EXPLORING THE POTENTIAL FOR USING VIDEO TO COMMUNICATE SAFETY INFORMATION TO CONSTRUCTION WORKERS: CASE STUDIES OF ORGANISATIONAL USE

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Legislation mandates that employers provide sufficient health and safety training and communicate relevant health and safety information to workers. However, the literature suggests that, globally, health and safety management in construction has to deal with a workforce with growing language and literacy barriers. Hence, conventional written and verbal safety communication approaches are of limited effectiveness. Research suggests that traditional safety training methods and the use of overly complicated, lengthy written statements about how work should be conducted are not very effective. A Melbourne-based firm (CodeSafe Solutions) has developed an innovative process for capturing and communicating health and safety training and safe operating procedures to field based workers using digital media (films) that can be accessed using Quick Response (QR) code technology. Two case study organisations in the water resources and home insulation sectors of the Australian construction industry are used to explore the potential of the CodeSafe system in communicating health and safety and technical information to workers. Data collected from the interviews and an examination of incident reports and video usage data were analysed in this study. Managers perceived the CodeSafe system to be beneficial and well received by workers. In one case study organisation, the introduction of the CodeSafe system coincided with a reduction in injury rates. However, without using a robust experimental design, causal inferences about the impact of the system cannot be made. Worker who were involved in making the films believed films would be an effective communication tool. However, the barriers to use the digital/mobile technology revealed from the interviews include limitations to use smart phones to access the material and limitations of internet connectivity to access the material. In addition, organisational and national level regulations related to mobile phone use on site significantly influence the technology adoption.

Keywords: health and safety, visual communication, visual learning, QR code, safety training, safe work procedures.

INTRODUCTION

Globally, the construction industry records high fatal and non-fatal accident rates compared to other industries. According to the European Commission, the construction sector in Europe recorded more than one in four (26.1 %) fatal accidents at work in 2009. In 2012, the USA construction industry reported about one fifth (19.6%) of worker fatalities (OSHA 2013). Given the industry's poor record, the Australian Work Health and Safety Strategy 2012-2022 has identified the construction

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industry as one of the priority industries for safety improvement (Safe Work Australia 2012).

Communicating health and safety in construction industry

Employers' responsibilities for health and safety (H&S) are mandated by law and include providing information to workers concerning H&S at the workplace. Responsibilities include providing adequate H&S training and communicating safety rules, policies, and procedures in a manner that can be understood by the workers. However, challenges exist in communicating H&S in the construction industry due to literacy barriers (Loosemore and Andonakis, 2007) and ethnic diversity (Brunette, 2005). Literacy barriers arise because construction workers have relatively low levels of educational attainment compared to workers in other industrial sectors (Loosemore and Andonakis, 2007). Communicating H&S is also believed to be difficult due to language and cultural differences within groups of migrant workers, so called hard-to-reach workers (Brunette, 2005). Globally, growing barriers to communication arise due to the increased involvement of migrant workers in construction projects. These challenges have been observed in the UK (Bust *et al*., 2008), the USA (Brunette, 2005), Australia and Singapore (Loosemore and Lee, 2002).

Are traditional H&S training methods appropriate for construction industry?
Research demonstrates that traditional H&S training methods are not particularly effective in the construction industry partly due to literacy and language barriers of learners, but also due to the educational approach underpinning this training (Wilkins, 2011). Pedagogical approach involved an *"expert"* instructor transmitting knowledge to recipients is arguably inappropriate and ineffective when applied to adult learning (Vella, 2002). We also acknowledge that communication is a complex problem in construction industry where the social factors such as workers' motivation, willingness and interest to take in information and cultural values (Hartmann 2006) also contribute to the communication problem in addition to the technological factors. Despite, as a technological solution, it is important that alternative and appropriate H&S training methods are developed and implemented in the construction industry. More specifically, Loosemore and Andonakis (2007) recommend conducting H&S training using multimedia and multi-languages.

An example of using technology to provide interactive and engaging H&S training is gaming. A gaming-based virtual construction site has been proposed as an effective method to achieve learning outcomes in construction H&S (Liaw *et al*., 2012). Gaming-based H&S induction training for construction workers was also proposed by Greuter *et al*. (2012). This game-based training covered hazard identification and hazard management/control and also linked productivity with H&S.

