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On occupational safety management in construction alliance projects

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Abstract

Construction work is one of the most hazardous industries worldwide. Accidents, incidents, injuries, occupational diseases, and illnesses at work represent a significant burden for various stakeholders, including society. Different project management approaches have been introduced to facilitate construction work and occupational safety (OS) in practice. This study focuses on OS in construction alliance projects. Alliances are an emerging new form of a project delivery method in construction. In construction alliance projects, the project stakeholders collaborate with mutual interest to achieve the best result for the entire project. Alliance projects are a relatively new mode of project deliveries in construction. A systematic literature review was conducted using Scopus, Web of Science and PubMed—to learn how OS has been acknowledged in alliance projects. The literature review shows the scarcity of research in this area. To in-depth the review, personal interviews were conducted at two large alliance projects in Finland. Interviews bring out the complex nature of OS management in alliances and highlight issues related to partner selection and site-specific OS management within alliances. This study deepens the very limited scientific knowledge of OS in alliance projects. By drawing together the existing knowledge on the topic, new insights are provided on developing OS management in alliance projects. In addition, several new arenas for novel empirical research in the field of OS in construction and the alliance context are proposed.

1. INTRODUCTION

Occupational safety (OS) or, more precisely, its lack has remained a problem in the construction industry around the world. At the same time, the construction industry is a significant industrial branch, creating employment and affecting national and regional economies (Lehtola et al., 2008; Lingard, 2013). Despite the work and efforts put into improving and studying OS, the reality is that construction work is still hazardous, and a disproportionate share of occupational fatalities and accidents occur in the construction industry (Liang et al., 2020; Lingard, 2013; Ringen et al., 1995). Accidents, incidents, injuries, occupational diseases, and illnesses related to construction represent a significant burden for employers and societies and individuals (Jaafar et at., 2018; Lingard, 2013; Schulte, 2006). Several scholars have concluded how an immature safety climate and culture, insufficient information and communication technologies and OS management systems, deficiencies in risk management processes and procedures and employees' own behaviour all affect poor OS performance with regard to construction (Costa et al., 2021; Jaafar et al., 2018; Jin et al., 2019).

A construction project is often undertaken on a specific construction site, where different stakeholders, often known as sub-contractors, interact with each other for variable lengths of time (Aapaoja and Haapasalo, 2014). Such stakeholders deliver their

contributions to the construction project at various stages and on different parts of the site; thus, their opportunities to interact and share information might be insufficient or restricted (Jaafar et al., 2018). In traditional forms of construction, like '*construct only*' or '*design and construct*' project types, different risks are allocated to the stakeholders, believed to be the best place to manage the risks. However, in reality, the risk identification and management processes performed by stakeholders are often inadequate and do not consider the complexity of the worksite eventually resulting in different unwanted events and the consequent disputes concerning liabilities (Hanioglu et al., 2017; Jefferies et al., 2014). The complex nature of construction work involving various stakeholders induces specific challenges for OS communication and results in unclear responsibilities (Manu et al., 2019; Trinh et al., 2020). Thus, an evident need for contractual development actions and governance regarding the stakeholders involved in the construction project and from the social perspective, including OS, has been highlighted (Adaku et al., 2021; Çelik et al., 2017; Gotcheva et al., 2019).

Stakeholder management in general (Engebø et al., 2020; Moodley et al., 2008; Xia et al., 2018) and different collaborative project arrangements in construction projects have been a topical discussion both in practice and in science (Chen et al., 2012; Engebø et al., 2020; Kwofie et al., 2018; Lahdenperä, 2017; Rahmani et al., 2018). The construction project stakeholders can vary significantly from internal contract-based stakeholders to external stakeholders, the latter of whom are not directly involved in the project activities but are affected by them and by the project outcome (Xia et al., 2018). In this study, the focus is on internal contract-based stakeholders. Lahdenperä (2013) discussed three global approaches in this context. Accordingly, project partnering, project alliancing and integrated project deliveries were identified as relational project delivery arrangements (Lahdenperä, 2013). The three approaches share many similarities; however, certain differences can be identified. All three approaches facilitate the early involvement and integration of key stakeholders, multi-party agreements and joint decision-making processes and include transparent financial and shared risk and reward structures and processes. Project alliancing differs from the other two in terms of its commercial contractual structures. Yeung et al. (2007) highlighted hard contractual elements, i.e., formal contracts and gain-share/pain-share arrangements, and soft relationship-based elements, i.e., trust, long-term commitment and cooperation and communication, as the key elements of alliance projects. Still, as Galvin et al. (2021) pointed out, these relational and contractual forms have not always been sufficient to eliminate opportunistic behaviours.

