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MANAGING SAFETY CULTURE IN COMPLEX CONSTRUCTION PROJECTS - INSIGHTS FROM A FINNISH RAIL ALLIANCE PROJECT

Abstract: *Construction projects are complex environments where diverse stakeholder subcultures shape safety culture. Dynamic information flows and changing work conditions challenge effective project and safety management. Ensuring high levels of effectiveness and quality demands robust coordination, adaptive planning, and stakeholder collaboration. This study examines safety culture development in the Raide-Jokeri (RJ) rail construction project (2019–2022), delivered via an alliance model. Quantitative data from project systems (annual occupational safety indicators) and two personnel surveys were used as secondary data, complemented by interviews with construction block managers as primary data. The secondary data indicated a mature safety culture, which was reinforced by interview insights from managers with localized oversight. The study contributes to alliance project management discourse by showing how integrated collaboration mechanisms can foster safety culture maturity in large-scale infrastructure projects.*

Keywords: *alliance, collaboration, construction, occupational safety, safety culture*

1. Introduction

Despite various development efforts on occupational safety (OS) throughout the years, the construction industry has been and remains plagued globally by occupational accidents, injuries, and illnesses (e.g., Johansson et al., 2019; Luo et al., 2022; Verstina & Magera, 2024). In addition to the complex negative consequences of the accidents, from the individual to societal levels, proof also exists for their negative influences on construction work itself (e.g., Jaafar et al., 2018). Hence, OS development should be of utmost interest for all stakeholders involved in a construction project (Alkaissy et al., 2020; Choudhry, 2017). Construction quality and OS are

intertwined; hence to achieve long-lasting efforts in this regard, construction project management should actively seek means to develop and maintain a shared positive safety culture at the construction site (Trinh & Feng, 2020; Wanberg et al., 2013).

The concept of safety culture is inherently complex and subject to various interpretations. It is also often considered a subcomponent of the broader organizational culture (Edwards et al., 2013; Jilcha & Kitaw, 2016). Safety culture is an elusive concept that relates to the values, attitudes, and perceptions of the members of an organization, and it seems to evolve over time through widespread organizational commitment, incentives, motivation, and personal identification. It is often discussed

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interchangeably with closely related terms like safety performance, safety management, or safety climate (Choudhry et al., 2007; Kalteh et al., 2021; Nielsen, 2014). Of these, the concept of safety climate is commonly seen as a narrower and more measurement-oriented concept that reflects a surface manifestation of deeper cultural levels (Bisbey et al. 2021; Nielsen, 2014). When considered from the safety management and safety performance perspectives, a safety culture can be seen influencing the deployment and effectiveness of the safety management resources, policies, practices and procedures (Kalteh et al., 2021; Nielsen, 2014).

In the literature the interrelated relationships between the safety culture, safety compliance and positive safety performance development have been argued (Bisbey et al., 2021; Kalteh et al., 2021; Nielsen, 2014; Schulman, 2020). Safety culture is reinforced by a mutual trust among employees across different units and hierarchical levels (Choudhry et al., 2007; Bisbey et al., 2021; Tear & Reader, 2023). The present study focuses on the safety culture in a large-scale Finnish infrastructure construction alliance project, the Raide-Jokeri (RJ) project. We see safety culture as a dynamic element of organizational culture. Safety culture is reflected in shared values, attitudes, and perceptions that influence safety management practices, performance outcomes, and are reinforced by trust and commitment across all levels of the organization.

RJ has been deemed a success in Finland as it was completed 10 months ahead of the schedule and with savings of several million Euros (Helsingin Sanomat, 2023). Alliances are a relatively new model of a collaborative project delivery in which all alliance partners (including clients, contractors, and consultants) work toward a mutual goal with shared responsibilities and profits. Differing from traditional forms of construction project types, such as the 'construct only' or 'design and construct', the alliance model underlines partner collaboration within a mutual 'pain-

share/gain-share' approach inside the project (Hietajärvi & Aaltonen, 2018; Lahdenperä, 2017; Lehto & Aaltonen, 2021; Love et al., 2010). Value creation dynamics that include, for example, project responsibilities and reward arrangements are settled in multi-party contracts between the alliance partners (Galvin et al., 2021; Pargar et al., 2019). The alliances require trust between the partners to avoid opportunistic approaches for profit-making and shifts in the focus for genuine collaboration with a 'best for the project' approach making it an interesting area for organizational culture research. One peculiarity on alliancing is the collaborative project identity being attained, e.g., through common practices where site personnel share the same symbols, such as logos, not depending on their employers, with the aim to create an atmosphere of joint enterprise and collaboration inside the alliance site (Nyameke et al., 2021; Pargar et al., 2019; Reuer & Ariño, 2007). Previous studies have shown the benefits of the collaborative alliance model (Lahdenperä, 2017; Love et al., 2010; Rahman & Adnan, 2020). Nevertheless, failures have also been documented (Day, 1995; Lahdenperä, 2017).

