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Article

Multilevel Safety Climate for Lone Heavy Vehicle Drivers in the UK Quarrying Industry: Validation of the Heavy Vehicle Safety Climate Scale (HVSCS)

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Abstract

The primary goal of our research was to validate a context-specific safety climate measure (the Heavy Vehicle Safety Climate Scale: HVSCS) in a sample of heavy mobile equipment operators (N = 277). An exploratory strategy was adopted, using exploratory factor analysis (EFA) to validate the items. The statistical results revealed a five-factor structure, with two factors at the organisational level and three factors at the group level. In addition, a nomological analysis showed that both organisational and supervisory safety climate factors presented distinct correlation patterns with other safety-related variables, including situational and routine violations, safety citizenship behaviour, context-specific safety behaviours and risk propensity. In this study we developed and psychometrically validated a context-specific safety climate tool for lone heavy vehicle drivers in the quarrying industry: the Heavy Vehicle Safety Climate Scale (HVSCS). It is hoped that the final 37-item HVSCS will be utilised by those managing heavy vehicle operations, particularly in the quarrying industry, to identify context-specific opportunities for safety climate improvements and in turn reduce the risk of safety incidents.

Keywords: safety climate; quarry industry; lone-workers; heavy vehicles; driving; accident risk; safety behaviour

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1. Introduction

On average, approximately seven workers die each year as a result of accidents involving vehicles or heavy mobile plant on construction sites, with a further 93 seriously injured [1]. The start of the construction process involves the extraction of minerals (quarrying) and the manufacture of construction materials. A large proportion of safety incidents in this industry are related to what in the UK are called heavy plant, or heavy mobile equipment (e.g., excavators, loading shovels and dump trucks—10% of fatal injuries in the UK in 2022/23 were due to being struck by a moving vehicle [2]. To avoid confusion for readers unfamiliar with this terminology, we will henceforth use the term 'heavy vehicles' to describe this equipment. Due to their size, these machines have the potential to cause serious harm to individuals and severe damage to company assets. This is a salient issue for many organisations involved in the extraction and manufacture of construction materials, and the construction industry more generally, which is considered high-risk for injury and death [3,4]. Despite advancements in safety management systems, many organisations that operate heavy vehicles in high-risk environments still have relatively high rates of incidents [5,6]. There is a pressing need to reduce mobile equipment incidents rates, but there is currently limited research in this area.

Because of the dearth of research on the antecedents of safety performance of heavy vehicle drivers in the quarrying industry, there is also a concomitant lack of context-specific measures. Safety climate is a valuable construct to explore as it conceptualises the way in which a workforce perceives safety values, priorities and procedures [7] and has also been shown to predict safety behaviours [8,9], however there is no existing measure for heavy vehicle operations. A notable context-specific characteristic of heavy vehicle driving in the quarrying industry is that for the majority of time on shift, drivers carry out their work tasks alone with a lack of face-to-face supervisory communication, oversight, and support. These workers operate in a high-risk environment due to the busy activity on site, proximity to other vehicles, barriers or buildings, weather conditions, the handling of heavy or sharp materials, near-by pedestrians, and other varied hazards. These lone workers must make daily decisions about safety at work because it influences or competes with other performance facets of the job. These can be related to the task itself (e.g., safety vs. productivity), or to the worker performing the task (e.g., safety vs. personal discomfort or extra effort). Little research has been done to examine how a company's safety climate influences lone workers and there is no existing measure of safety climate for heavy vehicle drivers in the quarrying industry. Therefore, the aim of the present study is to develop a context-specific measure of safety-climate for lone heavy vehicle drivers, test its validity, and explore its nomological network.

There are a number of existing safety climate scales in the literature, which have been validated in a variety of contexts [10]. Arguably the most widely used scale includes Zohar and Luria's [11] Multilevel Safety Climate Scale, which consists of two levels (organisational level and group/supervisory level) with three factors in each. While this scale is praised for its psychometric reliability, validity, and predictive ability for safety-related outcomes [12], it does lack context-specific applicability. It is vital that the dimensions measured correspond to the critical aspects of safety climate within the specific context, as subsequent organisational interventions and recommendations may misalign, reducing the effectiveness of efforts made to improve safety [7].

As a result, more context-specific adaptations have since been tested and validated, including one described by Huang et al. [13]. This version of the scale was adapted to measure the safety climate of lone workers, using truck drivers as an exemplar. Heavy vehicle drivers share many aspects of the truck driving job role in that they operate their mobile equipment alone, with limited contact with others, while transporting loads from one location to another.

Due to the lone-working similarities between truck driving and the operation of heavy vehicles in quarrying, for the present study, Huang et al.'s version of the scale will be adapted and put through a psychometric validation process within the context under study. Investigating the scale's internal factor composition at different organisational levels will strengthen understanding of the nature of lone heavy vehicle driver safety climate perceptions within the quarry industry.

The remainder of the article is structured as follows. First in Section 2 we provide an overview of safety climate measurement and its relevance for heavy vehicle drivers in the quarrying industry, followed by our study aims. In Section 3 we describe our methodological approach. The results of the psychometric scale validation and analysis of the nomological network are presented in Section 4, and their implications discussed in the general discussion in Section 5. Finally, we present a conclusion in Section 6.

2. Safety Climate in the Quarry Industry

2.1. Conceptual Foundations, Definitions and Distinctiveness of Safety Climate

There has been an increasing interest in the occupational safety sciences over the past few decades, in the concept of organisational safety climate [14]. Though there is yet to be a definitive definition of safety climate, there is a growing consensus about the concept and its parameters. The construct derives from the more general concept of organisational climate, which was first introduced as a function of a person and their interaction with the organisational environment [15]. More in-depth definitions have since been proposed; Argyris [16] defined organisational climate in terms of employee needs, values, personalities, and formal organisational policies. Over time, definitions have evolved and vary in their focus on individual perceptions versus organisational perceptions [17]. What is clear from the literature, is that organisational climate can hold a powerful influence over things like corporate performance [18] and employee health outcomes [19].

With employee health and well-being becoming an increasing societal concern, it is vital that health-related facets of organisational climate, such as safety climate, are studied. Safety climate is considered to consist of either individual perceptions, or shared perceptions about safety policies, procedures and practices [20]. In other words, employees' perceptions of organisational support and management's commitment to safety in the workplace [14]. Research has long established that safety climate has associations with safety performance, in that a more positive safety climate can increase safety participation and compliance [7,8,21,22] and reduce work-related incidents [23].

If it is, in fact, the case that safety climate is such a strong determinant of key safety outcomes, it is important for organisations to also understand its antecedents. A recent literature review suggests that these antecedents can be clustered into broad categories, consisting of situational factors, personal factors, and interpersonal interactions [24]. An organisation's understanding of the factors that influence safety climate can lead to more effective intervention design. For example, establishing whether it would be more effective to target organisational antecedents such as safety training, safety communication, management commitment, or systems and policies [7], or to have a focus on more personal factors, such as individual motivation or self-efficacy.