In a project alliance, different contractual stakeholders, i.e., the partners of a large and complex construction operation, collaborate with mutual interest to achieve the best result for the entire project. The effectiveness of alliance projects has been under discussion (Chen et al., 2012; Lahdenperä, 2017), and several authors, like Lahdenperä (2017), Lloyd-Walker et al. (2014) and Love et al. (2010), have shown the benefits of the gain- and pain-sharing project arrangement structure. However, authors like Day (1995) and Hughes and Weiss (2007) have pointed out how alliancing does not always succeed. Day (1995) highlighted how, in its beginning phases, the alliance model was not a huge success, and as many as 7 out of 10 examples fell short of expectations or were disbanded. Hundreds of alliances failed; nonetheless, they also produced valuable information about good practices (Hughes and Weiss, 2007). Over time, as experience has increased and good practices have been acquired, alliancing has turned out to be a successful delivery method for complex infrastructure projects (Love et al., 2010).

The interest in alliance projects has been extensive and growing (Engebø et al., 2020). In the country size of Finland, there have been almost 100 alliance projects worth over EUR 3 billion in the last ten years (Moradi et al., 2020). This can be seen as quite a significant change in the typically very conservative industry. Along with the practical transformation, the interest in alliance and collaborative models has been more extensive on the research side. One of the biggest reasons is that the models aim to provide more "value on many" and aim at the "*best of the project*" with an overall aim for better project and results (Hietäjärvi et al., 2017). Because of these positive features of the collaborative setup, it is reasonable to study alliances from the OS perspective. One of the fundamentals of alliance is "*early involvement and integration*" (Aapaoja and

Haapasalo, 2013). Therefore, it is logical to expect OS being involved early, too, as Costa et al. (2021) also propose.

The purpose of this study is twofold. First, the purpose is to examine what has been written on OS management in construction alliance projects in the existing scientific literature, especially with regard to what effects alliancing might have on OS when promoting collaborative aims and actions for the benefit of a project. Following the review part, interviews at two alliance projects were conducted to concretise OS management in practice.

To frame this study, recent reviews by Jaafar et al. (2018), Manu et al. (2019) and Trinh and Feng (2020) were highlighted. Accordingly, the essential role of sub-contractors for construction project success should be acknowledged, yet also the challenges they bring from the OS management perspective should be identified and understood. Taking this into account, special interest should be paid to partner selection in alliances from the OS management perspective. The first research question (RQ1) in this article builds upon this:

RQ1: How is OS present during partner selection when building an alliance?

Lingard and Oswald (2020) discussed how social and power relations between the stakeholders in a construction project are often ignored when discussing OS. They urged researchers to focus on these social relationships and interactions in future studies (Lingard and Oswald, 2020). Based on this, practical OS collaboration between the parties during an alliance project is of interest for this study and frames the second research question of this study:

RQ2: How are OS challenges managed in practice in alliances?

In their review, Xue et al. (2010) highlighted the business environment and human behaviour as two key areas impacting the performance of collaborative working in construction projects. Studies from construction (Alkaissy et al., 2020; Soltnmohammadlou et al., 2019) have shown how good OS performance contributes positively to project delivery. Still, in practice, OS is often discussed outside the core project areas of business productivity, costs, and quality (Mohammadi et al., 2018). From this perspective, a third research question is posed:

RQ3: What are typical key performance indicators (KPIs) used to measure OS performance in alliance projects?

2. MATERIALS AND METHODS

2.1 Systematic literature review

A systematic literature review (Grant and Booth, 2009) was conducted and supplemented with interviews at two alliance projects to answer the research questions. The review followed the guidelines for systematic reviews in occupational safety and health (Howard et al., 2017). Accordingly, prior to the review, both scientific literature and practical knowledge were utilised to define the RQs, review framework, review protocol, and study selection premises. Study selection was focused on three established and globally recognised scientific databases: Scopus, Web of Science and PubMed. These three databases were selected as the authors deemed them to represent databases where scientific literature on this topic is typically included. Scopus and Web of Science represent general databases, whereas PubMed is a database that might contain articles that discuss construction processes from an integrated occupational health and safety perspective. The database searches were performed in September 2020 (Scopus: 24.9.2020; PubMed and Web of Science: 29.9.2020). During all the searches and in order to maximise the amount of hits, no publishing period limitations were used. However, only articles published in English were included.

The authors determined the search words in two meetings, during which the means of achieving the best impact were also discussed. To find as many relevant articles as possible, standard terms were chosen, and a selective combination was constructed to avoid an excess of results. The keywords used were as follows: construction AND safety

AND alliance OR integrated AND project OR joint AND operation OR alliancing. The following inclusion criteria were used:

- Types of studies: qualitative, quantitative, mixed methods studies and literature reviews and overviews.
- Types of participants: any construction project with an alliance project structure.
- Types of interventions: articles describing OS at some level of an alliance project.
- Types of outcome measures: OS in alliance projects and indicators used to measure OS.

The search results are described in Figure 1. As can be seen, 411 articles were identified from the searches. After removing duplicates, a database of 381 articles was included in the analyses. During the screening phase, the remaining records were cursorily scanned by reading their abstracts to define their validity in terms of this review. Any articles with information about construction or project alliancing and OS were chosen for the following analysis phase. The discarded results were mostly completely off the mark and included, for instance, medical and health science articles discussing alliances in health care. Safety was also described in many articles from a general overall perspective, without specifically focusing on OS. This was the main reason for such a large proportion of non-eligible results. Additionally, the authors examined the reference lists of the selected articles and identified other relevant sources through their academic contacts.