OS literature focusing on alliances is narrow in scope as well as depth. In that respect, it has been recommended to focus on the development of their overall management systems, including the creation of sustainable partnerships with suppliers and project identity formation (Salomäki et al., 2022a). Project identity refers to personnel from different backgrounds and companies identifying themselves more as part of the alliance than as members of their respective employers. This makes it a fruitful topic for scientific discussion around the concept of safety culture and how it is rooted in alliance settings. In existing literature, it has been recommended to focus on how the organizational culture (and safety culture along with it) develops within alliance projects (Engebø et al., 2020; Galvin et al., 2021; Pargar et al., 2019; Reuer & Ariño, 2007; Salomäki et al., 2022a). Due to the

complexities continuously evolving multistakeholder construction sites bring along, such a study would benefit from a longitudinal and triangulated (i.e., mixed methods) research approach (see Kalteh et al., 2021; Zou et al., 2014). Combining quantitative and qualitative research methods allows for a deeper exploration of the phenomenon being studied and makes it possible to obtain a more comprehensive understanding of the subject (Hale et al., 2010; Kalteh et al., 2021; McCabe et al., 2017; Trinh & Feng, 2020; Zou et al., 2014). In this study, we employ qualitative and quantitative research data to 1) examine how safety culture evolved during the RJ project execution, and to 2) learn how RJ managers viewed this development.

2. Background

Modern construction projects are rarely completed by a single company executing all stages and details. Instead, construction work is usually conducted in continuously evolving multi-employer environments, with subcontractors and suppliers working for certain periods of time under the main contractor. This multi-employer perspective raises constant concerns regarding project management and related cooperation and communication between different stakeholders (Flanagan et al., 2007; Nyameke et al., 2021). Sustainable performance in terms of OS simultaneously with the production success and quality requires strong OS emphasis at the organizational and project network levels, and on the safety culture within the project personnel (Oedewald & Gotcheva, 2015; Yao, 2023). In this regard, emphasis should reach all individuals working at the site and their skills, knowledge, and cognition (Liu et al., 2023; Moradi et al., 2020).

From the safety culture perspective, constantly developing construction sites are challenging, as they consist of temporary work groups that represent different organizations (e.g., owners, clients,

contractors, and subcontractors) that bring with them their own sub-safety cultures to the site (Fang & Wu, 2013). These multi-employer environments are also challenging from the project management—and management systems’—perspective, due to the broad variety of information available in general (Głodziński, 2019) and related to OS (e.g., Alkaissy et al., 2020; De Minicis et al., 2011). From the organizational culture perspective, merging subcultures and their compatibility, and the complex information flows inside a project can be an issue that—if not managed properly—can lead to cultural ‘indigestion’ (Schein, 1990). In practice this ‘indigestion’ can manifest itself in several ways, such as resistance to changes and renewal, conflicting values and priorities, and decreased morale and engagement—all being potential causes for flaws in quality, and also sources for OS hazards. Creating a uniform safety culture at the site in these types of work environments requires collaboration between the management and the employees from the whole construction supply chain and covering the entire project life cycle. This can be fostered through jointly shared information and mutually agreed communication channels (Zou, 2011).

As discussed by Schulman (2020), an organization’s top management is an essential contributor to the safety culture. As decision makers they have a strong influence on the organization, for instance, through their ability to allocate resources to safety development. Furthermore, in their role, top management has the ability and possibility to communicate throughout the organization, making it possible for them to steer and reflect the organization’s attitudes and values, which are at the end interpreted and reproduced by its members. At the same time the role of localized actors, as practical modifiers of the safety culture, should also be acknowledged. Concerning construction, the highlighted cornerstones of the safety culture have been identified to include elements like the management and supervisor commitment to OS, their leadership orientation towards

OS and safety more in general, a holistic project life cycle and supply chain approaches to OS, successful implementation of OS management standards, systems, and manuals, utilization of reliable OS information, related OS rules and procedures, and effective OS training focusing on skills, knowledge, attitudes, and beliefs, as well as OS rewards and recognition arrangements (Aburumman et al., 2019; Choudhry et al., 2007; Kalteh et al., 2021; Zou, 2011).

3. Methodology

In this study, we used quantitative and qualitative research methods and data supplementing each other. The trends from the alliance project-level OS indicator data (annual accident frequencies, annual numbers of safety observations, and weekly site OS inspection index data) were collected from the project's existing information management systems as secondary data to obtain an objective contextual understanding of the OS performance and its development in

the project. As another secondary data, the personnel-level perspective on the safety culture at the site was collected through two safety culture surveys from the project site personnel in 2020 and in 2021.

