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# Fire safety in construction: site evacuation and self-reported worker behaviour

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**Highlights**

- First study to conduct and document unannounced evacuations of construction sites
- Workers' self-reports suggest good emergency knowledge and reception of fire alarm
- Yet only around half the sample stated that they evacuated immediately
- Wayfinding heavily reliant upon pictorial aids seen prior to and during evacuation
- Workers' tendency for risk-taking was low and not associated with safety climate

# Fire safety in construction: site evacuation and self-reported worker behaviour


## Abstract

It is estimated that between 500 and 600 construction site fires occur each year in the UK. The true figure – possibly higher – is obscured because such fires are not specified in official fire statistics. Despite reports of casualties, and despite site evacuation posing numerous challenges to construction workers, there has been a dearth of research into the human behavioural aspects of construction site fires and evacuations. This study provided a novel contribution to the issue of fire safety in construction by conducting unannounced evacuations at the sites of two tall UK buildings. Questionnaire surveys were administered to collect self-reports of related worker behaviour. Responses (N = 61) revealed that there appeared to be a positive safety climate at both sites, that workers were not risk-takers, that most knew the correct procedure to follow in a fire emergency, and almost all heard the alarm sound when it was activated. Yet, even though many believed there was a real threat, only around half of the sample reported evacuating immediately. When workers did commence their evacuation, wayfinding was reliant on pictorial aids seen either before or during the supposed emergency. "Vulnerable" workers – those of a younger age or whose first language was not English – did not appear to be disadvantaged with respect to comprehension of the fire emergency procedure and plan. However, it is suggested that this sample displayed a best-case scenario. Further studies should be conducted with a larger number of workers and a larger number of contractors with varying safety records.



**Keywords**

Construction; Fire; Evacuation; Risk; Age; Migrant worker

# 1. Introduction

## 1.1 Background

Construction is an important industrial sector in the UK. In the first quarter of 2021, around 2.2 million workers were estimated to be employed in the construction industry (Office for National Statistics, 2021a). Moreover, Britain's construction output was recorded at £14,251 million, with new work contributing majorly to that figure (Office for National Statistics, 2021b). The demand for new buildings has been driven by an increasing population, while the trend to build upwards reflects a need to optimise urban spaces to accommodate this growth in people. A spring 2021 survey showed that, in the UK capital alone, there were 587 tall buildings projects currently in the pipeline (New London Architecture, 2021). The fatal consequences of the 2017 Grenfell Tower fire do not appear to have deterred such projects. However, those consequences have forced attention on the fire safety challenges that tall buildings present to those who occupy them (Hackitt, 2018). Yet tall buildings, and smaller buildings, also present fire safety challenges to those who construct them. This too requires attention.

Neither the UK Government nor the bodies for Scotland, Wales, and Northern Ireland specify the number of construction site fires in their annual fire statistics. However, an independent investigation did manage to obtain relevant data from the Home Office (Fire Industry Association, 2020). It revealed that, between the periods 2014-2015 and 2018-2019, there were an average of 370 construction site fires each year in England alone. A separate investigation obtained data from fire and rescue services via Freedom of Information requests (CE Safety, 2020; Fire Safety Matters, 2020). It further revealed 180 fires in Scotland and at least 17 fires in Wales during the most recent period (no figures were available from Northern Ireland). The former investigation showed that the majority of fires (63%) were accidental. The latter showed that some form of "hot work" – i.e. a task generating a flame, heat, or sparks, such as welding – was the cause in well over 70% of cases.

Fires on construction sites are not just a UK problem. For instance, an American study found that, between 2013 and 2017, firefighters attended an average of 6,420 fires each year at the sites of structures undergoing construction or major renovation (Campbell, 2020). Moreover, that study and the UK study using Freedom of Information requests (CE Safety, 2020) uncovered reports of casualties. To avoid non-fatal and fatal injury, individuals need to recognise the presence of a fire and, if not involved in fighting the fire, evacuate to a place of safety. Moreover, they need to do so rapidly but in a way that does not introduce other risks to life or health. On a construction site, this could be difficult. For example, the noise on sites can mean construction workers have a hearing impairment (Health and Safety Executive, 2006; Suter, 2002). This raises the possibility of some not noticing an auditory alarm and therefore remaining unaware of the threat. According to UK regulatory guidance, once workers do become aware of a fire, "everyone should make their immediate escape without delay" (Health and Safety Executive, 2010, p. 42). However, evacuation research has documented that people may be reluctant to leave if they doubt there is a real threat, e.g. if they think it is just a drill (Rigos et al., 2019). With workers spread out vertically and horizontally across a site, some in enclosed spaces and others in the open air, many may not be in a position to see or smell corroborative fire cues initially. Therefore, scepticism and delays might manifest. Additionally, other research, on occupational illness/injury, has revealed reluctance among construction workers to halt work (e.g. to consult a doctor or recuperate), fearing a loss of income or disapproval from their employer (Bean, 2016; Taylor Moore et al., 2013). So, such fear might also prompt reluctance to halt work for the purposes of evacuation, particularly if not yet sensing fire cues.

Once evacuation movement has commenced, it could still take some time to reach a place of safety. If working on a tall building, construction workers may need to descend tens of storeys. They may encounter obstacles on the way, e.g. barriers preventing access to exclusion zones or congestion due to the number of workers evacuating simultaneously. Moreover, the means of descent (e.g. ladders, scaffold stairs) may be steeper, narrower, and perceptibly less stable than permanent stairs in completed buildings. Given that construction is already one of Britain's most dangerous industries, with falls from a height being the most common kind of fatal workplace injury (Health and Safety Executive, 2020), workers need to ensure that attempts to make a speedy exit do not create an unsafe exit. Additional difficulties relate to developing familiarity with the emergency procedure and escape routes. For construction workers, this may prove challenging for various reasons. These include the transient nature of the job, language issues if a non-native speaker, and the ever-changing physical layout of the structure being built (Debrah & Ofori, 2001; Health and Safety Executive, 2010).

So, despite the fact that (a) fires occur with some frequency on construction sites, (b) physical harm has been incurred during such incidents, (c) site evacuation poses numerous challenges to workers, and (d) worker behaviour would appear to play an important role in the success or failure of evacuations, there is a surprising dearth of research on construction site fires and evacuations. The few studies that do exist currently tend to be on developing frameworks and tools to help site managers plan for evacuation (El Meouche et al., 2018; Hua et al., 2020; Kim & Lee, 2019; Marzouk & Al Daour, 2018). Their attention is focused heavily on the physical environment and technology that can model it, rather than on the humans working in those spaces and their behaviour. Instead, worker perceptions, beliefs, and actions have been the focus of research on safety culture and climate (Choudry et al., 2007; Schwatka et al., 2016). However, those studies examine these elements more generally. For instance, safety climate relates to whether workers currently perceive their sites to be safe workplace environments, day-to-day (Teo & Feng, 2009). Fire emergencies, and especially evacuation, are rarely if ever mentioned in conjunction with these safety concepts. Yet, safety climate could conceivably be relevant to emergency evacuation. Research has indicated that, although workers might be afraid of giving a frank appraisal of safety on their own site, there are signs that those who perceive a positive safety climate will have a lower tendency to take risks at work (Low et al., 2019). Therefore, it seems logical that those who perceive a positive safety climate might also be less inclined to take risks related to site evacuation.