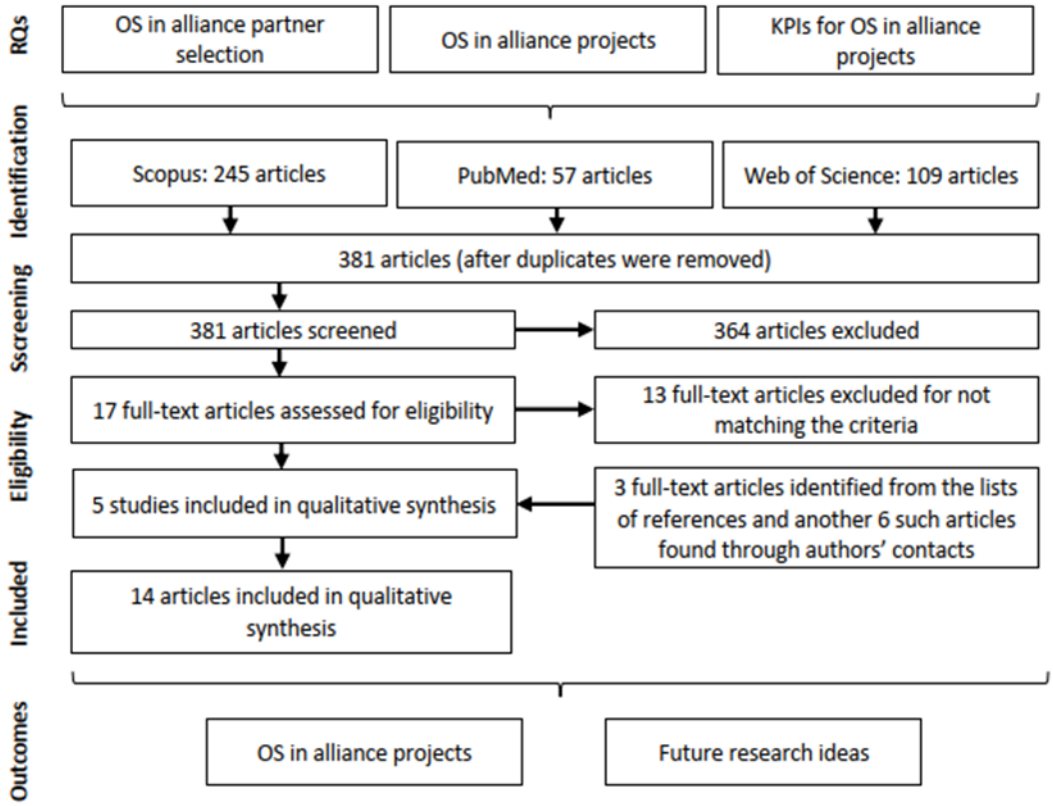

Figure 1. Structure and search results of the systematic review

The articles included in the analysis phase are summarised in Table 1. OS was discussed in 14 articles, and these formed the final sample of this review.

Table 1. Articles included in the analysis

Source	Type	Topic
Evans et al. (1997)	Conference article	Study presents civil engineering interfaces within petrochemical construction in the context of alliancing.
Ross (2000)	Popular article	General information about project alliancing.
Jefferies et al. (2006)	Conference article	Review of a West Australian programme alliance (water infrastructure construction).
Lahdenperä (2009)	Technical report	Description of a project alliance in a road construction project in Finland.
Love et al. (2010)	Journal article	Success factors researched in West Australian alliance model infrastructure projects.
Aapaoja and Haapasalo (2013)	Journal article	Stakeholder management framework applied to two construction projects in Finland.
Jones (2014)	Conference article	Alliance model and its challenges from an IPD (integrated project delivery) point of view.
Love et al. (2016a)	Journal article	West Australian programme alliance (water infrastructure construction) and how rework affects work-related accidents.
Love et al. (2016b)	Journal article	West Australian programme alliance (water infrastructure construction) and its methods for creating a no-harm environment.
Hietajärvi et al. (2018)	Journal article	Alliancing in two Finnish large-scale construction projects.
Hietajärvi and Aaltonen (2018)	Journal article	Case description of the first Finnish infrastructure alliance project.
Kujala et al. (2020)	Journal article	Framework for the governance of inter-organisational projects with practical case examples.
Nyameke et al. (2020)	Journal article	A case study with two renowned construction companies in Finland.
Saukko et al. (2020)	Journal article	Case description of a large Finnish industrial engineering project.