It is important to acknowledge that there has been some debate over the distinctiveness of safety climate in regard to its allied construct 'safety culture'. The two terms are often used interchangeably in the literature, despite having distinct etymology [25]. Many studies have also used measurements that they claim to measure safety culture, when they are, in fact, better suited to the measurement of safety climate [7]. It is now generally agreed among researchers that the two constructs, although similar in nature, can be distinguished. While safety culture can be considered to encompass an organisation's safety values, beliefs and assumptions that shape the conduct of their workforce [26], safety climate can be considered a 'snapshot' or cross-sectional indicator of the priority that is given to these values by the workforce at any given point in time [27–31]. In this way, some argue that safety climate is more of an attitudinal or psychological phenomena [26] based predominantly around employee perceptions. Overall, assessing safety climate perceptions as opposed to culture can provide insight into the current safety conditions of an organisation, which can be used to inform the necessary changes needed to improve safety. As a result, this study focuses on the psychometric validation of a safety climate scale designed to measure lone heavy vehicle driver perceptions.

2.2. Safety Climate Assessment and Outcomes for Industries and Organisations

Many studies have established that safety climate has associations with key safety outcomes in a variety of industries and organisations, including aviation [32], construction [33], and railway maintenance [7,34]. There is also a growing body of research that demonstrates a relationship between safety climate and safety behaviours within a variety of work-related driving contexts, predominantly within the trucking industry [35–38]. However, the findings remain inconsistent across and within industries, both for correlational research and scale validation papers. This is likely to be due to the complex nature of safety climate in that it is both a multilevel construct (i.e., consists of an organisational level and a group level) and a multidimensional construct (i.e., consists of several elements including safety commitment, priority, practices, etc.) [39]. In addition, it has been suggested that some dimensions are more or less relevant, depending on how they are conceptualised, particularly in specific work contexts [40].

There has been increasing interest in using and validating safety climate assessment measures within specific industries to counteract the inability of generic scales to capture the nuances of context. These scales have been found to outperform the general safety climate measures, in terms of both face validity [40], and criterion validity such as the amplified association with safety knowledge, and safety behaviour [41]. Casey et al. [40] provided a much-needed commentary and reflection on the merits of developing context-specific safety climate scale based on their experience across six different industries. They conclude that there is a place for both generic and specific scales in the assessment of safety climate depending on the situation and strategic intentions of an organisation. They suggest generic tools remain useful if a company wants a general "pulse check" organised as an overall safety climate score or according to several broad dimensions. They may also want to use this information to compare themselves with others irrespective of industry domain. Given the availability of richer feedback, industry-specific scales appear to be the most useful when seeking to identify factors for improvement or evaluating the success of safety interventions. If adopted across an industry they also facilitate domain-specific norm comparisons and benchmarking.

In regard to heavy vehicle operations in the quarrying industry, there is a lack of research in relation to both the validation of a context-specific safety climate scale, and exploring the relationships between safety climate and key safety performance outcomes. The only comparable safety climate scale validation studies we are aware of at the time of writing are also based within the mining/extraction fields, but did not focus on heavy vehicles. For example, Parker, Tones and Ritchie [42] applied their scale validation process across a variety of work groups, including load/haul drivers, administrative/technical, maintenance and drill/blast fields. They examined the factor structure of a 67-item health and safety climate scale (HSCS), which "represented prioritisation and attitudes towards health and safety across multiple domains and organisational levels". Although their scale demonstrated reliability and validity for use within the mining context, we are seeking to validate a safety climate scale for lone heavy vehicle drivers specifically, as transport-related incidents are currently a concern; it is reported that transport accounts for 40% of all incidents in quarries and 60% of all deaths [43].

The only study we have been able to identify at the time of writing, which specifically samples heavy vehicle drivers (dump truck drivers), did not include safety climate, and instead looked at the psycho-physiological state of the drivers [44]. Whilst this makes a useful contribution to our understanding of the cognitive and physical states that precede risk behaviour, and acknowledges organisational influences on risk behaviour, it did not examine employee perceptions of safety climate.

Of the studies that do examine the relationships between safety climate and safety outcomes in the quarry industry, similarly to the scale validation studies, these lack a specific focus on the operation of heavy vehicles [45–48]. The majority of this research references "miners" or, even more broadly, "workers", who perform a wide range of work tasks and activities, including drilling and blasting raw material, maintaining and repairing equipment, and operating fixed plant machinery.

2.3. Multilevel Model of Safety Climate

Safety climate has long been considered a multilevel construct. As a result, Zohar and Luria [11] measured the construct at two levels: the organisational level and the group (or supervisory) level. They developed and validated the Multilevel Safety Climate (MSC) scale within the manufacturing industry. Subsequent studies have supported this multilevel framework by testing it across different industries and have found positive associations between safety climate and safety behaviours at both the organisational level and group level [49–51].

The original MSC scale by Zohar and Luria [11] consists of 16 items at each level. The items included in the organisational level reflect "top management's commitment to safety or the priority of safety over competing operational goals such as production speed and costs." Items included in the group-level "cover a range of interaction modes between supervisors and group members by which supervisors can indicate the priority of safety versus competing goals such as production speed or schedules". Many studies have since attempted to either validate the existing scale or adapt it to suit other industries or contexts.

Huang et al. [13] used the original MSC scale to develop and test the reliability and validity of an adapted version to suit lone working, using haulage truck drivers as an exemplar. This scale consisted of 20 items at the organisational level, and 20 items at the group level. In their analysis three factors emerged at the organisational level: proactive practices, driver safety priority, and supervisory care promotion. Three factors also emerged at the group level: safety promotion, delivery limits, and cell phone disapproval. Results showed the scale to be a valid and reliable instrument for measuring safety climate for lone-working truck drivers. In addition, they found that the whole scale containing both generic and context-specific items as opposed to only generic items provided a stronger predictive value for self-reported safety behaviour and objective safety data, including hard-braking and road injuries. In the absence of an existing safety-climate scale for heavy vehicle drivers in the quarrying industry and given the overlapping aspects of job role (lone working and transportation of loads), the current study draws upon these findings and adopts a similar approach to validating a context-specific version of the scale, using Huang et al.'s scale as a framework.

2.4. Multilevel Safety Climate Scale in the Quarry Industry: Research Aims

Determining the factor structure of a multilevel safety climate scale within the context of heavy vehicle operations will ensure greater validity and utility for measurement and subsequent intervention design [49]. Therefore, this study will draw from this notion and conduct an exploratory validation process for an adapted version of Huang et al.'s [13] lone-working safety climate scale in a sample of heavy vehicle drivers, operating within the aggregates and asphalt divisions of a quarrying company.

Empirical findings are presented in relation to: (i) The investigation of the internal factor structure of the adapted lone-working safety climate scale in the quarry industry through explorative factor analysis (EFA). This is the first step in the validation process and is therefore essential as no previous published studies have attempted to validate this particular version within the context of heavy vehicle operation. (ii) The construct validation of the scale through the definition of the nomological network of the factors underlying the scale in the quarry industry.