Elaborating from Schein (1990) and Denison (1996), we believe that safety culture, like organizational culture, is unlikely to be measured merely within a quantitative survey method; it also requires qualitative perspectives. Surveys often have underlying dimensions determined in previous research, and before a survey is administered, it is challenging to obtain knowledge regarding the relevance or salience of these dimensions in the culture being examined (Kalteh et al., 2021; Schein, 1990). Hence, to supplement the above secondary data, qualitative data as the primary data were collected through manager interviews. These data were collected to learn what managers, as localized key actors, saw behind the secondary data and how they connected that to alliancing (see Figure 1).

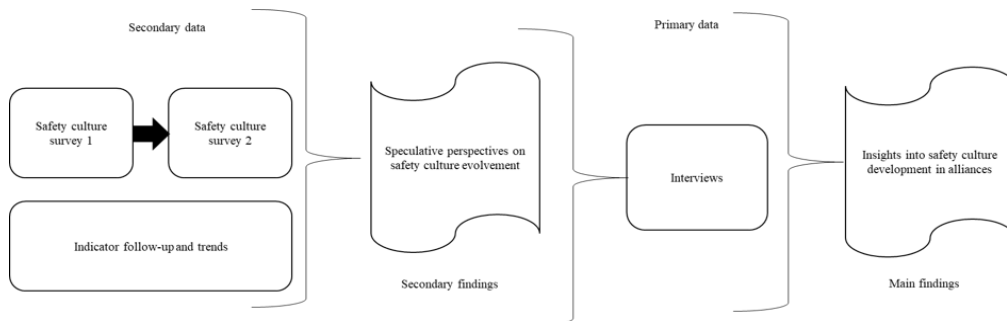


Figure 1. Study approach applied in this study

3.1. Study context

The context of this study draws from a large-scale Finnish infrastructure construction alliance project (the RJ project), which was the largest light-rail construction operation in Finland at that time, with an estimated cost of 550M Euro. The project spanned the urban metropolitan area of Finland, through the cities of Helsinki and Espoo, for 25 kilometers.

The RJ project began in 2019, and the construction work phases were finished at the end of 2022. It was conducted in the form of an alliance project with eight participants as alliance partners: the cities of Helsinki and Espoo and a local light-rail operator (clients), three engineering companies (designers), and two construction companies (constructors). In addition, over 200 subcontractors participated in various building, transportation, and support activities.

The RJ project was divided into five geographical construction blocks and a maintenance and overnight storage depot. Each construction block worked relatively independently under a block manager who oversaw construction activities and coordinated cooperation with and between certain specific units (special construction, track, and welding and electric operations) working all over the alliance. All alliance activities (including alliance OS management and OS coordinator tasks) were coordinated in a 'Big Room' that served as the heart of the operations, controlling the big picture, coordinating activities, and providing support to the construction blocks. Each block had its own OS engineers and OS representatives, who were responsible for day-to-day OS routines at the block. The most important OS measures and practices were decided during the project design phase. These included uniform processes for worker inductions, weekly OS toolbox talks, weekly on-site safety inspections, processes for collecting and analyzing safety observations, and processes for accident and near-miss investigations. In addition, regular management safety walks were arranged for the top management and for the block managers with the alliance OS management. These block manager safety walks were an essential tool in supervising OS measures in and between blocks. Regular and constant contact was also upheld between the OS manager, workers' safety representatives, and block safety supervisors.

3.2. Data collection and analysis

The perspectives on safety culture development were examined using a longitudinal study approach through two surveys with a structured safety culture questionnaire. The survey was conducted twice: at the end of 2020 and 2021. Results of the first survey have been discussed by the Salomäki et al. (2022b). In this study, the focus is on the development trends between the two surveys. The questionnaire was

developed by a team of long-term OS professionals for commercial purposes. Thus far, the questionnaire has been used in 13 countries around the world, with over 25,000 respondents (Kiwa Inspecta, n.d.). In the present study, both online and paper versions of the questionnaire were made available. The questionnaire consists of 30 questions, and the respondent is asked to provide responses on a scale from poor (1) to excellent (4). Open questions were also used. By the questionnaire protocol, the questions are divided evenly into six categories: I) Organizational culture, II) Leadership, III) Safety systems, IV) Personal Actions, V) Atmosphere, and VI) Questions for supervisors. The respondents were also asked to provide some background information (age, work experience, block, position, employer).