2.2 Interviews

To support the systematic literature review, semi-structured thematical interviews were conducted for key persons in top management representing two typical Finnish alliance projects where tram lines are constructed in city area: *Raide-Jokeri* at the metropolitan area in Helsinki and *Tampereen Ratikka* at the City of Tampere area. The interviews were conducted between 12/2020 and 1/2021. In the interviews, representatives from OS management, production management, project management and block management were interviewed from both alliance projects. In total eight interviews were conducted, with an average of 30 minutes in length. The interviews focused on interviewees' experiences on alliance projects in general and concerning OS and issues related to OS in partner selection, OS management at the site and OS indicators were of interest in this study. The interviews were recorded and transcribed for the analysis.

3. RESULTS

3.1 Occupational safety in partner selection when building alliances

Love et al. (2016a) described the role of OS in partner selection by introducing six core values that should be considered when an alliance project is established. Accordingly, the values, categorised under the acronym STRIVE, are safety, teamwork, respect, innovation, vibrancy, and excellence. Ross (2000) pointed out the contractual perspective when forming an alliance and highlighted the need to appoint a principal contractor for the alliance project to meet the legal requirements concerning OS. In a case study of an Australian water treatment project, Jefferies et al. (2006) described how the client had decided that a safe workplace, along with the objective of zero incidents and injuries, would be one of the key focus areas in the project and an important part of partner selection. However, details of the partner selection process and OS considerations were not given. Three articles (Jefferies et al., 2006; Love et al., 2016a; 2016b) revolved around the same infrastructure environment and discussed OS in general in partner selection but showed very little empirical evidence on how OS was practically considered in this context.

Hietajärvi and Aaltonen (2018) and Hietajärvi et al. (2017) described two Finnish alliance projects where OS was identified among schedules, operations, usability, and

public image as a shared project goal; however, they did not define the role of OS in detail. OS performance and management processes were also mentioned as a partner selection criterion by Lahdenperä (2009) in his technical report that described good practices in alliance projects in Finland. Lahdenperä (2009) pointed out that OS should be included in partner selection criteria when forming alliances. Accordingly, OS performance in the partner selection phase can be verified, for instance, through partner candidates' descriptions of OS and risk management procedures and control systems, OS performance and lessons learned from their past projects and OS planning and training. Lahdenperä (2009) did not provide any empirical evidence on the subject in his technical report.

The literature review above summarises the current scientific knowledge on OS in partner selection in alliance projects. Accordingly, there are indications of OS being present in partner selection, however, the knowledge shown in the literature is very narrow. The interview part of this study opens partner selection from the OS management perspective in two alliance projects in Finland. Accordingly, OS performance is present in partner selection and when negotiating with potential subcontractors. Not surprisingly, the variety of different subcontractors is a challenge from an OS management perspective. Different actors bring their own work practices and work along with their own OS culture. This challenge must be acknowledged in the contracts, as highlighted by one interviewee representing production management: "*…surely we must have clauses for sanctions in the contracts making it possible to intervene to improper OS by the subcontractor".* This was not limited merely to subcontractors, and similar challenges also existed concerning the main partners.

The participatory nature of alliances provides possibilities for discussing OS in practice, as pointed out in a reference quotation by another interviewee also representing production management: *"From the OS perspective, alliance is more flexible. There is a lot of conversation with the whole environment, including the client. It is possible to negotiate things considering* [for instance] *mass transportation and street areas in a completely different level. In traditional contracting there is only stick used* [referring to a "carrot for rewards and stick for negative consequences of poor behaviour' approach] *and there are not such conversations on rewards taking place. Tools for solving issues are therefore scarce* [in traditional project deliveries]". However, in practice, discussion on OS was still not considered very deep when the project partners are selected, as brought out by another interviewee: "*When negotiating with subcontractors and making contracts, OS could be considered much better*". Overall, the collaborative nature of alliance supports transparency, trust and discussion between the project participants - increasing understanding of the progress of the project.

3.2 Overcoming occupational safety challenges in alliance projects

Lahdenperä (2009) pointed out that OS is, in general, a key competence in an alliance and that all alliance partners have shared responsibilities concerning OS. A best for the project attitude was emphasised as a success factor by Jefferies et al. (2006) in their study on an Australian alliance project. Even though OS was not discussed in detail in their article, they still pointed out that it was selected as one of the key objectives by the client. Supplementing this best for the project approach, they highlighted how it is important to 'form a single entity', meaning that all attachments related to the stakeholders involved (such as logos and titles) should be removed and a single alliance name and uniform should be adopted in order to succeed (Jefferies et al., 2006). Nyameke et al. (2020) introduced a "project identity" as a platform for overall collaboration, including OS for alliance projects, to form a single alliance entity. Love et al. (2016a) described how existing norms in work practices and rework processes were challenged in an Australian alliance project, forcing the alliance project management team to adopt an authentic style of leadership that engendered trust, integrity and openness. This was deemed especially important in terms of overcoming old-fashioned attitudes from traditional price competition in construction contracting and sub-contractor supervision.

The alliance model is underpinned by no-blame provisions to create a culture of collaboration and joint accountability values, as Love et al. (2016a) reported. In

practice, as Love et al. (2016b) described in their study on the same alliance project environment, the alliance project management team was aware that OS was endangered, especially in rework tasks. Thus, the important link between the quality of work and OS was understood and selected as a target during the project.