Are written H&S rules, policies, and procedures effective in communicating H&S in construction industry?
Traditional methods of communicating H&S rules, policies and procedures in construction utilise the written form. For example, Safe Work Method Statements (SWMSs) are mandated for high-risk construction work in Australia. While these documents are criticised for being overly long and complicated, Besnard and Greathead (2003) recommend that rules and procedures should not aim at being exhaustive but rather workable.

The combination of relatively low levels of literacy with possible language barriers and lengthy written statements about how work should be conducted create problems for comprehension. Hence, long written documents are arguably an ineffective means

to communicate H&S rules, policies and work procedures to construction workers. Bust *et al*. (2008) advocate that it is crucial to identify audio-visual methods that can effectively communicate construction H&S to workers employed in multicultural context to overcome these barriers.

Use of digital and mobile technology for communicating H&S

The provision of critical H&S information in visual form is an effective way to ensure that important information is communicated to workers whose levels of language and literacy may be low. One of the challenges in using alternative audio visual forms for communicating H&S to field based construction workers is how to disseminate learning resources and H&S procedures at the workplace so that workers can choose when they want to access them. Quick Response (QR) codes have been recently incorporated in accessing learning resources successfully (Bonifacio *et al*. 2012; Chaisatien and Akahori, 2007).

QR code technology for accessing learning resources
A QR code is a two-dimensional bar code. The use of QR codes has been popular as they became license free and with the increasing use of smart phones. Some examples of the use of QR codes to support learning and teaching are provided below.

Liu *et al*. (2010) developed a novel QR code and handheld augmented reality (AR) supported mobile learning (m-learning) system called Handheld English Language Learning Organization (HELLO). The HELLO system provides learning resources and functions to facilitate English learning for undergraduate students. Bonifacio *et al*. (2012) created a system to use QR Codes to access the elements of the periodic table. The periodic table with the audio description of elements is proposed as a learning resource for high school students and first year undergraduate students. QR codes have also been used to provide a lecturer support system (Chaisatien and Akahori, 2007). QR codes were attached to the posters displayed in the classroom to aid student learning. Other activities of this lecturer support system that used QR codes include student registration and theme registration. In the UK, the University of Bath encourages to use QR codes in education where a getting started guide for academics was developed (Ramsden, 2008).

Successful use of QR Code to access learning resources in number of disciplines indicates its potential to be a promising technology to access H&S information recorded in audio visual form. Adopting QR code technology as a critical information dissemination mechanism needs to carry a level of due diligence around choosing the right, secure and robust QR code generator platform, to ensure data transfer is reliable (not corrupted) and access is instantaneous.

RESEARCH METHODS

The CodeSafe system

The CodeSafe system has the potential to address some of the above challenges in communicating H&S and technical information to field based workers in construction industry. The CodeSafe system is a systematic method for capturing, representing and disseminating construction workers' tacit H&S knowledge in visual (film) format. The CodeSafe method addresses the need to change both organisational H&S delivery practices and workers' behaviour through the key elements given below.

22. Development of healthy and safe work tasks using workers' own tacit knowledge: The involvement of workers in writing, acting and producing films

reflects an engagement, rather than an enforcement orientation to H&S. The discussion on this element is out of focus of this paper. However, the details are available in Lingard *et al*. (2015).

23. Representation of H&S procedures and learning materials in video format: Films featuring colleagues showing the safe way to perform a task in the field may support the transfer of knowledge more effectively than traditional modes of training delivery. Filming workers undertaking tasks safely can be a more effective way of communicating H&S information (policies, rules and procedures) to construction workers than traditional written documents and manuals.
24. Use of QR code technology to improve the dissemination of critical H&S knowledge throughout the industry: The use QR code technology to disseminate video enables workers to access H&S information quickly and easily when they need to use it – particularly when they are at the work-site, at the point of task.

Research Question

The research sought to explore the effectiveness of the CodeSafe system in communicating H&S knowledge in construction industry. Particularly this paper focuses on the case study organisations that used the CodeSafe system to investigate the potential of the CodeSafe system in improving H&S.

The research initially conducted in-depth interviews with the managers of the organisations who directly involved in the CodeSafe's video-based intervention. Five managers were interviewed from four organisations. During the interviews, CodeSafe system's potential to impact on H&S performance of the organisation was questioned. Any available quantitative data and statistics were also collected subsequently.