**Table 1. Main and supplementary research questions**

| Main: What percentage of workers will... | Supplementary: Will the following relationships be observed? |
|---|---|
| • perceive a positive safety climate (when measured explicitly, and indirectly for sites in general)? | • positive safety climate = lower tendency to take site evacuation-related risks |
| • know the emergency procedure? | • shorter experience of site work (measured indirectly by Age), less time spent at the current site, or a non-native speaker = less familiarity with the emergency procedure |
| • hear the fire alarm sound across the site? | • longer exposure to noise (measured indirectly by Age), less time spent at the current site, or a non-native speaker = less able to hear/recognise the alarm |
| • believe there is a real threat when the alarm sounds across the site? | • greater exposure to drills, due to longer experience of site work (measured indirectly by Age) or more time spent at the current site = more sceptical of there being a real threat |
| • follow procedure and commence evacuation immediately? | • less familiarity with procedure, greater scepticism about threat, or greater fear about losing money/incurring employer's disapproval by halting work = less likely to evacuate immediately |
| • retain information provided about escape routes and use that to find their way out? | • being older = less able to recall the information; also, less time spent at the current site, or a non-native speaker = less familiarity with escape routes and thus greater reliance on other wayfinding methods? |
| • encounter obstacles when evacuating? | • attempts to overcome obstacles and exit quickly = risks being taken during evacuation |
| • feel they faced danger during their evacuation? | • positive safety climate, or higher tendency to take risks = less likely to perceive risk during evacuation |

### 1.2 Research questions

This exploratory study took a first step at tackling gaps regarding construction fire emergencies. Site evacuations were conducted, workers surveyed, and the questions in Table 1 tested.

## 2. Methods

This study was part of a larger research project running from 2016 to 2019 on construction site evacuation, where multiple types of data (including observations from video recordings, measured travel speeds) were collected during evacuations and experiments (Deere et al., 2020; Galea et al., 2019). This paper focuses solely on the survey component of that project, which was designed to capture self-reports of worker behaviour.

### 2.1 Evacuated construction sites

The sites of the evacuations were two tall buildings under construction in London, UK, herein referred to as 100 BG and 22 BG. Now complete, these buildings stand at a height of 181 metres (37 storeys) and 278 metres (62 storeys), respectively. The same international construction contractor was responsible for both.

At the time of evacuation, the core of 100 BG had been constructed up to the 20$^{th}$ storey and the core of 22 BG had been constructed up to the 14$^{th}$ storey. The core is the first part of a tall building to be built. This is because this concrete shaft acts somewhat like a spine, supporting structural elements such as the floors that extend out from it. Floors are then constructed in stages using layers of e.g. steel framework, metal decking, rebar, and concrete. Climbing formwork systems (slipform, jumpform) were used to construct the cores at 100 BG and 22 BG; these reached even higher (22$^{nd}$ and 15$^{th}$ storeys, respectively).

The core also ultimately houses the means by which occupants travel up and down the building. Regulatory guidance instructs that permanent means of vertical travel be built as early as possible, so construction workers can use these to ascend or descend during both emergency and non-emergency situations (Health and Safety Executive, 2006; Health and Safety Executive, 2010). However, it is likely that temporary means of vertical travel will be used instead or in addition. As well as ladders and scaffold stairs, temporary means may include hoists. Hoists are often used for lifting materials and equipment, but some are designed to carry passengers also. On the day of evacuation, a hoist was in operation at both 100 BG and 22 BG.

Fig. 1 provides a simplified example of the various elements that comprise a tall building under construction. Fig. 2 shows more specifically these elements in one of the sites used in this study.

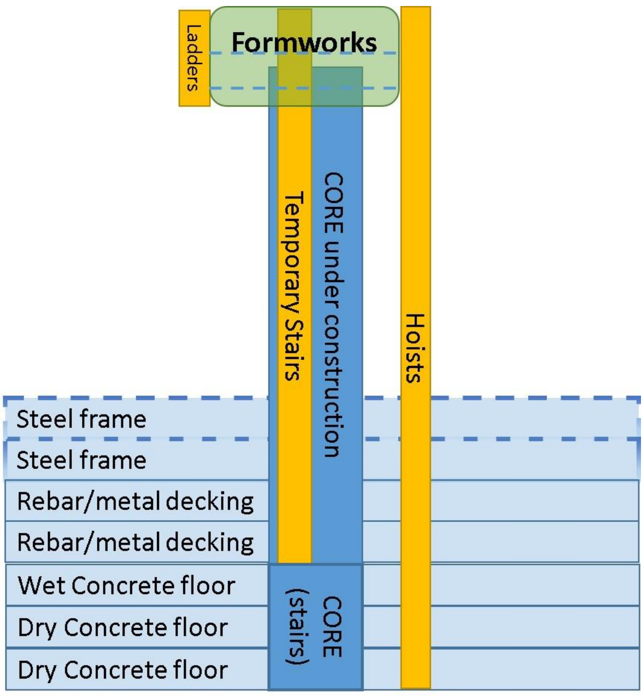


**Fig. 1. Simplified example of a tall building construction**

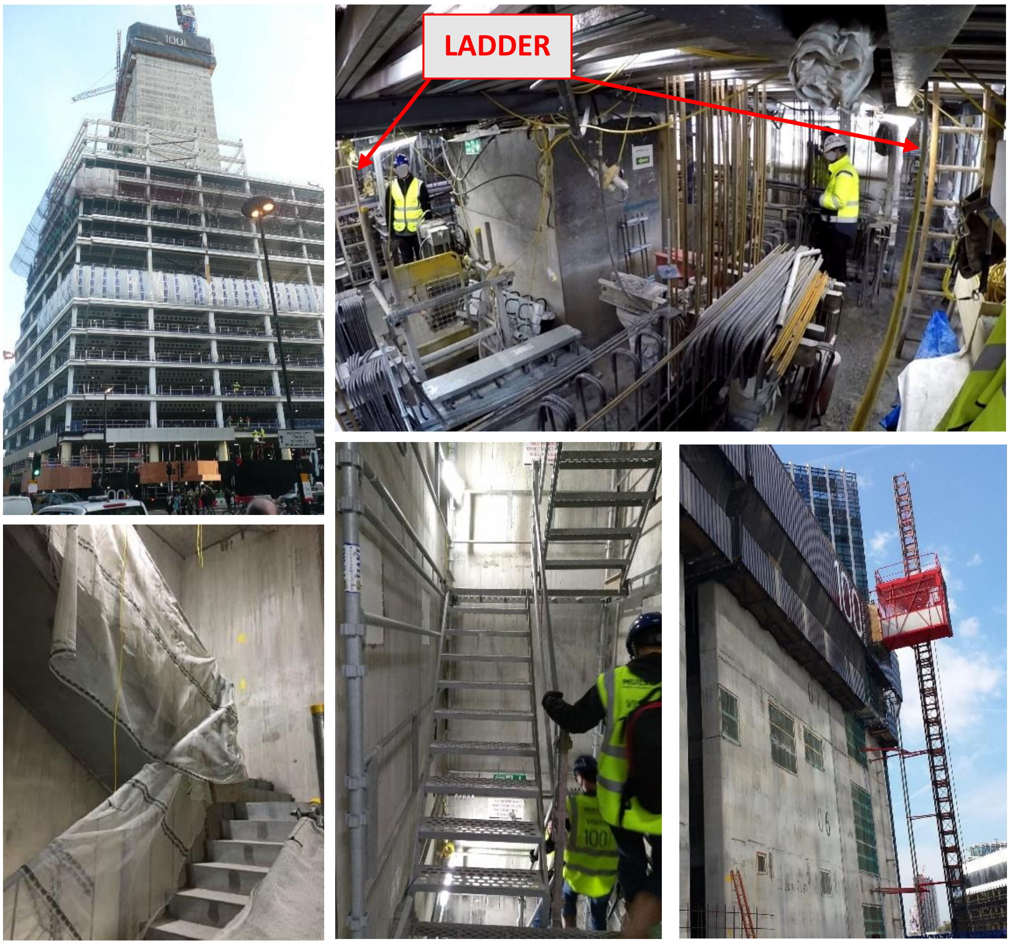


**Fig. 2. 100 BG: (top left) viewed from outside; (top right) ladders inside the formworks; (bottom left) permanent stairs; (bottom middle) temporary scaffold stairs; (bottom right) the hoist**

### 2.2 Procedure

Preparatory work was undertaken to gain insight into site layout, worker tasks, safety training, the fire plan, and various logistics related to data collection. This work included perusal of technical drawings and safety documentation, visits to sites, and meetings with site management. These activities revealed that, prior to starting on the sites, all workers had to hold a valid CSCS card (i.e. industry certification that they possessed an appropriate level of skill and competence regarding health, safety, and environmental awareness and practice). They also had to complete an induction in which the site's health and safety rules were outlined, along with the procedures to follow in the event of an emergency or other incident causing or almost causing injury. Additionally, workers would subsequently be required to attend monthly workshops on behavioural aspects of health and safety. These workshops covered topics such as risk perception and briefed the workers on their responsibilities regarding the company's Code of Conduct. Real-life cases and photographs were used in these workshops to aid engagement and learning. Furthermore, weekly team meetings afforded an additional opportunity to raise safety matters. The fire plan to be enacted in an emergency was presented in English. Text on signage was also in English (Fig. 3). However, pictorial aids were used to assist comprehension for workers whose first language was not English. Upon satisfactory completion of the preparatory work, ethical approval to run the evacuation study was obtained from the university's research ethics committee.