Poor OS performance led to a renewed and integrated safety, quality, and environmental risk management process, which aimed to identify and remove as many risks as possible through the design process (Love et al., 2016b). To facilitate OS management in practice, workplace risk assessments, activity method statements for managing the risks, safe work method statements and standard operating procedures were developed during the project. The objective was to create a culture where every stakeholder had the opportunity to openly communicate any accidents, problems, near misses or challenges without fear. Love et al. (2016b) described how this collaborative culture allowed and enabled learning throughout the project. Paralleling this, Aapaoja and Haapasalo (2013) pointed out that such a fundamental way of thinking and collaborative culture inside the alliance should be initiated to benefit the project. Their article highlighted the significant role of management in these kinds of activities. In addition, the need for a leadership team focused on bringing OS towards taking centre stage in the project and eliminating the fear-of-failure mentality was recognised (Aapaoja and Haapasalo, 2013).

To enable the creation of a collaborative culture, Jefferies et al. (2006) emphasised the need to establish an integrated office for the alliance stakeholders. Accordingly, OS, among other project matters, would be discussed in that joint office. Jones (2014) proposed integrated decision-making tools and systems and the use of new technologies and approaches (like Building Information Modelling and Big Rooms) for integrating OS into other project management activities.

Ross (2000) stressed the legal context for the project and pointed out that the alliance agreement must be customised to meet legal requirements, like the ones related to OS. To guarantee the best outcome for the project or even just to enable the possibility of success, the notification of these contractual issues and responsibilities should take place at the beginning of the project, as Aapaoja and Haapasalo (2013) pointed out. Concerning individual responsibilities, signing a code of conduct—a list of things everyone is responsible for—was identified as a functional tool to increase involvement toward common goals, including OS (Love et al., 2016b).

The interviews conducted in this study paralleled the existing literature with a constantly shared opinion on the challenging complexity of OS management in alliance projects. A need for a rigorous, yet positive-oriented attitude towards OS management and the role of highly skilled OS professionals was mentioned as success factors in several interviews. Interviewees also pointed out a common concern relating to the different safety cultures the stakeholders might bring along to the alliance project site. Creating a uniform safety culture was considered a challenge. This comes out well in practice in an interview quotation by one interviewee representing project management: "*Having a lot of subcontractors, with different practices, causes problems in getting ours in their place. These are briefly discussed in the induction phase, but how well will those work after that. Therefore, we have had to add sanctions to our contracts'*. One of the interviewees with on-site responsibilities had a slightly different view: '*In spirit of an alliance, safety is viewed differently in the field. Interventions are much more thorough than in traditional contracting, where there are just a bunch of subcontractors who are reprimanded* [in case of OS violation]". From the alliance management perspective, it seems that alliances overall have better chances to influence OS performance at the site than in the traditional project deliveries where the consequences of the risks, including OS are faced by the companies themselves, not jointly. This arises from one of the initial reason alliance joint revenue logic – OS problems for some partners become problems for all. It is therefore reasonable to prevent problems and manage challenges.

3.3 Occupational safety as a key performance indicator in alliance projects

Even though the articles included various mentions of KPIs in alliancing, they did lack detailed discussion on KPIs from an OS perspective. Ross (2000) discussed how sharing

pain or gain should be based on generally measurable outcomes in all key performance areas, which typically include OS, among other more business-oriented areas. OS as a basis for alliance incentives was mentioned by Evans et al. (1997) as having a 50% influence on total incentives in a petrochemical construction alliance; however, the KPIs concerning OS were not explicitly defined. Kujala et al. (2020) described how exceptionally high OS performance in a Finnish alliance project led to a joint bonus for the contract parties, but, yet again, the specific KPIs were not provided. Australian water projects (Jefferies et al., 2006; Love et al., 2016a; 2016b) reported that OS had been included in the project KPIs; however, they were specified at some level in only one article (Love et al., 2016a). In that project, incident frequency and near-miss ratios were reported as OS indicators and KPIs (Love et al., 2016a). More generally, Saukko et al. (2020) described how OS should not only be seen from fines and punishments perspective in alliance projects, as violations tend to be covered up as an alternative to performing corrective actions. Still, they did not specify whether and how OS should be measured in this context (2020).

Lahdenperä (2009) proposed various OS criteria to be utilised in alliance projects as KPIs. These included the amounts and frequencies of different types of accidents, lost working hours and the value of the material damage caused by an accident. Lahdenperä (2009) emphasised how such criteria are reactive and only measure things that have already happened. In addition, Lahdenperä (2009) proposed proactive criteria, which included tidiness, orderliness, and monitoring compliance towards safety instructions. These are all leading indicators that measure the level of OS performance as opposed to issues that have already occurred (Lahdenperä, 2009). Ross (2000) suggested basing OS-related assessments on a combination of process-based leading indicators and outcome-based lagging indicators. These may include, for instance, compliance audits, statistics analyses, stakeholder surveys and subjective ratings. Further, Ross (2000) highlighted that the selection of a measurement system and the KPIs used usually varies according to the size of the construction project, i.e., the larger and more complex the project is, the more sophisticated the measurement system should be.