In one case study organisation, field-based observation of workers engaged in video development was conducted together with the interviews of the workers. Five workers were interviewed who participated in the video development. It is acknowledged that this sample might be skewed because the workers involved in making the videos could be biased to have a positive perception. Workers' willingness to use the digital mobile technology and the CodeSafe system were also questioned. All the interviews were audio-recorded and transcribed before being subjected to content analysis.

This paper reports use of the CodeSafe system in the two CSOs. Where possible, quantitative data indicating the use and H&S statistics is also provided.

CASE STUDIES OF ORGANISATIONAL USE OF THE CODESAFE SYSTEM

Case Study Organisation 1 (CSO 1)

H&S challenge

CSO 1 was an alliance between a major construction company, engineering design firm and a government-owned statutory water authority. CSO 1 was responsible for improving, maintaining and expanding water storage systems and the distribution network for reliable and high-quality water.

CSO 1 developed a cultural change program to encourage workers at all levels within the organisation to act as drivers for improved H&S. A survey undertaken in the organisation at the same time that the CodeSafe system was developed, revealed that the workers preferred H&S requirements and procedures to be communicated as

demonstrations rather than as written procedure documents or SWMSs. The CSO 1 adopted CodeSafe system's engagement to develop mobile visual H&S procedures as a means to communicate H&S information more effectively.

Introduction of the CodeSafe system

CodeSafe initially developed two mobile visual procedures as a pilot, one for the use of a demolition saw and the second showing how to fit a rubber ring in a large diameter water pipe. CSO 1's H&S incident data was carefully examined to identify other areas in which visual procedures could be implemented to reduce the risk of accidental injury. CSO 1 developed a series of procedure-specific short videos which were made available to the workforce at point of task via QR code technology. These procedures included asbestos removal, dealing with chemical spills, working in a confined space, building a mobile scaffold tower, H&S aspects of electrical installations in construction, and the provision of site emergency information. All digitised visual procedures were distributed to workers using QR codes placed on relevant equipment and in the site sheds so that workers can access them using the smart devices such as phones and tablets. Social media, the organisation's intranet and USB sticks were also used to disseminate the visual procedures within CSO 1.

As a result of the CodeSafe's collaborative approach which engages H&S with technology, CSO 1 was awarded the Australian Water Association Water Industry Safety Excellence Award in 2012.

Impact Statistics: Video Usage Data Analysis

Figure 1 shows the video usage data of each visual procedure during the period of the CodeSafe system implementation in CSO 1. *"Number of hits"* represents the number of times each video was viewed to completion using a mobile device via scanned QR codes.