Altogether, 360 responses were received for the first survey in 2020 (appr. 50% of all site personnel) and 160 responses in the second survey in 2021 (appr. 75%). The respondents' demographics are shown in Table 1. Pairwise comparisons for categories I–VI were conducted to analyze the development trends between the surveys. The statistical testing procedure was: 1) Testing for statistically significant differences between the surveys based on the respondents' position; 2) For significant differences, performing post hoc analyses for a) differences between the alliance employees (partners) and non-alliance employees (subcontractors), and b) differences on the individual question level. The non-parametric Kruskal-Wallis (K-W) test (adjusted for ties) was used to test differences in medians between groups due to the non-normal distributions of the category means and to the ordinal scale used for the individual questions. The analysis was performed using Minitab 21 software. To denote the statistical significance of p-values, *** is used to signify p at 0.01, ** for p at 0.05, and * for p at 0.1.

Table 1. Respondent demographics for the surveys

	Survey 1 (n/%)	Survey 2 (n/%)
Position		
- Worker	237/65.4	71/44.4
- Supervisor	80/22.2	62/38.8
- Support staff, planners	35/9.8	21/13.1
- Senior management	8/2.2	6/3.8
Employer		
- Alliance member company	192/53.3	119/74
- Subcontractor company	168/46.7	41/26

As suggested in the OS literature (e.g., Kalteh et al., 2021; Oswald et al., 2018; Xu et al., 2021), the RJ project followed a combination of leading and lagging indicators for measuring project OS performance. Annual indicator data and their development trends were used for this study as secondary data. As a lagging indicator, the annual accident frequency (occupational accidents leading to an absence of one or more working days per million working hours) was used. Accident frequency is a common OS indicator in Finland. The average for the construction industry in general in Finland has remained rather stable during the last years (2019: 19.5; 2020: 17.8; 2021: 19.4) (Confederation of Finnish Construction Industries, n.d.). As leading indicators, the annual number of safety observations (made by the personnel) and the MVR index were used. Safety observations are a common indicator in construction (e.g., Hinze et al., 2013). The MVR index is a commonly used safety observation method for civil engineering works in Finland (Occupational Safety and Health Administration in Finland, n.d.). MVR index is based on a standardized site inspection checklist, and the index is formed from a weekly inspection. In addition to these alliance-level indicators, the corresponding author had access to block-specific OSH indicator data. These data are not presented in the article for privacy reasons but were used as background information when interpreting the results of the interviews.

In the interviews, the interviewees were made familiar with the secondary data and were asked to reflect those with the following themes from the RJ project perspective: 1)

Differences in the OS perspective between the alliance delivery model and traditional construction project deliveries, 2) Practical manifestations (good and bad) of a safety culture, 3) Partner and personnel OS behavior and its effects on the safety culture, 4) Tools and measures for developing the safety culture, 5) Developing the safety culture among the personnel, 6) Safety culture transfer to newcomers entering the site for the first time, and 7) possible effects due to changing personnel on the safety culture at the site.

The interviews focused on block and technical discipline managers, as they were considered to have the best perspective on the situation at the site from the OS management perspective, (i.e., they were considered localized key actors supporting the safety culture development from their management position. Based on their project experience (working in that position for at least one year), ten managers were considered suitable for interviews. Of those, seven were reached for interviews. Two candidates had changed their workplaces and were no longer available for the interviews, while one had passed away during the project. Interviews were conducted remotely by the corresponding author in the fall of 2022. At that time, the RJ project was in its final construction phases, so some of the interviewees had already moved on to new projects inside the company and were therefore spread around the country. As the corresponding author had worked on the RJ project, all interviewees were already familiar with the interviewer. The interview lengths varied from 20 to 41 minutes and were recorded and transcribed for analysis. In the

analysis, the corresponding author first became familiar with the data by reading through it several times and then based on the accumulated understanding identified 1) general indications of a safety evolution in practice and 2) related to alliancing.

4. Results

4.1. Secondary data

Concerning the indicators, the annual accident frequency decreased by half during the inspection period (2019: 12; 2020: 10; 2021: 6). At the same time, the annual number of observations varied (2019: 683; 2020: 1919; 2021: 1350), and the MVR index remained in a rather stable mode (averages: 2019: 96.49; 2020: 96.39; 2021: 97.04). Concerning the MVR index, annual figures seem somewhat similar, but there is a difference between the number of MVR measurements (2019: 219 measurements, 2020: 481; 2021: 513) relating naturally to the start of the construction phase in August 2019. Additionally, in summer 2020, the MVR inspection protocols were updated by the alliance OS management to take a stricter approach to on-site deficiencies while making the inspections. In practice, this meant a temporary decrease in the result percentage.

Concerning safety observations, a point worth noting is that the depot area was finished in July 2020, construction block 1 in September 2020, and block 2 in August 2020, leading to a decrease in the number of personnel that naturally affected the number of safety observations made by the personnel.