For the construct validation, we explored the nomological network for the constructs expected to be associated with safety climate based on previous safety climate research and generally accepted conceptual frameworks. It is important to note that not only does safety climate consist of conceptually distinct dimensions, but that these dimensions are related to a variety of constructs in ways that are predictable and logical. The current study aims to investigate the nomological validity of the adapted lone-worker scale by examining the correlations between its multilevel and multifactor dimensions with existing related measures.

In line with previous safety climate research literature, we are expecting measures of safety behaviour at the individual level (violations, safety citizenship behaviour, risk propensity and context-specific target behaviours) to be positively associated with safety climate dimensions. Within the construction industry, top-down safety mechanisms have been shown to filter down the organisation and improve safety performance at the individual level [49], highlighting its influential properties. An organisation's safety systems and priorities are directly communicated to the workforce, which shapes the safety values of the employees and subsequently affects the implementation of work activities [29]. In addition, the perceived social or psychological support provided by the organisation to its workforce has been shown to increase things like safety citizenship behaviour as a product of social exchange [52]. This can be considered an expression of safety commitment that is exhibited as reciprocation for the attention they receive in regard to their health and safety [7].

3. Method

3.1. Participants

The participants were all employed by an organisation that specialises in the extraction and manufacture of raw construction materials in the UK, either directly or through contracting. They were all responsible for the operation of heavy vehicles for at least some portion of their job role. This includes dumper trucks, loading shovels and excavators. A total of 280 online or paper-based questionnaires were received from a population of 483 drivers from the aggregates and asphalt divisions representing a response rate of 58%. These two company divisions were targeted because heavy vehicle operations are conducted within these areas of the business and not in other departments. Three participants were removed from the analysis due to incomplete responses. The present study retained data from 277 participants (including 4 non-direct employees who differed from permanent workers only in their method of recruitment and renumeration—via an agency). This workforce is involved in safety critical operational work that involves: loading and unloading material from stockpiles onto other vehicles or a conveyor, loading and unloading material directly from the quarry face, excavating, digging or loosening material, as well as general driving and transportation of materials around the site. The age of participants were as follows: 3.8% aged between 16–24, 25.2% aged between 25–34, 19.9% aged between 35–44, 27.8% aged between 45–54, 22.2% aged between 55–64, and 1.1% aged 65+. 94% of the participants were male, 4.5% were female, 0.4% were transgender and 1.1% self-described.

3.2. Measures

3.2.1. Adapted Lone-Worker Multilevel Safety Climate Scale (Here on Referred to as the Heavy Vehicle Safety Climate Scale: HVSCS)

Participants responded to items concerning safety in relation to top-management (organisational level) and their supervisor or line manager (group level) on a five-point Likert scale ranging from, strongly disagree (1) to strongly agree (5). The majority of items from Huang et al.'s [13] lone-working scale were kept identical; however, some of the terminology within the items were rephrased to suit the operation of heavy vehicles rather than haulage truck driving. These changes were informed by consultations with subject matter experts including a quarry supervisor and a plant team leader. In addition, three items were removed from the group level due to their lack of applicability to the population, and three items were removed as they involved mobile (cell) phone use, technology not used for work-related communication in the operation of heavy vehicles. Drivers are also instructed not to use their personal mobile phones while driving. To replace these six items at the group level, six new items were created to measure "supervisor safety behaviour encouragement", based on key safety behaviours identified by interrogating the quarrying organisation's incident data from the previous two years (described in Section 3.2.2, below). In line with the original Huang et al. measure, in the adapted lone-worker scale the organisational level consisted of 20 safety-related items oriented towards top management. For example, "My organisation tries to continually improve safety levels in each department". The group level consisted of 20 safety-related items oriented towards supervisors or line managers, for example "My supervisor frequently talks about safety issues throughout the work week". Negatively worded items are reversed scored so that higher scores represent a stronger safety climate.

3.2.2. Nomological Network Measures

To provide further construct validation for the heavy vehicle safety climate scale (HVSCS) we also included additional measures related to relevant safety dimensions in line with previous literature.

Situational and routine violations were measured using a 10-item scale by Hansez and Chmiel [53]. The scale is divided into two sections, with six items oriented towards situational violations ($\alpha = 0.82$), and four items oriented towards routine violations ($\alpha = 0.90$). Situational violations refer to rule breaking that occurs due to the situational context an individual finds themselves in, for example, they do not currently have the appropriate equipment to perform an action safely. Routine violations refer to more regular, habitual rule breaking. All item responses were recorded on a 5-point Likert scale ranging from, strongly disagree (1), to strongly agree (5). An example item includes "Production pressures mean that I sometimes bend the rules". A higher score indicates more rule-breaking.

Safety citizenship behaviour was assessed using a scale by Hofmann et al. [54]. The original scale consists of 27 items and contains six factors: helping, voice, stewardship, whistleblowing, initiating safety-related change and civic virtue. For the current study, only items from two factors (voice and initiating safety-related change) were included as the participant sample were lone-workers and therefore the other factors were less applicable within the occupational context. As a result, eight items remained and responses were recorded on a 5-point Likert scale whereby respondents indicated the frequency in which they engaged with the listed behaviours, ranging from, never (0), to always (4). An example item includes "Expressing opinions on safety matters even if others disagree". A higher score indicates more engagement with safety citizenship behaviour. In the present sample, the reliability of the scale was excellent ($\alpha = 0.95$).

Risk propensity was measured using a scale by Meertens and Lion [55]. The seven-item scale measured respondents' tendency to take risks, and uses a 9-point Likert scale ranging from, totally disagree (1) to totally agree (9). An example item includes "I take risks regularly". Higher scores indicate more risk-seeking tendencies. In the present sample, the reliability of the scale was poor ($\alpha = 0.50$).

A final set of outcome measures was drafted, which aimed to assess participants' engagement in context-specific safety behaviours. Four target safety behaviours were identified via an interrogation of existing company incident data involving heavy-duty vehicles from 2020 onwards using the HFACS framework. The four safety behaviours are: acknowledgement of other drivers, mirror checking, requesting assistance from others, and being patient. Items were validated by subject matter experts, including a quarry supervisor and plant team leader, to ensure their relevance and applicability to the operation of heavy vehicles. The scale consisted of 16 items, with four items assessing each safety behaviour. Responses were recorded on a 5-point Likert scale ranging from, strongly disagree (1), to strongly agree (5). An example item includes "I always make sure to acknowledge other drivers when we are in close proximity". A higher score indicates superior safety behaviour. In the present sample, the scale reliability for each of the behavioural categories were as follows: Acknowledgement $\alpha = 0.69$; Mirror Checking $\alpha = 0.62$; Requesting Assistance $\alpha = 0.63$; Patience $\alpha = 0.61$.

3.3. Procedure

Survey Preparation. The study design was approved by a university ethics committee. All scales described above were combined into one questionnaire pack, which was made available to participants either in paper format or through an online survey platform.

