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The Impact of Introducing Video Monitoring Systems (CCTV, Body Cam) in Construction Sites on Worker Safety Behavior and Accident Prevention: A Study on Effectiveness and Sustainability

Sung-Hoon LEE¹, Won-Mo GAL², Seung-Hyuck PARK³

1. First Author Researcher, Department of Environment Health & Safety, Eulji University, Korea.

Email: tiptop1@naver.com

2. Co-Author Professor, Department of Environment Health & Safety, Eulji University, Korea.

Email: wongal@eulji.ac.kr

3. Corresponding Author Researcher, Department of Environment Health & Safety, Eulji University, Korea,

Email: janghoon0301@naver.com

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Abstract

The purpose of this study is to verify the practical effectiveness and sustainability of accident prevention through the introduction of video monitoring systems, such as intelligent CCTV and body cams attached to signalers/workers, in construction sites. In particular, this study aims to investigate whether the introduction of such technology increases workers' compliance with safety regulations and how this effect changes over time specifically, the occurrence and dissipation of the 'Hawthorne Effect'. Existing literature and data analysis indicate that while the introduction of smart safety equipment (CCTV, AI integration, etc.) significantly reduced site disaster rates (e.g., an average reduction of approximately 23%), the behavioral change effect induced by monitoring tended to decrease after a specific period (e.g., about 8 weeks). Furthermore, it was confirmed that if the monitoring system is combined with a 'punitive culture,' it can lead to adverse effects such as a decrease in 'near-miss' reporting and the concealment of hazardous behaviors. Therefore, this study, focusing on actual cases, utilizes pre- and post-indicators to suggest that monitoring systems can achieve sustainable and positive accident prevention effects only when utilized as tools for 'data analysis' and 'real-time feedback' beyond simple 'surveillance and control'.

Keywords : Video Monitoring, Body Cam, Unsafe Behavior, Hawthorne Effect

1. Introduction

The construction industry is classified as a high-risk group with a high rate of serious accidents compared to other industries. Governments and companies are investing enormous human and financial resources to prevent serious accidents, and recently, the introduction of

'smart safety equipment' combined with IoT and AI technology has been actively taking place. In particular, CCTV (including intelligent AI) that monitors the entire site and body cams that secure the view of guides or signalers are the most notable technologies. These video monitoring technologies go beyond simply securing evidence in the event of an accident; they allow for the

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expectation of effects such as detecting workers' unsafe behaviors in real-time through AI (e.g., detecting failure to wear safety helmets or safety belts) and inducing workers to comply with safety regulations themselves. However, the question of how much these technologies actually contribute to accident prevention and whether the behavioral changes caused by the perception of 'being monitored' are sustainable is a very important issue. Accordingly, this study aims to answer the following two core questions:

- 1) Does the introduction of video monitoring systems (CCTV, black boxes, body cams) help prevent accidents at construction sites?
- 2) How long does the safety behavior change effect (Hawthorne Effect) of workers caused by video monitoring last? Furthermore, are there any adverse effects?

2. Accident Prevention Effectiveness of Video Monitoring Systems

The evaluation of whether video monitoring systems help prevent accidents is positive. For example:

1) Disaster Rate Reduction Statistics: According to the 2024 announcement by the Ministry of Land, Infrastructure and Transport and the Korea Authority of Land & Infrastructure Safety, the disaster rate of small and medium-sized construction sites (123 sites) that received support for smart safety equipment such as intelligent CCTV decreased by an average of 23% compared to sites that did not. This is an important basis for showing that video-based monitoring has a statistically significant impact on accident prevention.

2) Real-time Hazard Detection: Intelligent CCTV contributes to the preemptive removal of risk factors before an accident occurs by having AI analyze non-wearing of safety helmets, falls, access to dangerous areas, and signs of fire in real-time and sending immediate warnings.