**Fig. 3. Example of signage on site**

Each evacuation was unannounced. Only the research team, site management, and London Fire Brigade were involved in the planning of activating a fire alarm. Moreover, only these parties knew what time the alarm would be activated. Thus, while the sudden presence of video cameras on-site might have cued perceptive workers to the fact that something was afoot, they would not have known what was going to happen or when. Additionally, the cameras were small, positioned above eye level, installed at a late hour while few workers were around, and controlled remotely.

On the day of evacuation, workers were engaged in a variety of tasks. These included lifting operations, brick and block work, steelwork, joinery, and welding, among other things. The auditory fire alarm (sounder with a sweeping siren tone) was activated at approximately 09:00 on both sites. Video footage showed that the first worker to exit the building did so rapidly following alarm activation (100 BG = 0 minutes 41 seconds; 22 BG = 0 minutes 28 seconds) and the last exited after around 10-13 minutes (100 BG = 12 minutes 46 seconds; 22 BG = 9 minutes 14 seconds). Upon exiting the building, the workers congregated at their site's assembly point. There they stayed until told it was safe to return to work. There were no reports or observations of any injuries being incurred during evacuation.

At 100 BG, the research team attempted to survey workers at the site canteen during their staggered breaks. These breaks started approximately 30 minutes after alarm activation. Workers were physically approached and invited to complete hard-copy surveys. Paper notices, displaying hyperlinks and machine-readable barcodes for accessing an identical online version of the survey, were also placed around the room on tables and walls encouraging participation via mobile phone. As will be shown in section 2.4, this method of recruitment proved largely ineffective. Thus, at 22 BG, workers were instead physically approached when they arrived at the assembly point and invited to complete hard-copy surveys; as described further in section 2.4, this increased the participation rate considerably.

## 2.3 Materials

### 2.3.1 Questionnaire survey

The survey was available in English, and also Romanian, which was the most common other first language on each site. A forward-back translation method (where the English survey was translated into Romanian, then translated back into English, and the two versions compared, by separate individuals; Harkness & Schoua-Glusberg, 1998) was employed to ensure the questions and answer options were being interpreted as intended.

The survey began by providing details of the study, thereby allowing workers to make an informed decision as to whether to consent and take part or decline. Subsequent sections asked about personal and professional factors (but not data that could identify individuals; participation was anonymous), plus what happened during the unannounced evacuation. Questions were designed to be easy to self-complete. Most simply required a "tick box" answer. Various types of data were captured, which were mostly coded into categories (Table 2). Note, since it was known that the workforce was predominantly male, no data on gender were collected. Also note that the version of the survey used at 100 BG contained additional questions, mainly relating to the evacuation descent. Since some workers could potentially use multiple means of descending the building, the survey questions branched accordingly. However, it appeared that participants had difficulty following the skip logic of the branching, resulting in answers from this part frequently being missing, therefore making analysis largely impossible. Branching also extended the time to complete the survey (around 20 minutes at most). Consequently, these questions were dropped from the survey for 22 BG, and the time to complete also dropped (to around 5-10 minutes at most). However, it was possible to analyse data on one additional variable from the 100 BG survey: Descent Obstacles.

**Table 2. Types of data captured by the survey and their codes**

| Variable | Category Codes |
| --- | --- |
| • Age (in years) | • 1 = 18-24, 2 = 25-34, 3 = 35-44, 4 = 45-54, 5 = 55-64 |
| • Time At Site (in months) | • 1 = < 1, 2 = < 3, 3 = < 6, 4 = 6+ |
| • First Language | • English, Other |
| • Perceived Risk (current site) (i.e. danger currently perceived to be faced on this particular site everyday) | • No Danger, Some Danger |
| • Perceived Risk (sites in general) (i.e. danger currently perceived to be faced on construction sites in general everyday) | • No Danger, Some Danger |
| • Risk-Taking (i.e. tendency to engage in risky activities) | • not applicable – summed score on Risk-Taking instrument; see section 2.3.2 |
| • Emergency Knowledge (i.e. comprehension of the procedure to follow upon hearing a fire alarm activate) | • Correct (evacuate immediately), Other (secure workplace first; continue working until receive instruction; ask for instruction; copy others; don't know) |
| • Initial Location | • Formworks, Core, Floor, Other |
| • Means Of Alert (i.e. heard alarm or remained unaware until received other, social cue) | • Alarm, Other |
| • Credible Threat (i.e. believed there was a real threat or not) | • Real, Not Real |
| • Task Importance (to self) (i.e. perceived importance of finishing task) | • 1 = Not At All Important, 2 = A Little Important, 3 = Important, 4 = Very Important |

| | |
|---|---|
| • Task Importance (to employer) (i.e. as above but from the perceived perspective of the employer) | • 1 = Not At All Important, 2 = A Little Important, 3 = Important, 4 = Very Important |
| • Initial Action | • Commenced Evacuation, Other (continued task until completion; secured workplace; alerted others; sought information; miscellaneous action) |
| • Wayfinding (i.e. how the exit was found) | • Recalled Evacuation Diagram, Other (looked for emergency signage, directed by authority figure, followed fellow workers, retraced route in, miscellaneous method) |
| • Descent Obstacles (i.e. what hindered evacuation travel; 100 BG only) | • Encountered Congestion, Route Blocked By Barrier, Route Blocked By Authority Figure, Hoist Unavailable |
| • Perceived Risk (evacuation) (i.e. danger perceived to be faced during this evacuation) | • No Danger, Some Danger |

**2.3.2 Risk-taking instruments**

A multi-item instrument was included within the survey to measure the tendency to take risks related to site evacuation. Risk-taking scales applied elsewhere to investigate construction safety were either too limited in their connection to evacuation-related behaviours (e.g. Landeweerd et al., 1990) or not published when this study was designed (Low et al., 2019). So, a new, short instrument was created, borrowing items from two risk-taking scales used in other types of safety research: the DOSPERT scale (Blais & Weber, 2006; see also McCaffrey et al., 2018) and the road-user scale (Hulse et al., 2018). The six items listed in Table 3 were expected to tap into related kinds of risky behaviour that could hypothetically lower the probability of safe site evacuation. Participants were asked to rate their likelihood of engaging in each of the itemised behaviours using a 7-point Likert scale (where 1 =

Extremely Unlikely, 2 = Moderately Unlikely, 3 = Somewhat Unlikely, 4 = Not Sure, 5 = Somewhat Likely, 6 = Moderately Likely, 7 = Extremely Likely). The scores on the items were then summed to provide a score for Risk-Taking.