In the interviews conducted in this study, the focus was on project management and OS management in general. OS indicators used in the two alliance projects can be considered traditional and well-established, including for instance the frequencies of loss-time incidents (LTI), toolbox talks and safety observations. In addition, the results of the weekly safety inspections, i.e., TR (abbreviation from Finnish, meaning residential construction) and MVR (abbreviation from Finnish, meaning civil engineering works) measurements were followed systematically in the projects. From the indicators above, two (LTI frequency and MVR calibrations) were used as project-level KPIs and as a basis for bonuses. One of the interviewed project managers commented on the KPIs as follows. "*Safety incentives are important – it is useful to invest in safety, and in the future, it would be beneficial if the subcontractors could also be brought in these contracts*."

LTI frequency was considered a simple solution that is easy to follow. However, it was also criticised due to its' reactive nature. LTI frequency was considered having some direct influence on day-to-day operations at the site. The interviewees' pointed out how it has had visible effects outside OS as it has for example, resulted in improvements in on-site logging systems. LTIs calculate LTI frequency in a million working hours. Earlier the working hours were reported only partially in the project, which directly affected the LTI frequency ratio. However, to be able to calculate the ratio based on actual working hours, the system had to be improved. The system has been simplified from cumbersome online links to a single, block specific phone number, which automatically logs in any callers who are listed and permitted access within the alliance personnel system. The MVR calibrations were considered to bring substantial monetary value to the partners through factual improvements in the quality of OS management at the site. The importance of MVR calibrations comes out well from an interview quotation by a block manager: "*MVR is an important tool in improving safety. With that the work facilities will be put in order*".

The basic nature of alliance is to agree joint KPIs for the project. OS KPIs as practical indicators from the daily work should be more extensively acknowledged. Sharing the KPIs regarding project success might bring new perspectives also for OS KPIs.

4. DISCUSSION

This review was validated with interviews summarising the stakeholder collaboration and management in alliance projects from an OS management perspective. In the construction context, OS management should cover hazards arising in the workplace as well as those resulting from the work, as Adaku et al. (2021) pointed out. Our review identified only a fistful of scientific articles that discussed OS from the alliance project perspective. The interviews we conducted in this study shed some more light in this sparsely studied, yet important area. Based on the review, we raise a question whether OS really is identified as a salient element of successful project delivery or if experiences of alliance projects are so scarce that the possible benefits associated with alliancing have not yet been realised.

The small number of articles discussing OS from an alliance project perspective is somewhat surprising considering the accumulated knowledge—both in practice and in science—about the hazardous nature of construction, complex consequences of unsafe actions and the complex nature of construction projects with multiple stakeholders involved. Construction is, and always has been, an extremely hazardous industry, and several authors, like Jaafar et al. (2018), Sinyai and Choi (2020), Sousa et al. (2014) and Suárez Sánchez et al. (2017), have, in their review articles, summarised the extensive nature of accidents in construction and the challenges OS management confronts in practice on construction sites. When considering the consequences of occupational accidents in construction, it is important to remember that they are not restricted to the victim of the accident and his/her close relatives, but that they also affect various others, like the co-employees at the site. In addition to individual level suffering and harm, occupational accidents include direct and indirect cost elements and may affect the project delivery and schedules significantly, for instance, Burr (2016), Forteza et al. (2017) and Leopold and Leonard (1987), have highlighted in their empirical studies and reviews concerning construction projects. Given what we know about OS in construction in general, we consider it worrying to see how little scientific knowledge we have on OS in alliance projects as they are no longer a new project delivery phenomenon in construction. Despite alliancing having been around only a little over 20 years, scientific research has rather vigorously identified what makes alliances successful (e.g., Engebø et al., 2020; Yan and Lee, 2021). This made us consider the reasons for OS being discussed so sparsely. On the other hand, taking the types of projects (large and complex) that best utilise the benefits of alliances or the number of alliance projects in total, it is evident that organisations are not fully capable of realising the benefits offered alliancing.

4.1 Occupational safety management in alliances

Among others, Mitropoulos and Tatum (2000) presented a classification for the integration of mechanisms in alliances (contractual, organisational, and technological integration mechanisms), which may include impersonal, personal and group integration modes. These contractual and technical mechanisms are complex but also relatively straightforward to implement. Organisational mechanisms deal with social processes and how people cope with complex project settings. In this sense, people's multiple and conflicting interests, roles, identities, and asymmetries of power increase the difficulty of planning, organising, leading and controlling activities inside alliances. The social process of collaboration relates to people's interactions and relationship building and development in the alliance project, emphasising the importance of inter-organisational collaboration (Turkulainen et al., 2000). Further, as Zighan (2020) points out, in project-based organisations, such as in alliance projects, motivational aspects both at the individual and project team levels should be considered when discussing the success factors of the project.