3) Post-Analysis and Education: Body cam or CCTV footage can be used to clearly identify the cause of 'near-misses' or actual accidents, serving as data for retrospective reviews and educational materials.

3. Sustainability of Monitoring Effects: 'Hawthorne Effect' and Adverse Effects

Regarding the sustainability of the initial effects of introducing video monitoring systems, the 'Hawthorne

Effect' acts as an important variable. The Hawthorne Effect refers to a phenomenon where people temporarily change their behavior in a positive direction, unlike usual, when they perceive that they are being observed. When CCTV, black boxes, or body cams are first introduced to a construction site, workers comply with safety standards more strictly due to this effect.

The duration of this Hawthorne Effect is not permanent; according to related research, it appears greatest during the first 4 weeks, decreases during weeks 5 to 8, and tends to diminish to a negligible level after 8 weeks. However, if it stops at simple monitoring, it causes negative impacts (Negative Impact). First, it leads to a failure to improve overall safety management levels and the creation of erroneous safety data by inducing more dangerous unsafe behaviors, such as not fastening safety hooks in places where there is no monitoring, such as CCTV blind spots. Second, the reporting rate of 'near-misses' may decrease. Workers fear that the video will remain as 'evidence footage' of their mistakes and lead to disadvantages, making it impossible to secure the most important data (near-misses) to identify potential risk factors on site. When the monitoring system is combined with a 'punitive culture' rather than a 'safety culture,' workers may choose 'silence'. Furthermore, being conscious of the body cam itself can cause workers to miss changes in the important surrounding environment, unsafe conditions, or hazard detection, or such monitoring can cause severe stress, which may actually increase the rate of safety accidents.

4. Incentive Plans to Increase 'Near-Miss' Reporting Rates

Increasing the reporting rate of 'near-misses' is key to overcoming the negative impact ('silence' culture) of introducing monitoring systems and building a sustainable safety culture. The following specific incentive plans are proposed to induce near-miss reporting to lead to 'improvement' rather than 'punishment':

1) Monetary and Material Incentives

Provide direct motivation by differentiating payments according to the speed and quality of reporting to maximize motivation.

① **Immediately Reward System:** Vouchers or coffee coupons, which can be used immediately on-site, are provided to workers who discover and immediately report a near-miss. This immediately connects the reporting behavior with a positive experience.

② **Graded System by Reporting Quality:** Rather than just counting the number of reports, 'excellent near-miss

cases' that include high potential risk or improvement plans are selected to be awarded higher reward amounts than general near-miss reports (e.g., 100,000 KRW vs. 50,000 KRW).

③ **Safety Mileage/Point System:** Points are awarded for reporting near-misses, participating in safety training, and risk removal activities, which can be exchanged for vouchers to purchase desired goods such as high-quality personal safety equipment (safety shoes, etc.), appliances, or bicycles.

2) Non-monetary and Recognition-based Incentives

Recognition-based incentives contribute to increasing workers' psychological safety and spreading a culture of recognition within the organization (site).

① **Selection of 'Excellent Worker of the Month':** Every month, the worker who reports the most or most significant (high-risk) near-misses is selected as 'Excellent Worker of the Month'. They are awarded certificates and prizes at Safety Day events, posted on site bulletin boards, officially recognized at strategic headquarters meetings, and given certificates under the company name.

② **Improvement of Work Environment:** Provide non-monetary benefits such as dedicated parking spaces on-site or access to premium lounges for workers with excellent cumulative reporting records.

③ **Direct Feedback from Management:** When a reported near-miss leads to actual site improvement, the site manager or headquarters executives personally acknowledge and thank the worker to increase the value of the report.

3) System and Process-based Incentives

Strengthen the meaning of reporting by transparently showing that the reported content is causing actual change.

① **Transparent Feedback System:** When a near-miss is reported, the entire process—reception, cause analysis, completion of improvement measures, and notification of the result to the reporter—is disclosed transparently, and improvement results are clearly shared. The experience that one's report changed the site can be the most powerful motivator.