In the first stage of the statistical analysis between the two surveys, development trends were analyzed from the respondent position perspective. No statistical differences were observed between surveys for the supervisors, support staff, planners, and senior management; therefore, the survey analysis was focused on the largest respondent group: the workers. The two samples of workers from Survey 1 ($n = 237$) and Survey 2 ($n = 71$) showed statistically significant differences according to the procedure presented in paper. Table 2 presents the 95 % confidence intervals for the means and medians per category, as well as the results of the K-W tests for differences between the surveys for the Workers group. For the K-W test, the H test values, degrees of freedom, and p-values are reported in Table 2. Category VI (Questions for supervisors) was excluded, as it was not a section that the workers responded to, as they had no supervisory tasks.

Table 2. 95 % confidence intervals (CI) for means and medians for surveys 1 and 2 for each category of questions (lower bound; upper bound), and Kruskal-Wallis test statistics for differences between the two surveys (H(df); p-value) for Workers

	Survey 1 mean (95% CI)	Survey 1 median (95% CI)	Survey 2 mean (95% CI)	Survey 2 median (95% CI)	Kruskal-Wallis test (H(df); p-value)
Organizational culture	3.16;3.32	3.2;3.4	3.38;3.61	3.4;3.8	9.17(1);0.002***
Leadership	3.10;3.27	3.2;3.4	3.24;3.49	3.2;3.6	3.60(1);0.058*
Safety systems	2.91;3.07	2.8;3.2	2.98;3.24	2.8;3.24	1.49(1);0.222
Personal actions	2.92;3.06	2.8;3.0	3.09;3.31	3.0;3.4	7.34(1);0.007***
Opinions and Atmosphere	3.07;3.22	3.0;3.2	3.23;3.48	3.2;3.6	7.05(1);0.008***

A statistically significant improvement was seen in the Organizational culture category between the two surveys. A particularly large increase was noted in the questions related to the commitment to safety and the ability to participate in developing safety. For the workers of the alliance companies, this change was the most pronounced. In the Leadership category, some improvement was also apparent, particularly regarding questions pertaining to the superiors and managers acting as role models for safety. In the Personal actions category, a particularly large change appeared in the questions referring to commitment to cleanliness and to adopting safer working methods. In Opinions and Atmosphere, the largest improvements were found regarding the unwillingness to hide accidents and the individual commitment to safety. Regarding the Safety systems category, no significant difference was identified between the surveys.

4.2. Primary data

Above secondary data suggest that something positive has happened in RJ concerning safety culture evolution, but the data do not allow discussing what is behind the data. Interviews, as the primary data in this study opened possibilities for deepening the secondary data analyses. Survey data showed development in supervisors OS commitment. In the interviews these perceptions on their role to 'lead by example' and vigilance on 'intervening deviations' were constantly discussed as components structuring safety culture development. The perspectives on leadership and supervision were viewed as closely related to each other but were still regarded as separate features of successful OS management at the site. One interviewee explained leadership based on the negative consequences related to it: *'This comes down from manager's behavior. One belittling gesture or comment or turning a blind eye can have a significant [negative] effect on site safety.'* Overall, six interviewees described how site management should be continuously

vigilant and careful about what kind of attitude they project to personnel when OS is in question. Based on this observation it can be argued that managers' active and visible participation along with their capabilities and willingness to monitor behavior on site is crucial for the maturation of the safety culture as evidenced also by the survey data. In practice, this was manifested by the interviewees as actions that did not provide opportunities for 'turning a blind eye' to deviations from safety regulation or for being too busy to talk about safety-related topics. Notably, as a link to indicator data, the block managers who actively brought up these management perspectives during the interviews were also those leading blocks with the lowest accident frequency ratios inside the alliance.

Related to above leadership perspective, all interviewees highlighted the commitment certain site-specific 'key persons' (or localized key actors) had and the value they provided to the safety culture at the site where workers changed constantly based on the progress of the project. The presence of key persons committed to the project and its OS development from its beginning was considered imperative to secure sustainable safety culture development. One of the interviewees phrased it as follows: *'When you have good core personnel, you must hold on to them 'tooth and claw' when realizing that this is good crew, this is a good worker, this one is a professional. This also means they take care of safety. You simply must hold on to them. On the other hand, if there are [persons] who act unprofessionally or have such an attitude, you must get rid of them. That is not always that simple though.'*