**Table 3. Scale items, behaviours, and loadings relating to the site evacuation risk-taking factor**

| Scale | Item | Related Risky Behaviour | Loading |
|---|---|---|---|
| RU | Riding a bicycle without a helmet | Not wearing personal protective equipment | .81 |
| D | Disagreeing with an authority figure on a major issue | Not obeying the emergency procedure | .68 |
| D | Betting a day's income on the outcome of a sporting event [reverse scored] | Not taking action in case it results in personal financial loss | -.55 |
| RU | Crossing the road when the "Don't Walk" sign is indicated | Showing impatience when movement is impeded | .73 |
| RU | Exceeding the speed limit on a motorway | Travelling faster than recommended for the conditions | .64 |
| D+RU | Walking home alone at night in an unsafe area of town | Choosing a convenient but dangerous way to reach a place of safety | .72 |

*Notes: D = DOSPERT scale; RU = road-user scale; D+RU = both the DOSPERT scale and the road-user scale*

Before conducting the main analysis for this study, the Risk-Taking instrument's validity and reliability were assessed. This was assisted by factor analysis and Cronbach's alpha, using the participants' responses to each item[1]. If valid, the instrument's items should reflect the same underlying construct:

[1] See Field (2013). Tests showed that the six-item sample was adequate for factor analysis, or more specifically principal axis factoring (determinant = .02, overall KMO = .65, individual KMOs > .55, Bartlett's test of sphericity $p < .001$), and that 48% of the variance was explained by a single factor model, with a scree plot supporting the notion of a single factor model. Further tests showed that the sample reduced to five items was still adequate (determinant = .06, overall KMO = .69, individual KMOs > .63, Bartlett's test of sphericity $p < .001$), and now 51% of the variance was explained by a single factor model, which was again supported by a scree plot.

risk-taking. This seemed likely since all items derived from existing scales of risk-taking. However, the items had not been combined in this way previously and it needed exploring as to whether they all would sufficiently represent the construct in the current context. If so, they should strongly relate to a single factor, i.e. all loadings should preferably be .40 or higher for that factor. Additionally, if reliable, the instrument should have good internal consistency, i.e. Cronbach's alpha should preferably be .70 or higher. As the loadings in Table 3 show, the results revealed that the six items did strongly relate to a single factor ("site evacuation risk-taking"). However, internal consistency was lower than desirable (Cronbach's alpha = .62). Removal of the betting item improved internal consistency considerably (Cronbach's alpha = .84). Another round of factor analysis showed that, minus the betting item, the five items still related strongly to a single factor (loadings ranged from .64 to .77). So, the Risk-Taking summed score used in the main analysis comprised the scores from the remaining five items (summed score's possible range = 5 to 35).

A higher summed score indicated a greater tendency to take site evacuation-related risks. However, at what point would a greater tendency represent a high risk-taker? Arguably, if a summed score fell within the upper half of the possible range (> 20), it would suggest a high risk-taker. Also, if the score was greater than the average observed in the general population, it would denote a high risk-taker. Since this was the only study that had used the five-item Risk-Taking instrument, no comparison could be made with the general population on that. However, the instrument already contained several items from another safety-related risk-taking instrument, the road-user (RU) scale; the addition of the final RU scale item (about riding with a driver who could be over the drink-drive limit) meant the construction workers' mean summed score could be calculated for that scale (Cronbach's alpha = .83) and compared with the mean summed score from Hulse et al.'s (2018) sample comprising almost 1,000 members of the UK public.

## 2.4 Participants

At the time of evacuation, 184 construction workers were on-site inside the building at 100 BG; only 28 of those (15%) completed the survey (22 in English, 6 in Romanian). The low completion rate was due to workers wishing to use their break to engage in other activities (e.g. make phone calls, eat hot meals). At 22 BG, 46 workers were on-site inside the building at the time of evacuation and 33 of those (72%) completed the survey (28 in English, 5 in Romanian). The main reason the completion rate was not 100% there was because of a shortage of time. That is, the alarm stopped sounding soon after some workers arrived at the assembly point. Therefore, despite their willingness to participate, these workers were unable to complete the survey to any meaningful degree before having to return to work. So, the total sample for this study comprised 61 participants.

The minimum and maximum reported ages at 100 BG and 22 BG were the same (min. = 18-24 years, max. = 55-64 years). Also, the median age was the same for 100 BG (Mdn = 3.00 [35-44 years], IQR = 2.00-4.00) and 22 BG (Mdn = 3.00 [35-44 years], IQR = 2.00-3.00). Thus, the two sites did not differ according to Age ($U = 434.00$, $p = .829$). The minimum and maximum time spent working at one's site was the same for 100 BG and 22 BG (min. = < 1 month, max. = 6+ months). The median time at 100 BG (Mdn = 2.00 [< 3 months], IQR = 1.00-3.00) was not the same as at 22 BG (Mdn = 3.00 [< 6 months], IQR = 2.00-4.00), but the two sites did not differ significantly according to Time At Site ($U = 344.50$, $p = .120$). However, there was a significant site difference in First Language: 22 BG had significantly fewer native English speakers than 100 BG (24% vs. 57%, $\chi^2(1) = 6.87$, $p = .009$).

## 2.5 Statistical analysis

Statistics were produced using IBM SPSS Statistics version 26. Descriptive statistics included values representing the centre and spread of a distribution of data, i.e. the median (Mdn) and interquartile range (IQR) when ordered categorical data (e.g. Age categories), and the mean (M) and standard deviation (SD) when continuous data (e.g. Risk-Taking summed scores). Inferential statistical analyses were conducted using the chi-square ($\chi^2$), McNemar (no test statistic), Mann-Whitney (*U*), Wilcoxon signed ranks (*Z*), and independent samples (*t*) tests. A p-value less than .050 indicated a statistically significant result.

## 3. Results

Table 4 presents the overall results for each of the main research questions posed in this study. It also breaks the results down across the two sites, plus shows the outcome of the statistical tests comparing the responses at 100 BG with those at 22 BG. Note, since the question about encountering evacuation obstacles was only answered by 100 BG's participants, that data is presented separately in section 3.5.

**Table 4. Results for tests of the main research questions**

| **What percentage of workers will...** | **Overall** | **100 BG** | **22 BG** | **100 BG vs. 22 BG** |
|---|---|---|---|---|
| Perceive a positive safety climate ("No Danger")? | | | | |
| - current site | 64% | 63% | 65% | $\chi^2(1) = 0.03$, $p = .862$ |
| - sites in general | 45% | 53% | 38% | $\chi^2(1) = 0.84$, $p = .360$ |
| Know the emergency procedure ("Correct")? | 91% | 91% | 91% | $\chi^2(1) = 0.00$, $p = 1.000$ |
| Hear the fire alarm sound across the site ("Alarm")? | 98% | 100% | 97% | $\chi^2(1) = 0.83$, $p = .362$ |
| Believe there is a real threat when the alarm sounds across the site ("Real")? | 66% | 44% | 82% | $\chi^2(1) = 9.00$, $p = .003$ |
| Follow procedure and commence evacuation immediately ("Commenced Evacuation")? | 52% | 50% | 53% | $\chi^2(1) = 0.06$, $p = .813$ |
| Retain info provided about escape routes and use that to find their way out ("Recalled Evacuation Diagram")? | 39% | 23% | 52% | $\chi^2(1) = 4.41$, $p = .036$ |
| Feel they faced danger during their evacuation ("Some Danger")? | 24% | 25% | 24% | $\chi^2(1) = 0.01$, $p = .933$ |

### 3.1 Safety climate and risk-taking

As Table 4 shows, close to two-thirds of all participants, and those at each site, perceived their current site to be a safe workplace environment, posing no danger day-to-day. However, fewer than a half of all participants perceived construction sites in general to be safe workplace environments. Similarly, at each site, there was not an overwhelming majority who perceived construction sites in general to be safe environments. Overall, the perceived risk for sites in general was significantly higher than the perceived risk for the participants' current site (McNemar's: p = .031).