As earlier research (e.g., Dul and Neumann, 2009; Felknor et al., 2020; Law, 2020) has shown, OS (or more generally, human factor) specialists often work in their siloed roles outside core business processes, sometimes facing challenges in terms of promoting the value of OS for decision-makers. Based on our findings, we ask whether collaboration in alliance projects really is exploited in full concerning OS or if OS in practice is still managed based on more traditional construction project arrangements. In our review, only a few authors showed how OS had been keenly integrated into general project management practices; however, they did not describe this complexity, the possible challenges confronted, and the benefits acquired from the project management perspective in depth. Concerning our interviews, we found some signs of OS performance and management being important parts of the project. However, based on this limited information acquired both from the interviews and review, we need to ask whether and by which means OS is coordinated for the best of all parties in alliance projects and what the actual role of OS is in the project governance model.

As a continuum on the discussion Galvin et al. (2021) have raised on the interplay between governance, trust and culture in alliance projects, we further ask whether and how current OS management practices in alliance projects adhere to the principles of free flow communication between the project stakeholders and fully support trust and respect within the project. We see that OS promotion is ideally approached from the organisational culture development perspective. Similar to organisational culture, safety culture is also a phenomenon that should be formed and led actively by top management, as, for instance, Edwards et al. (2013) and Guldenmund (2000) have highlighted. However, given the long timespan in culture creation and the temporary project-based nature of construction, we find this challenging in practice. Thus, we highlight the importance of dedicated OS professionals within the project with practical responsibilities and adequate mandates to act on behalf of OS. Depending on the size and complexity of the project, such OS responsibilities might be given to the project manager (Sunindijo and Xou, 2012); however, these responsibilities might also be assigned to other people whose mandates are strong enough to cover all stakeholders inside the alliance project. Given this, we emphasise that OS responsibilities should be described in detail in people's contracts. As Tervonen et al. (2009) pointed out, OS is an element that must be prioritised in practice in order to achieve its objectives.

As discussed above, OS is an important element in a construction project. In order to succeed in terms of OS, it must be tied to top management decision making and led by a dedicated and competent professional (Tappura and Kivistö-Rahnasto, 2018). Alternatively, OS needs to be incorporated into incentives related to the project's success or even directly into the revenue logic of the project participants. A well-known management paradigm (Lowenstein, 1996) states that you cannot manage a thing that you cannot measure. Various authors have discussed this paradigm and the variety of indicators used for measuring OS over time (Barbosa et al., 2019; Pawłowska, 2015; Schwatka et al., 2016), yet still, in our database searches, we identified only a handful of articles where OS indicators were discussed at any level in alliance projects. Given the current knowledge on OS indicators and the broad range of different leading and lagging indicators available and in use in construction projects, we see it as a challenge for alliance projects to reveal their OS indicators in public.

The modest amount of scientific knowledge focusing on OS indicators in alliance projects was somewhat surprising and made us ask how manageable OS is if it is not systematically utilised as a part of the KPI selection for the projects, especially as the construction industry is typically normative in nature and regulated to a large extent (Saarenpää, 2010). Earlier research (Mayhew and Quinlan, 1997; Mohammadi et al., 2018; Oswald et al., 2020) has shown that the omission of OS when selecting KPIs might be a consequence of too narrowly focused purchasing processes emphasising cost savings and cost efficiency as the main indicators in partner selection. As the costs of occupational accidents are complex, including direct and indirect elements, and the savings are often calculated as potentially avoided costs (i.e., as accidents that did not happen), the business perspective regarding OS benefits may become too hazy for decision-makers in constantly evolving construction projects that involve multiple stakeholders. We observe that the indicators used in this context should provide

proactive information supporting OS development in alliances. Given the digitalised nature of construction, we point out that the overall measurement system should be automated as far as possible. Paralleling Haapasalo *et al.* (2006), we highlight that manual data collection, processing and analysis may cause unnecessary costs for the project and slow down the emergence of control information.

4.2 Future studies

Based on the above, we propose that future studies focus on OS in alliance projects from the following eight perspectives. First, we highlight the need to study the actual role of OS in top management decision making in alliance projects all the way from partner selection to project delivery (1). We point out that the above can also be discussed from its counter perspective, i.e., to study whether traditional construction project delivery forms can learn something to supplement their OS management processes and practices from alliancing. Further, we propose to study how OS is considered in tender and contract processes in an alliance project context (2), to learn how OS is measured during a project and how these measurements affect the project and (3) to analyse whether and how OS is discussed from an economics perspective in such projects (4).

As alliance projects are based on shared gain and pain, we highlight the need to study in more depth how OS is seen from this sharing perspective, which should enable the '*best for the project*' (5). More generally, our searches highlighted a '*no-blame culture'* as one key success factor for alliances. Such a culture would correlate well with the '*best for the project*' perspective proposed above. Would, for example, '*project identity formation*' enable a mindset resulting in the best for the project in OS too? However, we question how possible this is in construction in practice, where the traditional culture may support possible accidents, incidents and near misses being covered up to a certain degree to ensure the continuation of the project. Naturally, we also see how it might be easier to blame other stakeholders in an alliance project despite this being counterproductive when considering trust and cooperation.