As an individual-level feature related to vigilance and commitment to OS, an 'Attitude' was constantly highlighted as an essential part of the safety culture. Survey data showed development in this regard especially for those working for the alliance companies. As was observed from the survey data, commitment to OS and vigilance developed positively during the project. In

this regard, the role of attitude was described in many ways by the interviewees. Generally, it was seen as ‘taking OS seriously’ and ‘acting it out in day-to-day work.’ This connection to daily practices comes out well in the interview by a block manager, whose 50M euro block had been the most successful block from the OS perspective, with zero injuries reported: *‘At grass root level, it [safety culture] is visible in everyday work: everyone wears personal protective equipment (PPE), they use safe tools in a safe way. For example, people understand that no one uses a chainsaw without proper PPE, and so on.’* This quotation suggests how the safety culture can be observed—to some extent—from the day-to-day work at the site. Daily practices and mutually agreed rules were mentioned several times in the interviews as part of a mature safety culture. Most commonly, the interviewees associated these practices and rules with the proper use of PPE on every occasion and on visually perceptible actions related to site orderliness. These included daily activities and routines, like protection around trenches, fences in place, gates being closed during operations, and work equipment being in order and inspected when necessary. Their relation to the safety culture shows in the following interview quotation: *‘A clean site is always a safe site as well. It means safety is appreciated, which can be observed when workers clean out unnecessary boards and other clutter [without being ordered to do so]. That gives a good general appearance to the site.’* In this the interviewee also referred to the fact that despite site inspections are mandatory in Finland, it is still clear that not every site is in order and safe. Another interviewee reflected on these daily practices and site orderliness from a work community perspective, stating how responsibilities for safety belong to everyone at the site: *‘You can observe site safety from cleanliness, as in site being orderly. Fellows taking care of their tools and machinery, and so on. Refilling stations also. Lifting chains are inspected, and there is no need to repeat same [safety] instructions, day*

in and day out. And gates being shut, fences in place. This is a process that takes time before it is adopted by everyone.’ These responsibilities and commitment to OS also included a peer pressure perspective, as highlighted in the following interview quotation by an interviewee whose block had been the most successful in terms of OS: *‘If there is some fool that comes on site and neglects, let’s say PPE, others will tell him to stop, as they understand it’s not okay. Or inform the supervisors if this is not enough. They either learn to adjust or leave the site. Safety culture remains good when ‘rotten apples’ leave. Or mend their ways.’* In this interview the block manager regarded compliance as an integral part of a mature safety culture. Notably, peer pressure was not always regarded as having a negative ring to it, as can be interpreted from this interview quotation by another block manager: *‘There is a kind of peer pressure effect among workers. If you get one [worker] with some kind of occupational pride considering cleanliness of his working spot, he will hear the others who might not be so motivated to do so and get them back in line.’*

The above important insights characterized safety culture evolvement from the RJ perspective, but they were still of a general nature and did not explicitly point out perspectives pertinent to the alliance model. All interviewees speculated how the trends that could be observed from the secondary data seemed realistic when it comes to safety culture development in RJ. When going deeply into the alliances, five of the seven interviewees saw that there is a difference between an alliance type of project delivery and traditional types. This project type perspective, favoring alliances, emerges well in the following interview quotation: *‘In an alliance, managerial work is more like leading a project, and we can better influence through our own work. When I compare it to another huge [traditional] project, where there was something like twenty subcontractors. It was wild. Everyone was coming and going as they pleased, and no one*

knew who is who and who is 'that guy creeping around'. In here, if anyone comes on site, they are given inductions, and the first contact is formed that way.' This suggests that alliances, as a participatory model might be more suitable to OS management from the stakeholder management perspective. Further this provides possibilities to speculate how the collaborative approach, intrinsic to alliances, allows common safety culture creation from the beginning of the project.

Deepening this collaboration perspective, interviewees constantly discussed how alliance structures provided better possibilities for constructive collaboration and henceforth to better commitment to OS. This comes out well in the following quotation, where the interviewee discussed alliances from the project management perspective underlining the joint agreements in alliances: *'Alliance is a joint venture where a lot of emphasis is placed on a shared model where shared rules are created throughout the whole project... Traditionally when there is only one [main] contractor, it is only their rules that are 'grinded' [enforced] for years. In an alliance, new practices are formed together and this way they stay fresh in the memory.'* The previous quotation makes it possible to speculate how commonly shared OS practices and processes are an integral part when aiming to reach a mature safety culture. The previous quotation relates also to another important alliance perspective, the pain-share/gain-share approach, that was constantly emphasized in the interviews. This comes out well in the following interview quotation, where the interviewee ponders the differences between alliances and the more traditional types of construction project deliveries: *'I have found that there is a clear difference. In an alliance there is an emphasis on doing things together. Safety is better knitted in this kind of project model. In traditional customer-contractor projects there is often the situation where both sides are 'dug in their own foxholes' [entrenched in their own positions]. This leads to safety being dictated from above and often the focus*

is on trivial details and not in actual safety issues. In some instances, mistakes are searched purposefully [by customer's representatives for gaining financial benefits through sanctions] which reflects everything and underlines antagonism.' When these joint agreement perspectives were considered from the OS management perspective, the same differences arising from the collaborative approach were highlighted, as can be seen from the following interview quotation: *'There is a significant difference. Safety is at a completely different level in an alliance, as in traditional projects money is the number one thing above anything else. In alliance we have weekly toolbox talks and such, which are often the first on the chopping block... This level of investment [in safety] would be nearly impossible for smaller enterprises... We have a lot of different training, which are not normally available. This is a tremendous difference in my opinion.'*