Survey Administration. Employees were invited to take part in the study during a safety stand-down day, whereby all drivers were required to attend training and workshops by the organisation. The schedule for the day included a time slot dedicated to the study, where drivers were invited to take part on a voluntary basis. No incentives were provided. The lead researcher (LJ) attended the workshop for one of the largest sites in the organisation to promote the study and facilitate participation. Participants were provided with either paper copies of the questionnaire or a digital link and QR code to complete it online should they prefer. All paper copies were sealed and returned to site managers, who then returned them to the lead researcher. For employees who were unable to attend the workshop or preferred to complete the questionnaire later, the digital link was distributed via email and internal comms platforms over the following weeks. The final section of the questionnaire contained a study debrief.

3.4. Data Analysis

Given the absence of previous adaptations and validation studies of the lone-worker safety climate scale in the quarry industry, we adopted an exploratory approach. The technique of Exploratory Factor Analysis (EFA) enables the identification of the most appropriate factor structure for a given research sample, like the lone heavy vehicle driver sample in the current research.

3.4.1. Exploratory Factor Analysis (EFA)

EFA is a powerful method to reduce variable complexity by summarising a large quantity of variables as a smaller number of factors [56]. In accordance with [57], when trying to develop a novel psychometric measurement tool in absence of a pre-established framework in a particular research domain, an explorative approach to the data treatment based on EFAs is the most sensible strategy for the statistical analyses. Given the lack of established measurement frameworks for our industry sample composed of heavy vehicle drivers, we chose to adopt EFA to identify the latent factor patterns in the responses of our survey participants.

In the current study, EFA was used twice to identify the factor structure of safety climate at the two distinct level of analysis (organisational and supervisory levels). The first EFA was used to identify the appropriate factor structure of the measure adapted from the scale created by Huang et al. [13] composed of 20 items aiming to assess employee's perceptions of safety climate associated with the actions of the industry management (the organisational level). Then a second EFA was conducted on the measure adapted from the same authors' work to assess employees' perceptions of safety climate associated with the actions of the operative supervisors of the respondents (the group level), consisting of a further 20 items.

Before EFA, both the Kaiser-Mayer-Olkin (KMO) measure of sampling accuracy and Barlett's test of sphericity were conducted to evaluate the appropriateness of using the EFA method in this study. This preliminary check on the dataset revealed a value of 0.93 for the KMO index and Barlett's test significant at $p < 0.001$, which together indicate an excellent adequacy of the data for factor analysis treatment. As a frequently used extraction method whenever EFA is conducted, principal axis factoring (PAF) was selected for data extraction. In this method, variables are put together according to their mutual correlations and then combined to form a certain number of components [58]. The Oblimin oblique rotation method was used to interpret latent variables underlying a factor due to the potential correlations among these factors. The threshold of 0.40 was considered the minimum factor loading when determining an item to load on a latent factor [59,60]. This choice is coherent with Stevens's [61] recommendations that suggest retaining all the items presenting factor loading above 0.40 for interpretative purposes, in order to keep the distinctive contents of the underlying factor dimension, without potentially lose relevant content of the identified factor.

3.4.2. Nomological Network

Beyond testing the internal factor structure of the HVSCS, we also investigated the nomological network of the safety climate factors in relation to situational and routine violations [53], safety citizenship behaviour [54,62], risk propensity [55] and some subjective measures of target safety behaviours. In the results section, we will present the correlation of the safety climate factors with these measures. All the correlations were reported using the r Pearson index.

4. Results

4.1. Exploratory Factor Analysis (EFA)

The HVSCS was subjected to a factor analysis with PAF extraction and Oblimin rotation method. Two separate explorative factor analyses were conducted, the first for the items originally designed to assess safety climate perceptions at the organisational level, and the second for the items designed to assess safety climate perceptions at the supervisory level of analysis. The results are reported separately for each level.

Organisational level. The first analysis concerned 20 items designed to assess employees' perception of top management commitment toward safety. This analysis yielded a result of two factors, which explained overall 49.3% of variance. The two factors explained 39.41% and 9.9% of the variance, respectively. The two factors presented a correlation of 0.35; therefore, we concluded that there is a relative independence of the two factors. As shown in Table 1, the results of the factor analysis included 13 items loading in the first factor, with loading indices between 0.77 and 0.58. Some examples of items loading in this factor were "My organisation invests a lot in safety training for workers" and "my organisation listens carefully to our ideas about improving safety". Altogether, the items loading in this first factor included aspects of organisational management associated with proactive safety programmes and practices put in place by the management. On the other hand, seven items loaded onto the second separate factor, with loading indices between 0.72 and 0.43. Examples of these items were "My organisation expects me to sometimes bend safety rules" and "My organisation assigns too many drivers to each supervisor". Altogether, the items loading in this second factor included aspects of management commitment to, and support for, safe work operations. All the factor loadings of each item are shown in Table 1.

Table 1. The Heavy Vehicle Safety Climate Scale (HVSCS)—organisational level: Items and factor loading with the original 20 items (EFA) (N = 277).

Item Content Description *My Organisation...*	**F1**	**F2**
Invests a lot in safety training for workers	0.768	
Listens carefully to our ideas about improving safety	0.753	
Tries to continually improve safety levels in each department	0.748	
Reacts quickly to solve the problem when told about safety concerns	0.745	
Uses any available information to improve existing safety rules	0.734	
Allows drivers to change their schedules when they are getting too tired	0.728	
Gives safety a higher priority compared to other competitors	0.686	
Provides enough hands-on training to help new drivers be safe	0.677	
Cares more about my safety than on-time delivery	0.663	
Fixes mobile plant/equipment issues in a timely manner	0.632	
Is strict about working safely when work falls behind schedule	0.621	
Gives drivers enough time to deliver loads safely	0.608	
Creates programs to improve drivers' health and wellness (e.g., diet, exercise)	0.575	
Expects me to sometimes bend safety rules for important customers/projects		0.715
Assigns too many drivers to each supervisor, making it hard for us to get help		0.684
Hires supervisors who don't care about drivers		0.657
Turns a blind eye when we use mobile phones while driving		0.641
Turns a blind eye when a supervisor bends some safety rules		0.629
Makes it clear that, regardless of safety, I must complete tasks on time		0.569
Will overlook not adhering to scheduled break times if I meet targets/demands		0.433

Note. All responses for items with negative wording were reverse coded.

The first factor with thirteen items corresponded to the original scale adapted by Huang et al. (2013) [13]. However, in the present research sample, the latter two factors merged into a single latent factor, resulting in a total of only two factors at the organisational level. The second factor consisted of seven items, which were originally designed by the authors to assess both driver safety priority and supervisory care promotion.

In order to reduce the effect of cross-loading, a factor loading cut-off value of 0.40 [63] was established. This is coherent with the recommendations provided by Hair et al. [64] about the ratio between sample size and factor loading. Accordingly with these authors, samples larger than 200 participants (like in the present case) should be sufficient to assure empirical significance to all the items with factor loading equal or higher than 0.40. Eventually, no cross-loading was identified in the pattern matrix reported in Table 1. This led us to keep all the thirteen items for the first factor, and all seven items for the second factor. The Cronbach's alpha coefficients for the resulting factor scales were 0.93 and 0.83, respectively, which were all above 0.70 and considered to be acceptable [65,66]. In every case, the average of the item loading on every factor was higher than the correlation among the latent factors, giving us additional evidence of internal discriminative validity among the components of the model [67]. In summary, the organisational safety climate level was identified by two factors assessing “proactive practices” and “operational safety commitment”.