Further, we highlight the need to study the best protocols and practices concerning OS in alliances (6) and how they are selected, implemented, promoted, and executed by stakeholders who often tend to bring their own OS processes and practices to the site. Equally important is to recognise unnecessary bureaucracy (7), such as overlapping reporting or conflicting emergency protocols, which may confuse the project site. The latter is apparently connected to the current COVID-19 situation, through which alliance stakeholders might have implemented compulsory, yet not always compatible, requirements at the site. In the construction project context, the spread of COVID-19 has been identified as a critical OS management challenge (Hollingsworth, 2020; McLaughlin and Vercler, 2020). The COVID-19 pandemic offers a unique possibility to study OS management from a crisis management perspective within an alliance project (8).

4.3 Limitations

The following aspects should be considered as the limitations of this study. Four of the fourteen articles included in the analysis focused on West Australian alliance projects, and seven looked at Finnish projects, indicating a potential bias in terms of these representing alliance projects in general in this context. Even though alliance contracts have existed for a couple of decades, we have relatively limited experience and extremely inadequate quantitative research-based knowledge on the success of alliances in the long run. It is also known that alliances change the attitudes and roles and the revenue logic of companies. This, in turn, leads companies to assign their best performers to these new types of projects—leaving us wondering whether everybody in the company can perform at the same level.

While successful alliance projects and the related qualitative mechanisms have been thoroughly studied, they provide only a narrow source of variety for comparative research from the OS perspective. Further, only nine articles were published as journal articles, whilst the rest were published as conference articles, technical reports or articles intended for professionals in this field. This indicates that the research in this

area is still very immature. In addition, as the review did not include grey literature from sources outside the three scientific databases, some more in-depth information could potentially have been found from these sources. However, the nature of such grey literature varies wildly, making it difficult to deem the validity of this type of information.

The author team conducted the identification of search words and the searches in the databases. The authors were aware of the interlinked nature of OS and occupational health. Still, it was decided to omit the word health from the search words, as it was thought to be steering the searches strongly towards areas outside the scope of the review, i.e., to constructing alliances in health care or collaboration inside different health care organisations. The corresponding author performed the article analysis phase, obeying the guidelines for reviews relating to occupational safety and health (Howard et al., 2017). Potentially, there is a possibility of subjective biases in the analysis phase. To minimise this, the author team discussed the preliminary findings on several occasions during the process. Further, it should be noted that no single scientific article database has been deemed the most suitable for systematic literature reviews of construction in this context. Thus, three databases were examined to increase the validity of the results. Additionally, the search method could be biased as only English keywords were used, and only articles written in English were included. This might have meant that some articles from other linguistic areas were left out.

Finally, we highlight that the interview material was collected from a quite narrow population. Still, considering the nature of the alliance projects they represent, their role in those projects and certain saturation achieved, we argue that the interviews provided valuable insights into this sparsely studied area.

5. CONCLUSIONS

This article revealed the immature nature of scientific knowledge on OS in alliance projects. Further, this article expands this knowledge with interviews at two ongoing alliance projects in Finland. It is somewhat surprising how little we know from OS in alliances given the accumulated knowledge on OS challenges in construction and on alliancing in general. Experiences of OS-related challenges concerning partner selection and those that occur between the stakeholders during such projects were discussed in some form in the articles but often not implicitly. This in turn, hindered the critical appraisal of these studies by making exact data extraction and evidence rating impossible. Often the discussion related to culture creation and '*profit-loss sharing*' between the stakeholders. Naturally, different stakeholders in the alliance aim to increase their possibilities of making profits and decreasing risks. However, evidence of actions resulting in the best for the project was still rather modest. The articles discussed shared values between the stakeholders, such as honesty, trust and openness, as elements contributing to OS in practice at the site. In addition, accountability awareness was highlighted as a key challenge. This awareness related to mutual agreements and communication on the responsibilities concerning OS.

Even though OS might have been identified as a salient element of the alliance projects, only a little detailed information is available on how OS is managed in practice during the projects. For instance, some articles highlighted how OS was included in the KPIs of the project, but they did not describe the indicators or indicator data in detail. The interviews conducted in this study shed some light on this perspective by summarising the indicators used in the projects.

It is also important to note that alliances, as a way to organise especially large and complex projects, are in the early phases of their life cycle. There is extensive potential regarding their efficiency and effectiveness, and in terms of OS improvements, once organisations and the industry possess the full capability to apply and take advantage of these possibilities. This article urges researchers to study OS in alliance projects in more depth and proposes eight perspectives for future studies to provide more scientific knowledge on OS in terms of this promising collaborative project delivery method and serving the construction industry in general concerning overcoming the variety of

different OS challenges. Further, future studies could describe the close connection between OS and quality and productivity in a construction project.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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