5. Discussion

This study delved into the safety culture evolution in a large-scale construction alliance project in Finland. Alliances, as emerging forms of construction projects, are commonly characterized in the literature in terms of their intrinsic arrangements and management systems fostering collaboration, and features and shared values like trust, commitment, and co-learning between the partners (e.g., Ahmed & El-Sayegh, 2021). Despite being an emerging project delivery method—with various examples of high-quality alliance projects documented in the literature—relatively little attention has been paid in the scientific literature to OS management and safety culture, or to human factors in general, in the context of alliances (Salomäki et al., 2022a; Wang et al., 2022). The RJ project in focus here has been a success in terms of its schedule and budget, thereby providing a good area for studying it through a safety cultural lens.

As our study shows, the trends for lagging (accident frequency) and leading (MVR index and the annual number of safety observations) indicators collected from the project's information systems can be interpreted as being developed positively during the project. These positive trends in OS performance can be considered a practical implication of the evolving safety culture within the project. When examined through the lens of intertwined safety culture and OS management literature (e.g., Choudhry et al., 2007; Kalteh et al., 2021; Nielsen, 2014), it would be logical to associate these positive trends with the broader evolvement of safety culture, which is a cultural phenomenon that is socially constructed over time (Kalteh et al., 2021). This provides us with possibilities to argue on behalf of a mature safety culture and project identity creation inside the project and during its execution. Using only indicator data generates, however, a weak argument. Hence other data was also collected. As cross-sectional data, our safety culture surveys provided insights into cultural elements associated with OS—or more likely associated with the safety climate at a certain point of time (Kalteh et al., 2021; Mearns & Flin, 1999). When the surveys were analyzed using a longitudinal approach focusing on development trends, we considered that they likely provided a deeper understanding from the safety culture evolvement perspective. Supporting our indicator data, the longitudinal survey analysis showed how OS had developed positively when examined from the worker perspective. Nevertheless, we also determined that significant developments were not identified concerning other personnel group perspectives.

Arguments in the literature raise questions of whether a survey is too robust as a tool for measuring safety culture alone or whether it merely provides a more superficial view of the safety climate at a certain point in time (Antonsen, 2009; Håvold, 2005). For this reason, we supplemented our secondary data analyses with a qualitative analysis focused on our primary data: the interviews. As earlier

literature in the field of construction has shown, our study also revealed how management behavior and commitment, attitude to safety, and discursive approaches to safety communication can be seen as factors supporting safety culture evolvement. When we go deeper into the alliance models in this context, we can argue, based on the interviews, that the pain-share/gain-share philosophy and the collaborative project identity perspective behind the alliance projects also reflect the safety culture evolvement and project identity creation inside the alliance organization. Paralleling with the earlier general literature on alliances (Hietajärvi & Aaltonen, 2018; Fernandes et al., 2018), also our interview data uniformly supported alliance models and the benefits that the collaboration practices between the alliance partners may provide. Elaborating upon Galvin et al. (2021) and Deep et al. (2021), we argue that in the case of safety culture, alliances also benefit from their organization structures, where the primary driver is 'problem solving' rather than partner-specific cost savings or profit making.

5.1. Managerial implications

As a summary, we depict safety culture as a construct that requires common and jointly agreed activities from the overall alliance project management level to the alliance partner and the construction site and work community levels and reaching all the way to every individual working at the site. Based on this study, to initiate and lead safety culture development, we have collected in Figure 2 key perspectives that should be considered when forming and executing alliance projects. In practice, alliance-level OS rules, practices, and resources should be agreed upon during formal alliance contracting. These form the basis for collaboration inside the alliance making it possible to generate trust and develop openness inside the alliance personnel. These agreement-based alliance-level practices and processes and management commitment (leading by

example, key personnel motivation) create grounds for successful site-level activities (as it is of course also for other types of construction delivery models). Finally, as safety culture is something that evolves with time through underlying beliefs, attitudes, values, and assumptions, the role of the

individual-level OS attitude should also be acknowledged from the top management to every single worker at the site. This requires a strong OS management approach for which collaborative alliance models (and their tools, processes and practices) provide good possibilities, as highlighted in the interviews.