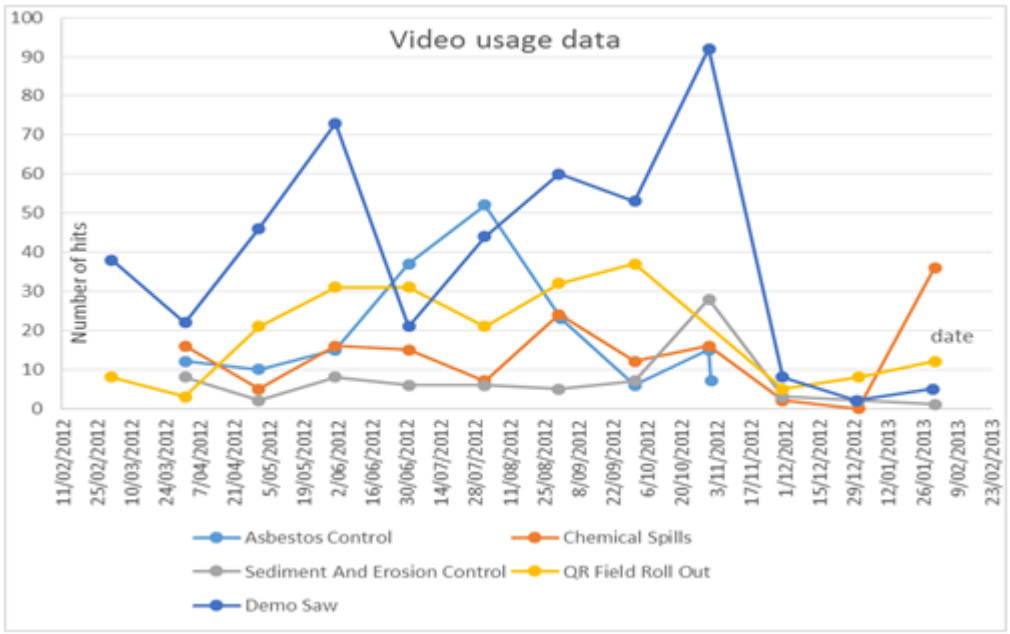

Figure 1: Video usage data in CSO 1

It is noteworthy that video usage fluctuated over time and some videos were viewed more frequently than others (e.g. demolition saw video). This may be due to certain activities ramping up and dropping off at different stages of the projects delivered across CSO 1. For example, the peak usage of the demolition saw video in November

2012 coincides with the receipt of the Australian Water Association Water Industry Safety Excellence Award, which may have prompted renewed interest in the video.

Perceived impact: Interview data
One manager of CSO 1 talked about the positive impact of the CodeSafe system in communicating H&S as, *"…the industry we have to become more visual in that communication so CodeSafe was a great emerging technology to deliver that instantaneously and I think discretely…"*

Another manager in CSO 1 who was involved in work procedure development also mentioned the ability to use CodeSafe's safe procedure related videos as a refresher training: *" … the benefit of, it's just refreshing people's memories on what the required procedure was."*

Case Study Organisation 2 (CSO 2)

H&S challenge
CSO 2 is an Australian company, which provides insulation and energy efficiency products for the residential and commercial building sectors. The vision for the business is to *"Safely Deliver Extraordinary Value to Our Customers"*. After reviewing organisational and industry incident data, CSO 2 identified the top risk areas (industry wide) that had the potential to cause a workplace fatality. These areas were electrical safety, working at heights, traffic management, mobile plant operation, and working in hot conditions.

Introduction of the CodeSafe system
CSO 2 initially used CodeSafe's consultative and collaborative approach in the development of visual procedures for electrical isolation and load restraint, trailer hitching and working in hot conditions with the residential installers. CSO 2 then engaged with commercial installers and construction supervisors on commercial sites to develop the visual procedures in the commercial sector. Qualitative analysis of the manager and workers' interview data evidence that the system has been very well received by workers.

Injury Rate Data
CSO 2's Total Recordable Injury Frequency Rate (TRIFR) data was analysed. Figure 2 shows the TRIFR data over a 12 months period. The figure shows a steady reduction in TRIFR that coincided with the implementation of the CodeSafe system at CSO 2 (indicated by the vertical line). [2] While it is not possible to draw any conclusions about causation, CSO 2 has reported an improved H&S performance since implementation of the CodeSafe system.

Impact Statistics: Video Usage Data Analysis
CSO 2's video usage data is shown in Figure 3. It is noteworthy that the video usage fluctuated over time and some videos were viewed more frequently than others were.

Activities of CSO 2 during the period of video usage data were investigated in order to understand the peak usage of video data. CSO 2 was invited to speak at an industry alliance forum in February 2014. The electrical isolation video was demonstrated there. In July 2014, the electrical isolation video was hosted in a state WorkCover authority website. In addition, the videos were used within CSO 2 to raise safety

[2] Without using a robust experimental design, it is not possible to establish a causal relationship between this injury rate reduction and the implementation of the CodeSafe system.

awareness of sub-contractor groups during the period of June 2014 to October 2014. The video usage might be affected by these organisational activities.