Supervisory Level. The second analysis concerned 20 items designed to assess employees’ perception of supervisory commitment toward safety. This analysis yielded a result of three factors, which explained overall 54.71% of variance. The three factors explained 43.8%, 7.2% and 3.8% of the variance, respectively. The first factor presented correlations of 0.56 and 0.62 with the second and third factor, respectively, while the second and third factor presented a correlation of 0.52. Despite the three latent factors presenting strong correlations, we still conclude their relative independence, considering indications in the literature that suggest the independence of latent factors presenting correlations lower than 0.70 [68].

Like before, we considered 0.40 as the factor loading threshold to retain a single item in a given factor. As shown in Table 2, the result of the factor analysis included seven items loading in the first factor, with loading indices between 0.91 and 0.41. Examples of items loading in this factor were “My supervisor compliments employees who pay attention to safety” and “My supervisor discusses with us how to improve safety”. Altogether, the items loading in this first factor cover aspects associated with a promotive approach in the management of the daily working routines in order to improve the safety of business operations. Six items loaded onto the second resulting factor, with loading indices between 0.90 and 0.44. Examples of these items were “My supervisor sometimes turns a blind eye with rules when targets/deliveries fall behind schedule” and “My supervisor expects me to sometimes bend driving safety rules for important customers”. Altogether, once negatively worded items were reversed scored the items loading in the second factor included supervisory actions that prioritise safety over productivity. Finally, four items loaded onto the third latent factor, with loading indices between 0.86 and 0.42. Examples of items were “My supervisor discusses the importance of regularly checking my mirrors with me” and “My supervisor reminds me about the importance of staying within the speed limit”. Altogether, these items cover contents associated with the reinforcement and encouragement of desired safety behaviours specific to the operation of heavy vehicles. All the factor loadings of each item are reported in Table 2.

The first two factors, for the most part, approximately corresponded with the first two original factors envisaged by the authors Huang [13] to assess supervisory safety commitment, although we felt that the original descriptor for the second of these—“delivery limits”—was not applicable in the present context. In the original scale, the third factor consisted of three items and was titled “cell phone disapproval”. In the current scale, these three items were instead exchanged for six items related to behaviour encouragement. Four of these six items loaded onto the third factor. Eventually, no cross-loading was identified in the pattern matrix reported in Table 2. This led us to keep all seven items for the first factor, all six items for the second factor, and all four items for the third factor. The Cronbach’s alpha coefficients for the resulting factor scales were 0.92, 0.87 and 0.77, respectively, which were all above 0.70 and considered to be acceptable [65,66]. In every case, the average of the item loading on every factor was higher than the correlation among the latent factors, giving us additional evidence of internal discriminative validity among the components of the model (Fornell and Larcker, 1981 [67]). In summary, the group safety climate level was identified by three factors assessing “safety promotion”, “prioritisation of safety over production”, and “safety behaviour encouragement”.

Table 2. The Heavy Vehicle Safety Climate Scale (HVSCS)—group level: Items and factor loading with the 20 included items (EFA) (N = 277).

Item Content Description *My Supervisor...*	**F3**	**F4**	**F5**
Compliments employees who pay special attention to safety	0.911		
Discusses with us how to improve safety	0.831		
Frequently talks about safety issues throughout the work week	0.798		
Provides me with feedback to improve my safety performance	0.775		
Respects me as a professional driver	0.706		
Uses explanations (not just compliance) to get us to act safely	0.675		
Is an effective mediator/trouble-shooter between the customer and me	0.414		
Is strict about working safely even when we are tired or stressed			
Is supportive if I ask for help with personal problems or issues			
Sometimes turns a blind eye with rules when targets/deliveries fall behind schedule		0.903	
Expects me to sometimes bend driving safety rules for important customers		0.864	
Encourages us to go faster when we are behind schedule		0.789	
Pushes me to keep driving even when I call in to say I feel too sick or tired		0.760	
Makes me feel like I'm bothering him/her when I use radio comms to communicate		0.615	
Would rather I tried to manoeuvre independently before asking for help		0.437	
Doesn't regularly encourage me to use hand signals with other drivers			
Discusses the importance of regularly checking my mirrors with me			0.858
Reminds me about the importance of staying within the speed limit			0.794
Encourages me to request assistance if I am worried about fitting through a tight space			0.547
Reminds me to acknowledge other drivers when passing			0.420

Note. All responses for items with negative wording were reverse coded.

4.2. Nomological Network

In addition to the EFA of the HVSCS, we aimed to provide a further validation step of the tool in the quarry industry context by providing a nomological network analysis. In Table 3, we report the correlations of the multilevel safety climate factors with pre-existing validated measures related to occupational safety, risk, and health management.

For the most part, we found that the safety climate factors presented higher mutual correlations compared with the correlations for the outcome variables. More specifically, the first factor at the organisational level (proactive practices) presented the strongest correlations with all three factors at the supervisory level (0.71 with safety promotion, 0.50 with prioritisation of safety over production, and 0.55 with safety behaviour encouragement). The second factor at the organisational level (operational safety commitment) presented a strong correlation with one of the factors at the supervisory level (0.71 prioritisation of safety over production) and moderate correlations with the other two factors at this level (0.42 for safety promotion and 0.34 for safety behaviour encouragement). Overall, these positive mutual correlations suggest that the factors are in fact measuring similar concepts, but on a multi-level framework, the correlations are also not too high as to suggest that a shared identity exists between the levels.

Table 3. Nomological Network of HVSCS: correlation links with other safety, risk, and health-related validated measures.

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Proactive Practices	3.73	0.64	(0.93)												
2. Operational Safety Commitment	3.87	0.67	0.43	(0.83)											
3. Safety Promotion	3.79	0.69	0.71	0.42	(0.92)										
4. Prioritisation of Safety over Production	3.99	0.72	0.50	0.71	0.54	(0.87)									
5. Safety Behaviour Encouragement	3.78	0.68	0.55	0.34	0.61	0.48	(0.77)								
6. Situational Violations	1.82	0.52	−0.45	−0.28	−0.44	−0.31	−0.38	(0.82)							
7. Routine Violations	1.76	0.76	−0.30	−0.44	−0.32	−0.45	−0.29	0.56	(0.90)						
8. Safety Citizenship Behaviour	2.67	0.85	0.38	0.21	0.40	0.30	0.36	−0.48	−0.19	(0.95)					
9. Safety Behaviour 1 (Acknowledgement)	4.17	0.56	0.33	0.32	0.32	0.34	0.42	−0.49	−0.34	0.37	(0.69)				
10. Safety Behaviour 2 (Mirror Checking)	4.18	0.52	0.22	0.32	0.26	0.34	0.24	−0.40	−0.41	0.33	0.53	(0.62)			
11. Safety Behaviour 3 (Requesting Assistance)	4.02	0.56	0.39	0.39	0.45	0.46	0.48	−0.49	−0.46	0.34	0.51	0.53	(0.63)		
12. Safety Behaviour 4 (Patience)	4.14	0.62	0.22	0.37	0.22	0.36	0.34	−0.37	−0.37	0.27	0.44	0.53	0.55	(0.61)	
13. Risk Propensity	2.33	1.08	−0.27	−0.28	−0.25	−0.30	−0.20	0.38	0.43	−0.16	−0.24	−0.27	−0.37	−0.36	(0.50)

Note: All correlations are significant at $p < 0.01$. Cronbach alpha indices for each scale are reported on the diagonal.