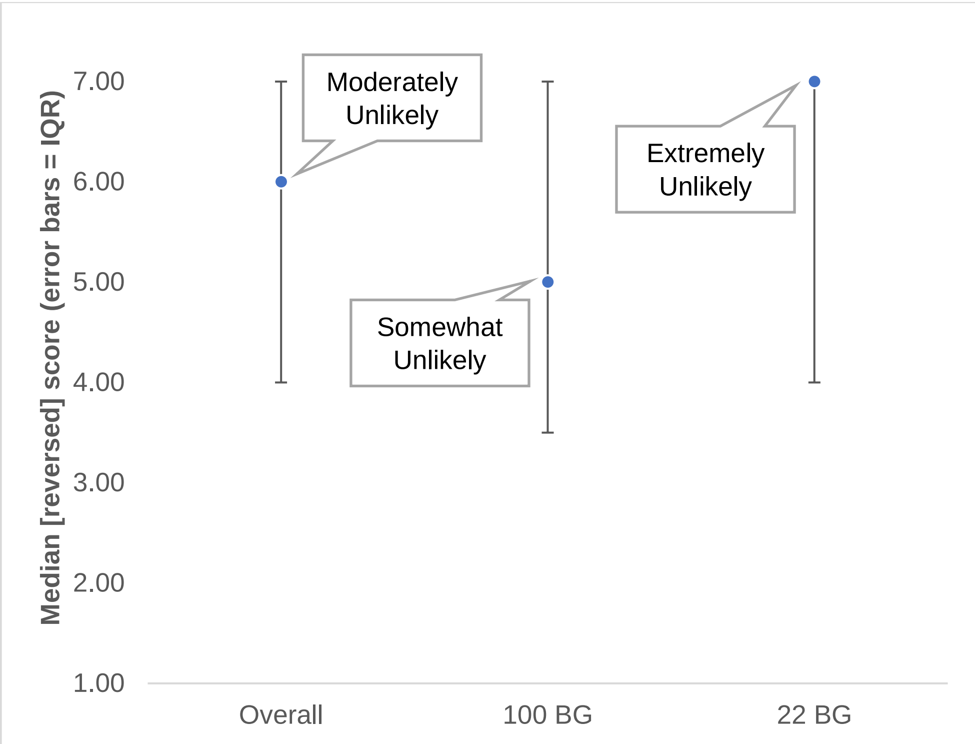


**Fig. 4. Scores on the risk-taking betting item**

Scores on the risk-taking betting item showed that participants were rather reluctant to take action that might lose them money (Fig. 4). This was the case overall, and at each site (100 BG vs. 22 BG: U = 142.00, p = .407). However, the summed scores on the 5-item Risk-Taking instrument suggested less likelihood of risk-taking related to site evacuation (Fig. 5). That is, the mean score for participants overall, and at each site (100 BG vs. 22 BG: t(36) = 0.99, p = .327), was less than 20 and therefore within the lower half of the possible range. In addition, the participants' mean RU scale summed score was significantly lower than that of Hulse et al.'s (2018) comparison group (t(953) = 2.58, p = .010).

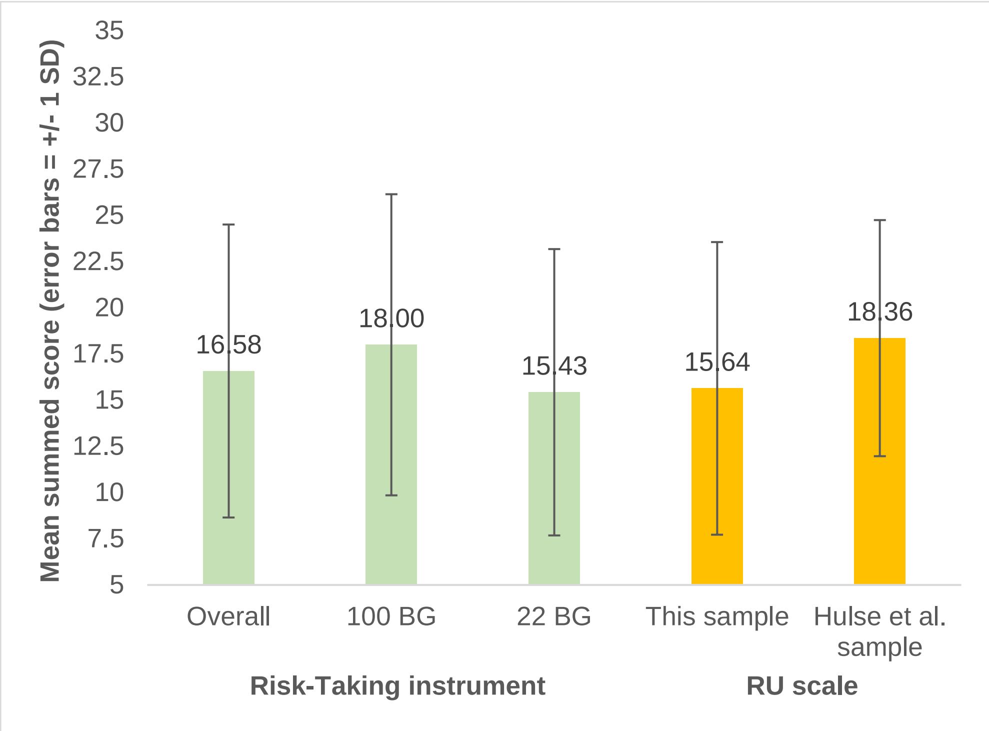


**Fig. 5. Summed scores on the Risk-Taking instrument and RU scale**

As can be seen in Table 5, overall, participants who perceived their site as being safe had lower Risk-Taking summed scores than participants who perceived their site as posing some danger. However, this difference did not result in a significant relationship being detected between Perceived Risk for the current site and Risk-Taking. Nor was there a significant relationship between Perceived Risk for sites in general and Risk-Taking.

## 3.2 Emergency knowledge

A large majority of all participants, and at both sites, possessed correct knowledge of the emergency procedure (Table 4). That is, most participants knew that they should evacuate immediately upon hearing the fire alarm. Of the remaining participants, 7% thought that they were supposed to secure their workplace and 2% did not know what they were supposed to do. Overall, there was no significant relationship between Emergency Knowledge and either Age, Time At Site, or First Language (Table 5).

**Table 5. Results for tests of the supplementary research questions – part 1**

| A ⬇ B ➡ | **Perceived Risk: "No Danger" vs. "Some Danger"** | **A and B related?** |
|---|---|---|
| Risk-Taking [M (SD)] | 14.90 (8.62) vs. 18.07 (7.08) [1] | t(33) = -1.14, p = .262 |
| | 16.47 (7.89) vs. 17.19 (8.10) [2] | t(34) = -0.27, p = .791 |
| **A ⬇ B ➡** | **Emergency Knowledge: "Correct" vs. "Other"** | **A and B related?** |
| Age [Mdn (IQR)] | 3.00 (2.00-4.00) vs. 3.00 (1.50-4.00) | U = 120.00, p = .954 |
| | i.e. 35-44 years vs. 35-44 years | |
| ⬇ Time At Site [Mdn (IQR)] | 3.00 (2.00-3.25) vs. 3.00 (1.50-3.00) | U = 114.00, p = .766 |
| | i.e. < 6 months vs. < 6 months | |
| **A ⬇ B ➡** | **First Language: "English" vs. "Other"** | **A and B related?** |
| Em. Know. [% "Correct"] | 96% vs. 88% | $\chi^2(1) = 0.92$, p = .338 |

*Notes: [1] = for current site (safety climate); [2] = for sites in general (safety climate); Em. Know. = Emergency Knowledge*

## 3.3 Receiving and believing the alert

As Fig. 6 shows, at the time the fire alarm was activated, participants at 100 BG were reportedly most frequently located on a floor, while a substantial percentage were in some other location such as "scaffold". In contrast, participants at 22 BG most frequently reported being in some other location such as "hoist". This site difference in Initial Location was significant ($\chi^2(3) = 13.90$, p = .003).