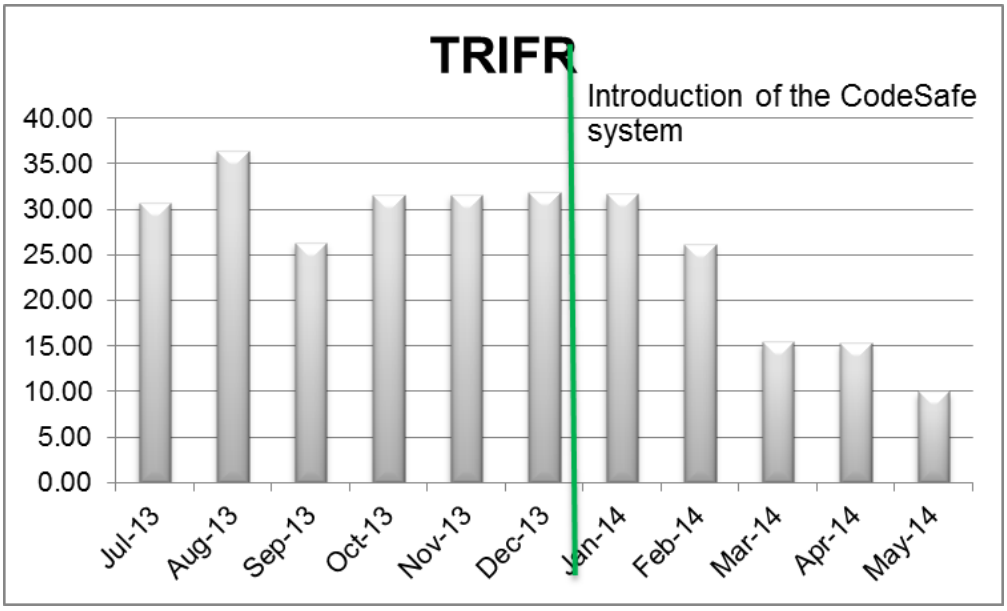

Figure 2: Total Recordable Incident Frequency Rate (TRIFR) for CSO 2 per million hours worked from July 2013 to May 2014

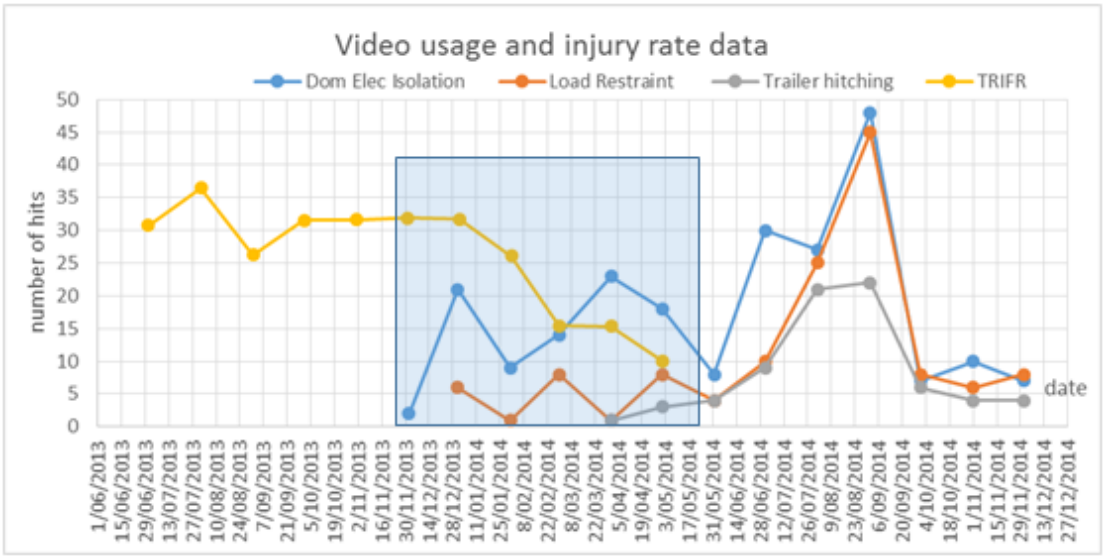

Figure 3: Video usage data and injury rate of CSO 2

Due to the limited overlap of the two datasets of injury rate reduction (TRIFR) data and video usage data (shown in blue colour window in Figure 3) the substantial decrease in injury rate is not possible to correlate with the video usage. Despite, it can be noted that workers' positive response to the CodeSafe system appears to continue.

Perceived Impact: Interview data

The manager of CSO 2 talked about the positive impact of the CodeSafe system in communicating training material:"…empowering the guys to understand the risks and to be able to communicate them … So the training is simple, the video itself is training support, and you follow the video…"

All workers in CSO 2 who involved in CodeSafe's digital intervention commented that presenting H&S information visually is more effective than using written

procedures. Participants commented that workers would be more likely to look at and understand videos than written H&S procedures.

Limitations of the CodeSafe System

Two limitations of the CodeSafe system in terms of accessing the H&S videos appeared through the interviews and are discussed below

Limitations to use smart phones to access the material.
The use of technology through the smart phones and willingness to access the H&S videos using workers' smart phone was investigated. The mixed responses received include a reluctance to use the personal mobile phone to access the material. The workers also proposed that the organisation provides a smart device (possibly with a larger screen than a phone) for each work group as a solution.