The statistical results were in the expected directions based on the current literature. All five of the safety climate factors had moderate correlations with the eight outcome variables (max: 0.48; min: −0.20). The negative correlations found for situational violations, routine violations and risk propensity were also expected as these were safety-negative measures. For example, a higher score for risk propensity indicated a higher tendency to take risks, so it would therefore be expected to correlate negatively with safety climate. Overall, no single safety climate factor stood out as having stronger correlations with any of the other measures; all five of the factors have mixed but similar correlational results.

Regarding situational violations, moderate, negative correlations were found with all five safety climate factors (max: −0.45; min: −0.28) with proactive practices (organisational level) presenting the highest correlation. Similar correlations were found for routine violations (max: −0.45; min: −0.29) but with prioritisation of safety over production (group level) presenting as the highest correlation.

For safety citizenship behaviour, moderate, positive correlations were found with the various safety climate factors (max: 0.40; min: 0.21) with safety promotion (group level) presenting the strongest correlation.

Context-specific safety behaviours were divided into four categories: acknowledgement, mirror checking, requesting assistance and being patient. All four of these behaviour categories presented moderate, positive correlations with all five of the safety climate factors. The first three safety behaviours presented the highest correlations with factors at the supervisory level. For acknowledgement (max: 0.42; min: 0.32), the highest correlation was with safety behaviour encouragement. For mirror checking (max: 0.34; min: 0.22), the highest correlation was with prioritisation of safety over production. For requesting assistance (max: 0.48; min: 0.39) the highest correlation was with safety behaviour encouragement. Finally, for being patient (max: 0.37; min: 0.22), the highest correlation was with a factor at the organisational level: operational safety commitment.

Risk propensity had the weakest correlations with the safety climate factors. It did, nonetheless, present moderate correlations in the expected directions (max: −0.28;

min: −0.20), with operational safety commitment (organisational level) presenting the highest correlation.

Overall, we concluded that the safety climate factors included at the supervisory level had the higher number of stronger correlations with the outcome variables. Specifically, prioritisation of safety over production correlated the highest with the greatest number of variables: routine violations (−0.45), mirror checking (0.34) and risk propensity (−0.30). In addition, safety behaviour encouragement had the strongest correlation of all, with requesting assistance (0.48). As a result, we can conclude that supervisory level safety climate has a stronger relationship with the measured outcome variables than organisational level safety climate.

5. General Discussion

To confirm the dimensions of the multilevel safety climate scale (the Heavy Vehicle-Safety Climate Scale: HVSCS) within the quarry industry, an exploratory validation process was completed. A stronger understanding of these dimensions for lone heavy vehicle operators is important as these drivers engage in daily safety-critical work processes, whereby safety climate has the potential to influence the associated safety behaviours and outcomes.

To begin the validation process, we used exploratory factor analysis. This allowed us to identify a set of latent factors underlying the items contained within the scale. Although conceptually similar to Huang et al.'s [13] version of the questionnaire, the organisational level appeared to consist of two latent factors as opposed to three: "proactive practices" (the same as Huang et al.), and "operational safety commitment" (different from Huang et al.). The third factor from the original scale merged into the second factor suggesting that lone drivers in the present quarrying context did not perceive two separate facets of organisational safety climate (driver safety priority, and supervisory care promotion), more so that the items were perceived to represent one overarching safety climate construct (the organisations commitment to safe work operations). "Proactive practices" consists of items related to the health and safety practices and policies that are initiated by top-level management, such as divisional managing directors. Examples of these items were "My organisation tries to continually improve safety levels in each department" and "My organisation provides enough hands-on training to help new drivers be safe". "Operational safety commitment" consists of items related to aspects of management commitment to, and support for, safe work operations. Example items include "My organisation hires supervisors who don't care about drivers" and "My organisation makes it clear that, regardless of safety, I must complete tasks on time" (both items reversed scored).

However, in line with the original scale, the supervisory level similarly consists of three latent factors: "safety promotion", "prioritisation of safety over production" and "safety behaviour encouragement". The latter two factor labels differed from Huang et al.'s scale due to the nature of the items that were used to replace those removed from the original scale and item wording changes to reflect the quarrying context. "Safety promotion" consist of items related to the active promotion of safety to workers by supervisors or direct line-managers. Examples of these items were "My supervisor frequently talks about safety issues throughout the work week" and "My supervisor provides me with feedback to improve my safety performance". "Prioritisation of safety over production" consists of items related to the protection provided by supervisors to drivers in terms of prioritising safety when faced with production pressures. Example items include "My supervisor sometimes turns a blind eye with rules when targets/deliveries fall behind schedule" and "Encourages us to go faster when we are behind schedule" (both items reversed scored). "Safety behaviour encouragement" consist of items related to supervisor reinforcement of context-specific safety behaviours, such as mirror checking and acknowledging other drivers. Examples of these items were "My supervisor discusses the importance of regularly checking my mirrors with me" and "My supervisor reminds me to acknowledge other drivers when passing".

The second research step involved analysing the associated nomological network of the questionnaire with related theoretical constructs. Our results demonstrated strong mutual correlations among the five factors contained within the scale. In addition, in line with Huang et al.'s [13] findings in relation to the criterion validity of their original lone-worker scale, we also found that all five factors in our scale presented moderate correlations with the other related safety constructs. Unlike Huang et al., who aggregated several self-reported trucking-related safety behaviours into one criterion variable, we sought to explore the potential differential relationships between our scale dimensions and distinct context-specific safety behaviours and other nomologically related variables. We found that the factors at the organisational level presented the highest corelation values with situational violations and safety behaviours related to patience. Higher scores for organisational safety climate resulted in reduced situational violations and increased patience. Both of these outcome measures can be considered to fall under reactionary behaviour in that both behaviours are performed as a result of the current situation and environment a driver finds themselves in. This raises the question as to whether safety-related impulsiveness can be mediated by organisational influences. It is well established that impulsivity can be related to risky driving behaviours and that risk-takers are more prone to breaking rules [69]. This could have practical implications regarding intervention design, as increasing organisational safety climate perceptions may improve such reactionary behaviours.

The factors at the supervisory level presented the highest correlation values with the remainder of the outcome variables (routine violations, safety citizenship behaviour, three of the context-specific safety behaviours and risk propensity). These outcome measures can be considered more intentional. This is important as intentional and proactive safety behaviours, such as safety participation, have been shown to have a lagged effect on subsequent accident frequency [23].