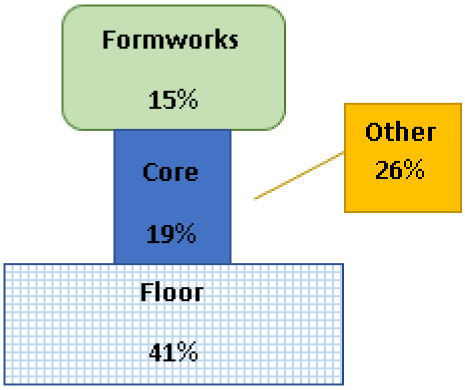


**Fig. 6. Participants' location in 100 BG (left) and 22 BG (right) at the time of alarm activation**

Nevertheless, practically everyone reported being alerted by hearing the alarm (Table 4), regardless of whether in the formworks, the core, a floor, or some other location (100% vs. 100% vs. 100% vs. 97%, $\chi^2(3) = 1.05$, $p = .789$). The one worker who did not was aged 45-54, had only been at the site less than a month, and was a native English speaker. Further probing revealed this worker had not been wearing hearing protection, had not been engaged in a noisy task, and did not know why they failed to notice the alarm.

Once alerted, many participants believed that they were facing a real threat. However, significantly more participants at 22 BG viewed the threat alert as credible (Table 4). Likewise, significantly more participants who were located in an "Other" area of the site, as opposed to in the formworks, core, or a floor, believed there was a real threat (83% vs. 33% vs. 45% vs. 50%, $\chi^2(3) = 8.56$, $p = .036$). Additionally, while there was no significant relationship between Credible Threat and Age, there was one between Credible Threat and Time At Site, with the more sceptical participants being those who had worked at their site for a shorter period of time (Table 6).

**Table 6. Results for tests of the supplementary research questions – part 2**

| A ⬇ B ➡ | Credible Threat: "Real" vs. "Not Real" | A and B related? |
|---|---|---|
| Age [Mdn (IQR)] | 3.00 (2.00-3.00) vs. 3.00 (2.00-4.00)<br>i.e. 35-44 years vs. 35-44 years | U = 352.00, p = .754 |
| Time At Site [Mdn (IQR)] | 3.00 (2.00-4.00) vs. 2.00 (1.00-3.00)<br>i.e. < 6 months vs. < 3 months | U = 204.00, p = .003 |

## 3.4 Responding to the alert

Around one-half of all participants reported evacuating immediately upon being alerted. This level of response was similar across sites (Table 4). Of those who took some other kind of initial action, most reported trying to alert others (22%). Securing workplaces, seeking information, continuing one's task until completion, and other miscellaneous actions were reported less often (9%, 7%, 5%, and 5%, respectively).

As Table 7 displays, although evacuating immediately was more often the initial action of participants who possessed correct emergency knowledge, than of participants who expressed alternative comprehension of the emergency procedure, this difference was not significant. Moreover, there was no significant difference in the initial action of participants who believed there was a real threat versus those more sceptical. Furthermore, the initial action had no significant relationship with either the risk-taking betting item score or the Risk-Taking summed score.

**Table 7. Results for tests of the supplementary research questions – part 3**

| | | | |
|---|---|---|---|
| **A** ⬇ | **B ➡** | **Emergency Knowledge: “Correct” vs. “Other”** | **A and B related?** |
| IA [% “Commenced Evac”] | | 57% vs. 20% | $\chi^2(1) = 2.52$, p = .113 |
| **A** ⬇ | **B ➡** | **Credible Threat: “Real” vs. “Not Real”** | **A and B related?** |
| IA [% “Commenced Evac”] | | 54% vs. 50% | $\chi^2(1) = 0.09$, p = .770 |
| **A** ⬇ | **B ➡** | **Initial Action: “Commenced Evac” vs. “Other”** | **A and B related?** |
| RT betting item [Mdn (IQR)] | | 6.00 (3.00-7.00) vs. 6.00 (4.00-7.00) | U = 159.50, p = .752 |
| | | i.e. Moderately Unlikely vs. Moderately Unlikely | |
| **A** ⬇ | **B ➡** | **Initial Action: “Commenced Evac” vs. “Other”** | **A and B related?** |
| RT summed score [M (SD)] | | 17.00 (8.95) vs. 16.11 (6.85) | t(36) = -0.34, p = .735 |
| **A** ⬇ | **B ➡** | **Initial Action: “Commenced Evac” vs. “Other”** | **A and B related?** |
| Task Importance [Mdn (IQR)] | | 1.00 (1.00-3.00) vs. 1.00 (1.00-2.25) [1] | U = 340.00, p = .824 |
| | | i.e. Not At All Important vs. Not At All Important | |
| | | 1.50 (1.00-3.25) vs. 1.50 (1.00-3.25) [2] | U = 331.00, p = .890 |
| | | i.e. ~A Little Important vs. ~A Little Important | |

*Notes: IA = Initial Action; RT = Risk-Taking; [1] = importance to self; [2] = importance to employer*

Overall, participants did not think it was important to finish their task first (Fig. 7). However, when they answered this question again, from their employer’s perceived perspective, importance was higher. This was a significant increase (Z = -2.44, p = .015). Further inspection showed that there was a significant change in perception at 22 BG (Z = -2.21, p = .027) but not at 100 BG (Z = -1.00, p = .317).


**Fig. 7. Task importance to self vs. to employer**

Nevertheless, the importance of finishing one's task had no significant relationship with whether participants evacuated immediately or took some other initial action. This was the case when importance was viewed from the perspective of one's self and when participants adopted the perceived perspective of their employer (Table 7).

## 3.5 Exiting the building

Once participants had commenced evacuation, they most often found the exit by recalling the evacuation diagram seen in their site's fire plan (Fig. 8). However, participants at 22 BG used this method of wayfinding over other methods significantly more frequently than did participants at 100 BG (Table 4). Of the other methods of wayfinding, looking for emergency signage was somewhat popular at both sites (100 BG: 27%; 22 BG: 24%). A substantial percentage of participants at 100 BG either followed their fellow workers (23%) or retraced their route in (18%), while these methods were reported less often at 22 BG (10% and 7%, respectively). Hardly anyone was directed by an authority figure (100 BG: 5%; 22 BG: 3%) or found the exit via some other miscellaneous method (100 BG: 5%; 22 BG: 3%).

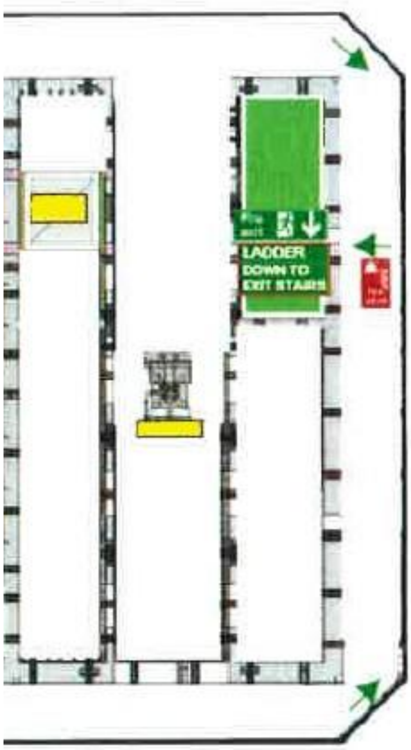


**Fig. 8. Portion of evacuation diagram from the fire plan showing escape routes**

As Table 8 shows, overall, Wayfinding and Age were not significantly related. This remained the case when examined separately at 100 BG and at 22 BG. Wayfinding and Time At Site were also not significantly related overall. However, when examined by site, a significant relationship was revealed at 100 BG, with participants who had spent less time working at the site being more reliant upon alternative methods of wayfinding; this was not the case at 22 BG. First Language was not significantly associated with Wayfinding, either overall, at 100 BG, or at 22 BG.