Positive response to use of smart phone as described by one worker is: *"… I don't think I know anyone that doesn't have a smart phone these days. .."*.

The other responses include willingness to use smart phone depends on the age, and the work environment (industry): *"… It's something that's fairly new, you know. People have old habits and it's like trying to teach an old dog new tricks…for older people I don't think, especially on a construction site, they're not going to get their smart phones out and, look at this industry, a lot of older people don't tend to have smart phones as well. But for the newer generation coming into the business I think it's a perfect way…"* However, the same worker thinks that the use of smart phone technology to provide H&S information would be effective for younger workers: *"But for the newer generation coming into the business I think it's a perfect way. I think it's a good move forward to having safety in the comfort of your pocket pretty much to access"*, The same worker suggests that organisation provides common devices with a larger screen to access information: *"… organisations could actually have like tablets, IPad's. We did a presentation today where we went out to a site and we just looked up on the iPad. So the screens a bit bigger and it means that guys can huddle around you as well, you're not sort of huddled in front of the phone."*

Another worker expressed the concern that many people do not use smart phones at construction sites. He described how he *"had a smart phone and it got broken on a building site and they're very expensive."* He now uses a basic mobile phone and continued: *"so my only concern would be – and I know a lot of people who are the same – they don't use smart phones on construction sites because they are delicate things."* However, the same worker described how this problem could be overcome because the supervisors usually have smart phones and/or tablets that could be provided for each workgroup to enable them to view H&S video content at toolbox sessions and as required.

Limitations of internet connectivity to access the material.
Even though the convenience of the CodeSafe system of being able to view the content in the field was noted some concerns were also raised around limited network coverage to access the material. Issues related to inadequate network coverage in remote sites and signal reception problems in a basement are among them.

For example, one worker commented that although he had never considered accessing information in the field using his smart phone before: *"But it is a good way of – rather than trying to call up the office [for information] you've got it there in your pocket pretty much."* However, another worker commented on connectivity problems experienced on site as a possible limiting factor to workers being able to access

CodeSafe system's content: *"It's a bit difficult sometimes being in this basement so you don't get any reception."*

In addition to the barriers revealed through interviews, wider adoption of the technology could be significantly influenced by the organisation and/ or national regulations and policies relevant to mobile phone use on sites. For example, in the UK use of mobile phones is becoming restricted which may hinder the adoption of CodeSafe system.

DISCUSSION AND CONCLUSIONS

To overcome the challenges around limited internet connectivity to access the material, CodeSafe supplied the visual procedures to workers on a Universal Serial Bus (USB) in some organisations. The aim of this was to enable viewing of the videos on demand on a laptop carried by the organisations' managers/supervisors.

We recommend that using information on a USB device, constraints the innovation of the CodeSafe system of accessing learning material using QR codes. In addition, it restricts the availability of information and potential to access knowledge freely. For example, experienced workers might not be comfortable going to a common laptop to access knowledge (feeling embarrassed that they did not possess know-how knowledge) as they would be accessing it on their personal phone privately.

Despite the above limitations, the comments made by the workers and managers who directly involved in making the videos indicated that the CodeSafe system's use of digital video and mobile technology was a convenient and efficient method to communicate H&S to workers. In addition, the video usage data evidence that the workers are watching the video content. The technology could be more effectively implemented in future by considering workers' age, phone use habits, provision for training and provision for devices.

However, due to the methodological limitations of the skewed and small sample, it is not possible to generalise whether the method is effective. There is a need to do further research with a larger sample that includes workers who were not directly involved in making the films to investigate the usefulness and effectiveness of the system.

The quantitative performance data available in the case study organisations were limited. It is therefore not possible to ascertain whether the use of the CodeSafe system produced an improvement in H&S performance in the organisations involved in this research. Hence, even though a continuing usage of video was observed, without using a robust experimental design, causal inferences cannot be made based on the limited quantitative data available.

Future research could also adopt a rigorous experimental approach to analyse the effectiveness and impact of the CodeSafe system to examine the cost-benefit analysis of using this type of digital and mobile technology together with social factors that affect the communication problem such as the workers' motivation, willingness and interest to take in information and the cultural values.

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