② **Anonymity Guaranteed:** Ensure that the reporting channel is primarily anonymous so it never leads to disciplinary action or disadvantages, and clearly announce and promise that reported data is used only for 'risk factor analysis and improvement'.

③ **Provision of Safety Training Opportunities:** Appoint excellent near-miss reporters as instructors for

worker safety training or TBM leader training, providing them opportunities to teach their experiences and improvement plans to colleagues to strengthen workers' sense of responsibility and ownership.

These incentive plans will play an important role in shifting the effect of introducing monitoring systems from a temporary 'Hawthorne Effect' to sustainable 'safety culture improvement'.

5. Solving Sustainability Issues: From 'Surveillance' to 'Data Utilization'

According to the above analysis, simply "surveillance" of workers makes it difficult to expect fundamental and long-term accident prevention effects. Therefore, "installing CCTV, black boxes, or body cams alone is not enough. How the collected data is utilized is more important to maintain a low accident rate even after the Hawthorne Effect disappears.

5.1. Research Results

Research Subjects: comparative study was conducted by selecting three construction sites with similar sizes and characteristics.[Table 1]

Site A: Video monitoring technology not applied

Site B: Only CCTV applied (simple monitoring and recording purposes)

Site C: CCTV + Black box + Signaler/Guide body cam applied + Utilization of collected data for feedback and education

5.2. Survey Questions and Responses (Psychological Burden)

Total Respondents: 30 people (10 people per site)
Psychological Burden of Workers According to Video System Introduction (Likert Scale)[Table 2]

- Scale 1 – Not at all
- Scale 2 – No
- Scale 3 – Neutral
- Scale 4 – Yes
- Scale 5 – Very much so

Table 1: Trends in Safety Indicators After Introduction of Video Systems

Metric	Measurement Result					
	Site A		Site B		Site C	
	Before	After	Before	After	Before	After
Monthly 'Accident Count' LTIR	0.01	0.005	0.02	0.01	0.01	0.00
Safety Compliance Rate (Corrective Action Requests)	50	20	30	12	27	15
Near-Miss Reports	25	10	17	7	11	5
Worker Survey (Psychological Burden)	3	5	2	4	3	5

*LTIR (Lost-Time Injury Rate), Number of lost-time accidents per 200,000 working hours.

Table 2: Trends in Safety Indicators After Introduction of Video Systems

No.	Survey Question (Psychological Burden Measurement Item)	Mean Score	Standard Deviation
1	I feel stressed by the feeling of being watched due to the video system.	4.25	0.72
2	After the introduction of the video system, behavior is inhibited and it is difficult to concentrate on the task.	3.88	0.95
3	I feel anxious that video recording might infringe on my privacy.	3.10	1.15
4	I worry that video records will be used as evidence for disciplinary action or disadvantages later.	4.51	0.58
5	Relationships with colleagues have become uncomfortable due to the video system.	3.65	1.05
6	I feel excessive tension or pressure for fear of making a mistake.	3.25	1.01
7	Distrust of the company/manager has increased after the introduction of the video system.	2.21	0.98
8	The fact that every single one of my actions is recorded is mentally fatiguing.	3.82	0.96

5.3. Interpretation of Results

5.3.1. General Interpretation

The survey results show that workers feel a significantly high level of psychological burden regarding the introduction of video systems. In particular, items related to 'concern about disciplinary action/disadvantage' and 'surveillance stress' recorded mean scores in the 4-point range, suggesting a very serious level. On the other hand, 'distrust toward the company/manager' appeared relatively low.[Table 3]

5.3.2. Key Implications

Workers perceive this system more as a punishment and disciplinary tool rather than a safety tool, which is the core factor of psychological burden. Additionally, 'surveillance stress' and 'work inhibition' appeared high, suggesting the system could negatively affect workers' autonomy and productivity. Although 'distrust' toward the company or

manager appeared low, the relatively large concern about disciplinary action (4.51) indicates an urgent need for clear communication and trust-building by managers regarding system transparency and usage purpose.