**Table 8. Results for tests of the supplementary research questions – part 4**

| A ⬇ B ➡ | Wayfinding: "Recalled Evac Diagram" vs. "Other" | A and B related? |
|---|---|---|
| Age [Mdn (IQR)] | 3.00 (2.00-3.00) vs. 3.00 (2.00-4.00) [1] | U = 297.00, p = .951 |
| | i.e. 35-44 years vs. 35-44 years | |
| | 3.00 (1.50-3.00) vs. 3.00 (2.00-4.00) [2] | U = 30.00, p = .359 |
| | i.e. 35-44 years vs. 35-44 years | |
| | 3.00 (2.00-3.00) vs. 2.00 (2.00-3.50) [3] | U = 80.50, p = .440 |
| | i.e. 35-44 years vs. 25-34 years | |
| **A ⬇ B ➡** | **Wayfinding: "Recalled Evac Diagram" vs. "Other"** | **A and B related?** |
| Time At Site [Mdn (IQR)] | 3.00 (2.00-4.00) vs. 3.00 (1.00-3.00) [1] | U = 217.50, p = .064 |
| | i.e. < 6 months vs. < 6 months | |
| | 3.00 (2.50-4.00) vs. 2.00 (1.00-3.00) [2] | U = 16.50, p = .039 |
| | i.e. < 6 months vs. < 3 months | |
| | 3.00 (2.00-4.00) vs. 3.00 (2.75-3.00) [3] | U = 100.50, p = .847 |
| | i.e. < 6 months vs. < 6 months | |
| **A ⬇ B ➡** | **First Language: "English" vs. "Other"** | **A and B related?** |
| Wayfinding [% "RED"] | 35% vs. 42% [1] | $X^2(1) = 0.25$, p = .620 |
| | 21% vs. 25% [2] | $\chi^2(1) = 0.04$, p = .848 |
| | 67% vs. 48% [3] | $\chi^2(1) = 0.68$, p = .411 |

*Notes: [1] = Overall; [2] = 100 BG; [3] = 22 BG; "RED" = "Recalled Evacuation Diagram"*

At 100 BG, 32% of participants reported encountering obstacles while trying to evacuate. In some cases, the same participant reported encountering more than one type of obstacle. Table 9 lists the obstacles, the amount of participants who encountered them, and contains some qualitative notes that provide context and describe the participants' reported responses to these obstacles.

**Table 9. Obstacles encountered during evacuation at 100 BG and participants' responses**

| Obstacle (n and %) | Notes |
|---|---|
| Encountered Congestion<br>n = 7 (25%) | 5 when on stairs, 2 when reached street level; delay was usually estimated to be less than a minute, no more than 5 minutes; response was always to just stay with the crowd |
| Hoist Unavailable<br>n = 3 (11%) | 2 did not wait around for the hoist to arrive, 1 estimated waiting for less than a minute; all ended up using the stairs |
| Route Blocked By Barrier<br>n = 2 (7%) | Neither tried to move round the physical barrier and use the blocked-off route |
| Route Blocked By Authority Figure<br>n = 1 (4%) | Did not ignore the instruction and try to use the blocked-off route |

## 3.6 Risk perceived during evacuation

Around one-quarter of all participants, and at both sites, perceived some risk while evacuating (Table 4). As can be seen in Table 10, while those who perceived a positive safety climate were less likely to report feeling some danger when exiting, there was nevertheless no significant association between Perceived Risk for the current site and Perceived Risk during evacuation. However, there was a significant association between Perceived Risk for sites in general and Perceived Risk during evacuation, in the expected direction (i.e. those who felt that construction sites were safe workplace environments were less likely to report feeling some danger when exiting). Lastly, Risk-Taking, as measured by the summed scores, was not significantly related to Perceived Risk during evacuation.

**Table 10. Results for tests of the supplementary research questions – part 5**

| **A** ⬇ **B** ➡ | **Perceived Risk: “No Danger” vs. “Some Danger”** | **A and B related?** |
|---|---|---|
| PRe [% “Some Danger”] | 11% vs. 33% [1] | $\chi^2(1) = 2.45, p = .117$ |
| | 0% vs. 33% [2] | $\chi^2(1) = 5.74, p = .017$ |
| **A** ⬇ **B** ➡ | **PRe: “No Danger” vs. “Some Danger”** | **A and B related?** |
| Risk-Taking [M (SD)] | 16.08 (8.07) vs. 21.00 (7.80) | $t(29) = -1.35, p = .188$ |

*Notes: PRe = Perceived Risk during evacuation; [1] = for current site (safety climate); [2] = for sites in general (safety climate)*

## 4. Discussion

The findings of this study paint a rather optimistic picture. For example, when asked about normal everyday conditions, the majority of sampled construction workers at 100 BG and 22 BG currently perceived themselves to be at no risk on their particular site. This indicates that both sites had cultivated a positive safety climate. However, when safety climate was investigated less directly, by asking about sites in general, significantly more participants reported currently perceiving some level of risk. This result could complement the previous one, by indicating that the workers’ particular site was considered especially safe. Alternatively, it could suggest that workers may be somewhat afraid of being critical of their current workplace, even when offered anonymity (c.f. Low et al., 2019).

Nevertheless, regardless of whether the site was perceived to be as safe as explicitly reported, safety climate was not significantly related to workers’ risk-taking tendency. It may be that a positive safety climate does not foster less risk-taking, as others have hypothesised (Low et al., 2019). Indeed, a different study showed that a lower willingness to take risks could be an antecedent of a positive safety climate (Mohamed, 2002). However, the current study only tested for an association, not causality. Therefore, even if the relationship was in the opposite direction, it should nonetheless have been significant if it genuinely existed. Moreover, the results do not support the contrasting – and controversial (Pless, 2016) – Risk Compensation and Risk Homeostasis theories, which argue that individuals will adapt their behaviour and take more risks when they perceive their environment to be safer (Peltzman, 1975; Wilde, 2014).

The risk-taking scores showed that the construction workers were rather risk averse. Previously, Landeweerd et al. (1990) hypothesised the opposite – that construction workers would be more inclined to take risks – and therefore tested for a related personality trait, sensation seeking. Instead, they found that workers had significantly lower sensation seeking scores than two arbitrary comparison groups: skiers and GP clients. However, both comparison groups could be high risk-takers, given that skiing is one of the more dangerous sports (Schmikli et al., 2009) and people tend to visit GPs when they have been exposed to some injury or illness-inducing hazard. Therefore, having a lower score than these groups might only suggest a relatively lower risk-taking tendency rather than an absolute one. Since Landeweerd et al.'s paper provides insufficient detail regarding scoring, it is difficult to tell. However, the current study utilised an additional risk-taking scale from another safety domain – the RU scale – and compared construction workers with a comparison group that comprised a representative sample of the UK general public (Hulse et al., 2018). From the findings, it can be said that this sample of construction workers were not more inclined to take risks, rather the opposite, i.e. they were significantly more risk averse than the average person.

So, given that self-reported safety was considered good, both at the organisational level (safety climate, if taken at face value) and independently at the individual level (risk-taking tendency), it is perhaps not surprising that most participants demonstrated correct knowledge of the fire emergency procedure. Younger participants, those who had spent less time working at their current site, and those whose first language was not English, showed no disadvantage. Therefore, at the sites included in this study, employers would appear to have taken adequate steps to communicate the procedure to all employees, regardless of their circumstances. Moreover, employees across the board would appear to have been sufficiently appreciative of safety to learn the procedure. Nevertheless, the industry should not become complacent since this may not be the case at other sites. A 2009 inquiry into the causes of UK construction accidents recommended that safety campaigns target “vulnerable” workers, classified as such by their age and migrant status (Donaghy, 2009). The Health and Safety Executive also currently have a dedicated area on their website regarding migrant workers in the construction industry, demonstrating that there are still concerns about communication, comprehension, and safety knowledge (Health and Safety Executive, 2021).