These findings seem to suggest that for lone heavy vehicle drivers, at least in the context of the quarry industry, supervisory factors might be more directly associated with the creation of a safer organisational context, perhaps due to the more proximal nature of supervisors and direct line-managers compared with top-level management. However, the contribution of organisational influences in safety outcomes is not to be overlooked and serves as a complimentary influence on safety performance.

5.1. Research Contribution to the Safety Climate Literature

The current study makes an important contribution to not only the safety climate literature, but to safety-critical industries seeking to further understand the inner-workings of their safety processes, employee safety behaviours and key safety outcomes. The results suggest some key differences in how safety climate is perceived at the organisational level and group level. At the organisational level, a more distal and holistic safety climate is perceived by employees. This perception is towards global influences, such as the development and implementation of safety policies, practices and procedures that shape their work activities. At the group level, a more proximal safety climate is perceived by employees. These perceptions have more of a direct influence over the day-to-day running of their sites and operations, which influences the level of proactive safety participation and commitment from the ground-level employees. Researchers should therefore consider the specific level at which they aim to assess safety climate and expect more complexity or intricacy at the group level, especially if the focus is on workers who spend a large amount of their shifts on their own, with only brief interactions with their supervisors and colleagues.

The separate factors that emerged at the group level may also provide useful insights for researchers and organisations. For example, it is important to distinguish between the effects of reducing negative supervisory behaviours, such as applying production pressures, compared with the increasing of positive supervisory behaviours, such as safety behaviour encouragement (e.g., mirror checking, acknowledgement, etc.). This links to the notion of evaluating the effectiveness of reducing barriers versus increasing enablers of safety behaviours for subsequent organisational safety performance [70].

Overall, these findings highlight the need to investigate the gaps in our understanding of safety climate, not only variations in how it is perceived but how it can influence safety-critical work differently or similarly across a range of context-specific industries. For example, when we compare the results of the present scale validation with a similar context-specific adaptation of Zohar and Luria's generic safety climate scale for rail industry workers (see Curcuruto et al. [7]) it is notable that there are both differences and similarities in how safety-climate is perceived, and the pattern of relationships with other safety-related factors, between these industrial contexts. In the rail study validation only one factor was identified at the organisational level (labelled "Organisational Safety Climate") in comparison with two more specific factors in the present study. At the group level in the rail worker safety climate validation study two factors emerged, namely "supervisor safety communication" and "supervisor safety monitoring" compared with three factors in the presents study. This reinforces the importance and utility of context-specific scales to capture aspects of safety-climate that are most relevant in a particular setting. While supervisor communication is captured in scale items across the three group factors of "Safety Promotion", "Prioritisation of Safety over Production", and "Safety Behaviour Encouragement" in the HVSCS, because of the lone-working nature of the work, supervisor monitoring is not as relevant compared with rail maintenance work.

Although the development and validation of context-specific safety climate scales for every individual safety-critical operation would be ideal, under similar working conditions the HVSCS could be utilised by other industries that also operate heavy mobile equipment such as construction and mining. These sectors could also benefit from its implementation to better understand the emergence or changes in safety climate within their workforce if operating in conditions close enough to. The use of context-specific measures like this also has the potential to increase the chances of expanding our understanding of the nuanced relationships between safety climate and other related constructs. For example, an organisation that utilises heavy mobile equipment is more likely to incorporate a scale specifically adapted for these operations into their existing employee assessments (e.g., annual employee opinion surveys) as opposed to a more generic instrument, as it will provide a more accurate measure of their occupational experiences and perceptions. This increase in face validity has the additional benefit of being more relatable to workers and thus increases engagement and completion rates [40].

5.2. Practical Implications for Management and Interventions for Heavy Vehicle Safety in the Quarry Industry

This validation paper provides a factor structure that can be used to assess safety climate perceptions of lone heavy vehicle drivers within the quarry industry (the HVSCS is provided as an Appendix A). The tool can be used to compare groups within an organisation or used longitudinally to compare any changes over a period of time. A current practical issue experienced in the quarry industry, is that there is no context-specific, validated instrument that can be used to measure safety climate perceptions of lone heavy vehicle drivers and support an organisation's understanding of their own employee perceptions of the safety conditions within their company. Without context-specific measures, there is a risk that organisations instead adopt generic safety climate tools, that do not reflect the nuances of the industry and work conducted, and the conceptual definitions of the relevant safety climate constructs [39] In addition, when using generic tools, it is difficult to benchmark or compare findings with other organisations within the industry, especially if they are not using the same measures. These comparisons can become valuable statistics when, for example, it becomes clear an organisation is falling behind on health and safety when compared with competitors. We propose that the HVSCS will provide a more accurate and reflective measure of heavy vehicle safety climate within the quarry industry, which can support safety regulators towards ensuring a more consistent, standardised and theory-driven approach to safety climate assessment.

Further practical implications derived from our findings involve the nomological network of safety climate. Our correlational results offer practical advantages to safety practitioners and decision-makers, in that they can help shape potential safety behaviour change intervention design. For instance, our correlation findings showed that the supervisory safety climate factors had the strongest correlations with most of the outcome variables, including routine violations, safety citizenship behaviour, three of the context-specific safety behaviours and risk propensity. On the other hand, factors at the organisational level presented the highest correlation values with situational violations and context-specific safety behaviours related to patience. Overall, these distinct correlation patterns not only highlight the need for researchers to analyse safety climate using a multidimensional approach, but also can provide specific indications for practitioners about how to design appropriate and effective intervention strategies to improve safety behaviour. For example, with the results indicating that there is a relationship between employee's perception of poor supervisor prioritisation of safety over production and their own tendency to routinely violate the rules, perhaps an effective intervention would target the communication about production pressure that comes from supervisors. Furthermore, when safety communication programmes are combined with interventions that aim to facilitate the expression of suggestions for changes and innovations, they can be even more effective [71]. If properly combined, data-driven, integrated intervention strategies have the potential to improve observable safety behaviours and subsequent accident prevention.

6. Conclusions

In this study we attempted to address several research gaps. A safety climate measurement tool for heavy vehicle drivers in the quarrying industry had not been introduced before the current study. This was particularly necessary because it is an industry where safety issues, such as high accident rates, need to be addressed. The target participants included in the study were lone workers who operate in high-risk environments for long periods of time, with a lack of face-to-face supervisory oversight. Prior to the present study there was very little research on the role of context-specific safety climate perceptions for lone-workers. The study shows that safety climate can be very important for this unique population because it can act as a frame of reference that guides normative safety behaviour. The findings from the nomological network analysis showed that safety climate can be a strong indicator of safety behaviours and safety violations, even in lone working situations.