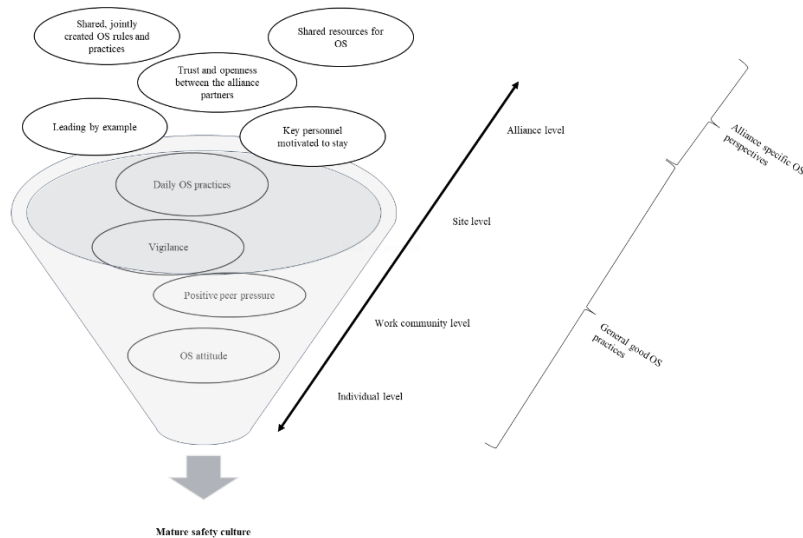


Figure 2. Key perspectives to be considered when seeking mature safety culture in alliance projects

5.2. Limitations of this study and proposals for future studies

From a data collection and analysis perspective, the following should be acknowledged when considering the limitations of this study. The number of respondents varied between the surveys (S1: 360, S2: 160), yet the response rates (~50% in 2020 and 75% in 2021) can still be considered adequate for organizational research (e.g., Baruch & Holtom, 2008). Similarly, the respondents also varied, as the surveys were aimed at those working on the project at the times the surveys were conducted. This is common for construction work. The timeframe between the surveys was approximately one year. From an organizational change management

perspective, this period might be somewhat short for seeing sustainable changes (e.g., Kaplan & Norton, 2004). The timeframe was tied to the project execution and was not merely designed from an optimal study perspective. The survey was conducted through a commercial survey tool that has not been validated for scientific purposes. However, we argue for its feasibility because it has been widely used globally and because we did not use it as the only measure for our safety culture analysis. In addition, the raw data from the surveys were available for our analysis.

The interviews were conducted by the corresponding author, representing the alliance OS management. Possibly, in this role as a person responsible for the alliance OS management, and with access to all RJ

information systems some biases could be associated with the interpretations made from the data. These possible biases were reduced through constant interaction with the research team concerning data collection and analysis. This role was also considered positively, as it eased the analysis (contextual understanding, access to information systems and related primary and secondary data collection, and interpretation). Interview data were limited (in terms of the number of informants and the length of the interviews), yet a certain level of data saturation was considered to have been achieved in the analysis. As a future study perspective, we recommend supplementing the interview study part with interviews from other stakeholder groups, such as the alliance top management, workers, and OS personnel. Concerning indicator data, we used existing data collected from the alliance's information systems for practical purposes. We see that accident frequency ratio as a lagging indicator (in which we refer to when speculating on the trends in OS performance during the project) is not a perfect measure, as it is similarly to any collected data, influenced by some subjectivity, such as how, why and what kind of accidents are included (e.g., Oswald et al., 2018; Xu et al., 2021). Hence we included also leading indicators (the annual number of safety observations and the MVR index) in our study. In future studies, we recommend enriching the data for instance with indicators on employee turnover and discussing the indicator data from the perspectives of the separate construction blocks. Employee turnover is an interesting variable in construction projects, as construction sites are constantly evolving work environments where personnel change continuously according to the project phases.

6. Conclusion

This study explored the development of safety culture within a large-scale Finnish rail construction alliance project. The data collected, including OS indicators, safety culture surveys, and interviews, allowed us to discuss safety culture and its' evolvement in this specific mode of construction project delivery. Surveys such as the one used in this research provided snapshots of the current states of affairs inside the project. When analyzed within a longitudinal approach, these two surveys provided insights into developmental trends that allowed speculation also on safety culture evolvement. These conclusions were also supported by the positive trends on indicator data collected from the project's information management system. To further deepen these conclusions arising from this so-called secondary data, an interview study was conducted. The interviews, as the primary data, targeted construction block and technical discipline managers, who were considered to have a comprehensive view in the project execution also when it comes to OS and safety culture. These experienced professionals uniformly verified the conclusions drawn from the secondary data and highlighted how the intrinsic feature of collaboration, natural to alliance projects, supported the safety culture development among alliance partners. These findings align well also with quality management principles that advocate cross-functional integration and stakeholder engagement. Collaboration can be initiated with common alliance level agreements that guide daily OS activities, practices, and processes. At the end, management is in a crucial role, securing that these are actively implemented in the project during its execution. This is welcome information for future alliances aiming to enhance their safety culture. However, future studies in other alliances and in other country contexts are needed to confirm our findings.

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