Speculation that the fire alarm might go unheard was unsupported by the survey responses. Likewise, there seemed little evidence to suggest that the alarm went unrecognised by certain groups even when heard. There was only one worker who reported not noticing the alarm; their answers failed to provide clear insight into whether this was due to perceptual or cognitive reasons. Thus, this may be one issue better investigated by observation than self-report. For example, in a later evacuation trial for this project, video cameras captured one worker in the middle of a phone conversation when the alarm began sounding; they continued their call for more than two minutes before hanging up and then commencing evacuation (Galea et al., 2019). Therefore, along with adequate fire alarm technology and procedural training, construction employers should consider their policies on distractions like mobile phones. While some already ban phone use from all areas and times other than e.g. while on break in the canteen, workers may nonetheless be tempted to take calls during productive hours, especially if working in isolation. One solution could be to insist that workers place their phones in secure storage in the canteen, thereby ensuring that access to the devices is restricted to break times. Others have taken a more trustful approach, by identifying “safe zones” around the site, marking them with posters, and allowing workers to use their phones when stood next to these posters (CCS Best Practice Hub, 2015). Although workers in these zones could still be distracted from a fire alarm, employers would nonetheless know which areas to send supervisors to first, for intervention purposes. Of course, mobile phones could in some cases serve to warn workers of an emergency (e.g. by vibrating to alert them to a received “evacuate” text message); however, a one-way pager would be a safer means of using wireless telecommunications to alert workers in this way.

A substantial percentage of participants believed that the alarm signified a real threat. This is positive, in the sense that their behaviour in this study likely represents behaviour that would be seen in a real fire evacuation. The threat alert’s credibility did vary significantly across sites, which probably reflects the fact that participants were located differently on the sites, i.e. 22 BG had significantly more participants located in “Other” areas such as the hoist and participants in “Other” areas were significantly more likely to believe there was a real threat. It is possible that those areas affected the workers’ perception: not of the threat itself (since there was no fire and so workers could not have perceived corroborative environmental cues), but of the need for evacuation (e.g. being able, from their vantage point, to perceive social cues such as others leaving). Thus, the effect of location on credibility might be rather complex.

Those who had spent less time at their current site were more sceptical of there being a real threat. One possible explanation is that an optimism bias existed: i.e. workers still new to their site might have thought that they could not be facing an emergency, not so soon, especially if their current site appeared safer than other sites. Optimism bias has been discussed within the general fire evacuation literature (Kinsey et al., 2019). Moreover, Caponecchia and Sheils (2011) found an optimism bias among a sample of Australian construction workers when investigating a range of workplace hazards.

However, there was no evidence that scepticism contributed to the delayed evacuation response reported by almost half the sample. Indeed, none of the hypothesised influencing factors were found to be significantly associated with not following procedure and evacuating immediately. A further look at the initial action undertaken shows that participants reported delaying evacuation not so much to continue working but rather to alert others. So, participants appeared to be actively engaging with the alarm and behaving in ways that could potentially increase safety – of others, if not themselves. What is curious is why participants felt the need to do so, given the alarm was reportedly well heard and recognised across the site. It is recommended that, during training, employers ensure their workers fully understand both their role in a fire emergency and what “evacuate immediately” means. Alerting others is the primary responsibility of the fire wardens/supervisors. Workers may go and warn others, but only those in their immediate area and this should only be necessary if the others appear unresponsive to the alarm. Workers should understand that rapidly commencing movement is not the same as evacuating immediately unless that movement is towards a place of safety. An additional point worth noting here is that not all participants may have been honest about their initial action. The video footage suggested that far more than 5% of workers on-site delayed evacuation to continue working on their task, only beginning evacuation when a supervisor intervened (Galea et al., 2019).

Once participants had commenced evacuation, their wayfinding was heavily reliant on pictorial aids (more so at 22 BG, for which no reason is immediately apparent). These pictorial aids included evacuation diagrams seen prior to evacuation and signage seen during evacuation. Therefore, it is very important that employers ensure the salience (and accuracy) of pictorial aids, during inductions, subsequent safety briefings, as well as on-site, despite the continual changes to building layout. When they fail to do so, the results from 100 BG suggest that workers will instead turn to following others or will attempt to retrace their route in. Both these alternative methods could prove problematic, e.g. if the others are also unsure of the way out, or if the route in happens to be in the path of the fire.

While obstacles to the descent were reported by around a third of participants at 100 BG, these obstacles did not appear to hinder progress greatly. Nor did participants appear to have taken risks to overcome the obstacles. This likely partly explains why the majority of participants did not perceive themselves to be in danger while evacuating. Of course, the fact that there was no actual fire, and therefore no hazards present such as smoke, will also likely have influenced risk perception here.

As before, perceived risk was not significantly associated with risk-taking tendency. So, the lack of a relationship between the two variables extended beyond the normal day-to-day context to an emergency context as well. However, perceived risk during evacuation was significantly associated with safety climate, albeit only when measured indirectly. This could be attributable to prior experience – i.e. participants who felt unsafe during evacuation might have experienced a fire emergency with a negative outcome at one or more of their previous workplaces. So, although their current site appeared safer on the whole, the activation of a fire alarm could have triggered memories of past danger on other sites and thus evoked concern during this evacuation.

Due to the bounded opportunity for data collection, and thus the need for a short survey, it was not possible to include additional questions about factors such as prior experience. Likewise, it was not possible to use an established, multi-faceted, and longer measure of safety climate such as the Safety Climate Tool (Sugden et al., 2009). Therefore, one limitation of this study is that certain variables were investigated in simplistic terms, potentially obscuring nuances in the workers' thoughts, feelings, and actions. Another limitation was the small sample size. Overall, this meant that more complex exploration of relationships between variables could not be conducted. More specifically, at 100 BG, it meant that only a small proportion of the workforce present on the day was included in the analysis. So, it leaves open the question of whether those who participated were more safety-minded individuals, thus positively skewing the results from that site. The fact that responses from 100 BG and 22 BG were similar in several respects somewhat allays that doubt. The similarity likely stems from both sites being run by the same contractor. While this helped facilitate a better like-for-like comparison, researchers should attempt in future to sample from a wider range of employers, as well as from a larger pool of employees. This would increase the chance of including sites with a poorer safety climate and more varied worker behaviours. Indeed, it may be wise to specifically target sites with a history of fire or other emergencies prompting site evacuation. Future studies could also include buildings at a stage of taller height than examined here, as this might provide different results regarding descent obstacles, for example.

Lastly, it must be borne in mind that the data in this study are self-reports, which could in places be vulnerable to a social desirability bias. Although video footage of the evacuations was recorded and was useful for validating some of the patterns of reported behaviours, it could not be used to verify the self-reported behaviour of individuals. It would have required workers to display some means of identification on their person (e.g. a unique number clearly displayed on their safety helmet) to match them to their survey answers. This would have primed them to the study and meant their behaviour would no longer have been naturalistic.

## 5. Conclusions

This study is the first research to conduct and document unannounced site evacuations, tackling a surprisingly neglected yet important safety topic. Some findings were encouraging, e.g. regarding construction workers' lower risk-taking tendency, their knowledge of the procedure in a fire emergency, their reception of the fire alarm, and – from a methodology point of view – the fact that a substantial number of workers believed the alarm signified a real threat, thereby helping elicit natural emergency behaviour. Moreover, the importance of pictorial aids in evacuation wayfinding was revealed. However, site managers clearly need to ensure that workers better understand what immediate evacuation means and what their role is in an emergency.

This study also highlighted some challenges ahead. The sample here was small and likely represents a best-case scenario. Therefore, future studies will need larger samples of workers as well as more sites, run by different contractors, with varying safety records. Future studies will also need more opportunity (time) to collect self-reports. Therefore, researchers will need to work closely with those in the industry to gain trust, access, and co-operation. They will also need to conceive ways of collecting survey data that is sufficiently comprehensive yet does not interrupt workers' downtime nor site productivity. Finally, in order to know the fire safety record of individual sites, or the construction industry as a whole, more transparency is required at a national level, where construction site fires are currently concealed within building fire statistics. Therefore, while this study represents a first step at shedding light on fire safety and evacuations in construction, many more and greater steps are needed.

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