In summary, we developed and psychometrically validated a context-specific safety climate tool for lone heavy vehicle drivers in the quarrying industry: the Heavy Vehicle Safety Climate Scale (HVSCS). Exploratory factor analysis (EFA) resulted in two factors at the organisational level, the first consisting of 13 items, labelled "Proactive Practices". The second organisational level factor consisted of 7 items and was labelled "Operational Safety

Commitment". EFA also identified 3 factors at the supervisory level, with the first of these consisting of 7 items labelled "Safety Promotion". The second factor at the supervisory level consisted of 6 items and was labelled "Prioritisation of Safety over Production". The third and final factor at the supervisory level consisted of 4 items, and this factor was labelled "Safety Behaviour Encouragement". A nomological network analysis provided further evidence of construct validity and support for the multilevel measurement contained in the scale. All correlations between the HVSCS factors and safety-related constructs were in the expected direction, and additionally, there was evidence of differences in the strength of these correlations between the scale factors at the organisational and supervisory levels.

The present study is not without its limitations. Firstly, the sample size was insufficient to perform a confirmatory factor analysis (CFA) as a second stage of the validation process. Future studies should aim to sample from multiple quarry organisations to ensure a sufficient sample size is obtained to perform a CFA. Second, several Cronbach's alpha reliability coefficients for our nomological network scales were below the 0.70 acceptability threshold (risk propensity in particular), so some caution should be adopted in the interpretation of the correlations with our scale factors. Thirdly, only self-report data was collected for the safety outcome variables, as directly provided by the survey participants. This may have potentially introduced in our study issues such as common method bias and social desirability effects. Future studies should consider collecting more objective indicators of safety performance. For example, supervisory perceptions of driver safety behaviours or official organisation records involving accidents, injuries, and near-misses. This could help to establish better criterion-related validity of the safety climate scale. In addition, although we sampled drivers from one of the largest quarrying companies in the UK working across a wide variety of geographical locations, the findings come from one source, something that restricts the external validity of our study. For example, our findings may not generalise to other heavy vehicle contexts, to other companies in the UK, or internationally, if we consider national differences that may affect quarrying contexts in different countries. Future studies should diversify the sampling sources, including drivers working in different countries under different organisational conditions. Finally, a limitation of context-specific safety climate scales versus generic ones is the capacity to benchmark findings with organisations from different industry domains. If deemed necessary, a generic scale could be used for this purpose. However, we also suggest that research should attempt to test and replicate the factor structure of the HVSCS in other industrial contexts that utilise heavy vehicles, such as construction, especially where drivers are operating alone. If the findings presented in this article are replicated, it will also be possible to benchmark the status of safety climate within the quarry industry with other industrial sectors.

It is hoped that the final 37-item HVSCS (provided in the Appendix A) will be utilised by those managing heavy vehicle operations, particularly in the quarrying industry, to identify context-specific opportunities for safety climate improvements and in turn reduce the risk of safety incidents.

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Appendix A

The Heavy Vehicle Safety Climate Scale (HVSCS)

The following statements ask about your organisation (insert company name). Please indicate your response on the following scale: 1 = Strongly Disagree; 5 = Strongly Agree.

My Organisation...					
	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Uses any available information to improve existing safety rules (Proactive Practices)	1	2	3	4	5
Tries to continually improve safety levels in each department (Proactive Practices)	1	2	3	4	5
Invests a lot in safety training for workers (Proactive Practices)	1	2	3	4	5
Creates programs to improve drivers' health and wellness (e.g., diet, exercise) (Proactive Practices)	1	2	3	4	5
Listens carefully to our ideas about improving safety (Proactive Practices)	1	2	3	4	5
Cares more about my safety than on-time delivery (Proactive Practices)	1	2	3	4	5
Allows drivers to change their schedules when they are getting too tired (Proactive Practices)	1	2	3	4	5
Provides enough hands-on training to help new drivers be safe (Proactive Practices)	1	2	3	4	5
Gives safety a higher priority compared to other competitors (Proactive Practices)	1	2	3	4	5
Reacts quickly to solve the problem when told about safety concerns (Proactive Practices)	1	2	3	4	5
Is strict about working safely when work falls behind schedule (Proactive Practices)	1	2	3	4	5

My Organisation. . .					
	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Gives drivers enough time to deliver loads safely (Proactive Practices)	1	2	3	4	5
Fixes mobile plant/equipment issues in a timely manner (Proactive Practices)	1	2	3	4	5
Will overlook not adhering to scheduled break times if I meet targets/demands (Operational Safety Commitment)	1	2	3	4	5
Makes it clear that, regardless of safety, I must complete tasks on time (Operational Safety Commitment)	1	2	3	4	5
Expects me to sometimes bend safety rules for important customers/projects (Operational Safety Commitment)	1	2	3	4	5
Turns a blind eye when we use mobile phones while driving (Operational Safety Commitment)	1	2	3	4	5
Assigns too many drivers to each supervisor, making it hard for us to get help (Operational Safety Commitment)	1	2	3	4	5
Hires supervisors who don't care about drivers (Operational Safety Commitment)	1	2	3	4	5
Turns a blind eye when a supervisor bends some safety rules (Operational Safety Commitment)	1	2	3	4	5

Note. All responses for items with negative wording should be reverse coded.

The following statements ask about your supervisor. Please indicate your response on the following scale: 1 = Strongly Disagree; 5 = Strongly Agree.

My Supervisor. . .					
	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Compliments employees who pay special attention to safety (Safety Promotion)	1	2	3	4	5
Provides me with feedback to improve my safety performance (Safety Promotion)	1	2	3	4	5
Respects me as a professional driver (Safety Promotion)	1	2	3	4	5
Frequently talks about safety issues throughout the work week (Safety Promotion)	1	2	3	4	5
Discusses with us how to improve safety (Safety Promotion)	1	2	3	4	5

My Supervisor...					
	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Uses explanations (not just compliance) to get us to act safely (Safety Promotion)	1	2	3	4	5
Is an effective mediator/trouble-shooter between the customer and me (Safety Promotion)	1	2	3	4	5
Makes me feel like I'm bothering him/her when I use radio comms to communicate (Prioritisation of Safety Over Production)	1	2	3	4	5
Encourages us to go faster when we are behind schedule (Prioritisation of Safety Over Production)	1	2	3	4	5
Would rather I tried to manoeuvre independently before asking for help (Prioritisation of Safety Over Production)	1	2	3	4	5
Expects me to sometimes bend driving safety rules for important customers (Prioritisation of Safety Over Production)	1	2	3	4	5
Sometimes turns a blind eye with rules when targets/deliveries fall behind schedule (Prioritisation of Safety Over Production)	1	2	3	4	5
Pushes me to keep driving even when I call in to say I feel too sick or tired (Prioritisation of Safety Over Production)	1	2	3	4	5
Reminds me to acknowledge other drivers when passing (Safety Behaviour Encouragement)	1	2	3	4	5
Discusses the importance of regularly checking my mirrors with me (Safety Behaviour Encouragement)	1	2	3	4	5
Reminds me about the importance of staying within the speed limit (Safety Behaviour Encouragement)	1	2	3	4	5
Encourages me to request assistance if I am worried about fitting through a tight space (Safety Behaviour Encouragement)	1	2	3	4	5

Note. All responses for items with negative wording should be reverse coded.

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