous group of all operators in the workplace.

During the research, it was observed that many actors, such as companies from different branches, companies in shared workplaces, research organisations and international associations, are aiming for healthier and safer workplaces, but at times, the direction differs to some extent. For example, incongruent HS terminology reflects the active development. Differences in external and internal HS definitions were observed as well. Thus, it is important to standardise definitions and requirements inside the company, between the operators in shared workplaces, and extensively between global associations to avoid misunderstandings and confusion. Despite the challenges in global working environments, there are also benefits. They are great environments to share good HS(EQ) practices.

After the empirical research was conducted, the HSEQ AP was developed further. In addition, the case company has utilised the results of this research among other observed development needs, and it has developed its HS management practices further. These are examples of how active development is on-going in this field of academic research and, simultaneously, in the practical context. The future looks promising for the development of safer, healthier, and more sustainable and productive workplaces. The findings in this study will likely lead to several projects and campaigns to develop excellent practices and tools in HS(EQ) management in
one form and context or another. Excellence in HS(EQ) management and performance could be achieved exploiting the results gained in this research.
List of references


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## Appendix 1

OHSAS 18001 (SFS, 2007) and ISO 45001 (ISO, 2018) are both based on the PDCA cycle. The ILO Guidelines (2009) have a similar philosophy. The main elements of each HS management system are presented below.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>OSH policy, worker participation</td>
<td>OH&amp;S policy</td>
<td>Leadership and worker participation (leadership and commitment; OH&amp;S policy; organisational roles, responsibilities and authorities; consultation and participation of workers)</td>
</tr>
<tr>
<td><strong>Planning</strong> and implementation (initial review; system planning; development and implementation; OSH objectives, hazard prevention including e.g. management of change, emergency prevention and contracting)</td>
<td>Planning (hazard identification, risk assessment and determining controls; legal and other requirements; objectives and programmes)</td>
<td>Planning (actions to address risks and opportunities; OH&amp;S objectives and planning to achieve them)</td>
</tr>
<tr>
<td>Organising (responsibility and accountability, competence and training; OSH management system documentation; communication)</td>
<td>Implementation and operation (resources, roles, responsibility, accountability and authority; competence, training and awareness; communication, participation and consultation; documentation and control of documents; operational control, emergency preparedness and response)</td>
<td>Support (resources, competence, awareness, communication and documented information)</td>
</tr>
<tr>
<td>Evaluation (performance monitoring and measurement, investigation, audit and management review)</td>
<td>Checking (performance measurement and monitoring; evaluation of compliance; incident investigation, nonconformity, corrective action and preventive action; control of records; internal audit, management review)</td>
<td>Performance evaluation (monitoring, measurement, analysis and performance evaluation; internal audit; management review)</td>
</tr>
<tr>
<td>Action for improvement (preventive and corrective action and continual improvement)</td>
<td></td>
<td>Improvement (incident, nonconformity and corrective action; continual improvement)</td>
</tr>
</tbody>
</table>
## Appendix 2
Definitions for leading and lagging indicators in the case company.

### Lagging indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fatalities</td>
<td>Death from a work-related accident as certified by a medical professional.</td>
</tr>
<tr>
<td>Number of lost time injuries (LTI)</td>
<td>Direct result of a work-related activity, where the injured party was absent from their next scheduled period (e.g. day) of working. Includes fatal accidents.</td>
</tr>
<tr>
<td>Number of non-lost time injuries (non-LTI)</td>
<td>Workplace accident that is the direct result of work-related activities, where the injured party received treatment for the injury, but the injury didn't incur loss of work time not more than the shift which it occurred. The injured person continues with the normal scheduled work. Restricted duties without absence are included to this category.</td>
</tr>
<tr>
<td>Number of occupational diseases</td>
<td>Occupational disease is any chronic ailment that occurs as a result of work or occupational activity, such as noise induced hearing loss, industrial dermatitis, occupational asthma, etc.</td>
</tr>
<tr>
<td>Total sick leave hours</td>
<td>Number of total sick leave hours during the reporting period. Sickness absence includes sick leave hours certified by doctors, self-certified hours (if applicable) and sick leave hours due to injuries. Sickness absence excludes bereavement, maternity and paternity.</td>
</tr>
<tr>
<td>Sick leave hours due to injuries</td>
<td>Number of sick leave hours as a consequence of injuries that have taken place during working hours at the work place.</td>
</tr>
</tbody>
</table>

### Leading indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of near misses</td>
<td>Near miss is an unplanned event where someone or something interacts with a hazard but did not result in injury or illness – it had the potential to do so. Near miss is more serious situation than hazard (below).</td>
</tr>
<tr>
<td>Number of hazards</td>
<td>Hazard is any situation or action that has a potential to cause harm (injury or ill health, environment or property damage).</td>
</tr>
<tr>
<td>Number of Safety Behavioural Observations (SBO)</td>
<td>Safety based discussions between an auditor (typically the supervisor or manager) and the person being audited.</td>
</tr>
<tr>
<td>Number of other preventative safety actions</td>
<td>Near misses, hazards and SBOs do not include all preventive safety actions. These actions are included to other preventive safety actions. Examples are H&amp;S audits, walks, inspections or ideas.</td>
</tr>
<tr>
<td>Safety training hours</td>
<td>Safety training hours to personnel is the sum of the hours of safety training received.</td>
</tr>
</tbody>
</table>
Original publications


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691. Alavesa, Paula (2018) Playful appropriations of hybrid space: combining virtual and physical environments in urban pervasive games

692. Sethi, Jatin (2018) Cellulose nanopapers with improved preparation time, mechanical properties, and water resistance


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CASE DESCRIPTION AND DEVELOPMENT NEEDS