5.4. Analysis of Psychological Burden of Construction Site Signalers/Guides Regarding Video Systems (CCTV, Black Boxes, Body Cams)

Construction site signalers and guides may feel a much larger psychological burden due to the introduction of video systems than general workers. This is because their work is directly linked to site safety, and they become the main subjects of monitoring and core entities for identifying responsibility.

Table 3: Detailed Interpretation by Item

No.	Survey Question (Psychological Burden Item)	Mean	S.D.	Interpretation
4	Worry about video being used as evidence for disciplinary action.	4.51	0.58	Highest burden factor. Workers perceive the system's purpose as 'punishment' rather than 'safety'. (Very strong agreement)
1	Stressed by the feeling of being watched.	4.25	0.72	Second highest factor. The system is perceived as 'surveillance' rather than 'observation', causing high stress.
2	Behavior is inhibited and difficult to concentrate.	3.88	0.95	High mean. Concerns about surveillance and punishment lead to psychological withdrawal, potentially affecting productivity.
8	Mentally fatiguing that every action is recorded.	3.82	0.96	High mean. Indicates that the recording environment itself causes chronic mental fatigue.
5	Relationships with colleagues became uncomfortable.	3.65	1.05	Above 'Neutral'. Suggests the system induces tension or distrust in social relationships at work.
6	Excessive tension or pressure for fear of mistakes.	3.25	1.01	Slightly above 'Neutral'. Indicates work-related pressure from the fear that minor mistakes will remain on record.
3	Anxiety about privacy infringement.	3.10	1.15	Mean is 'Neutral' but standard deviation is highest. Indicates large individual differences in perception of privacy.
7	Distrust of company/manager has increased.	2.21	0.98	Lowest burden factor. Suggests the system did not directly increase 'distrust' or acts independently of it.

5.4.1. Pressure of 'Passing the Blame' and 'Proof' in the Event of an Accident

The biggest psychological burden signalers/guides face is the anxiety that video records will capture their mistakes and be used as a basis for responsibility in the event of an accident. When an accident occurs, the appropriateness of signals from the signaler or guide, who has final authority over equipment movement, is analyzed first. Video records permanently fix every action and signal timing of the signaler/guide, making it impossible to avoid being held accountable if a mistake is made. The obsession that "I must not make a mistake" becomes extremely high, and the concern that minor signal errors or judgment mistakes will be recorded and become evidence for later disadvantages leads to a state of excessive tension. Even if an accident occurred due to equipment operator negligence or another worker's sudden action, they worry that the video will be used to find 'insufficient signaling or control' rather than exonerating the signaler/guide.

5.4.2. Increased Mental Fatigue due to Constant 'Surveillance'

The work of signalers or guides requires high concentration near heavy equipment, and video systems can interfere with maintaining this concentration. CCTV or black boxes focus on filming the area around heavy equipment, and body cams are either worn by or located near the signaler or guide themselves. The signaler knows they are the most detailed target of recording. Moreover, behavior is inhibited for fear that taking a short rest, stretching while waiting, or communicating via personal calls or words will be recorded as 'insincere work attitude'. Also, the addition of 'constant recording' to the tension

already caused by high responsibility can induce severe mental fatigue (Burnout). This can lead to a vicious cycle of decreased concentration and an actual increase in safety accident risks in the long term.

5.5. Increased Sensitivity to Privacy Infringement and Human Rights Issues

In the case of body cams, since they are attached to the signaler or guide's body (mainly the chest area) and record all working hours, concerns about privacy infringement are more specific and significant. Anxiety is felt that personal conversations or break times might be recorded if the boundary between when the body cam is on and off becomes blurred. Furthermore, the fact that a signaler or guide is wearing a body cam can lead fellow workers to perceive them as an 'information leaker' or 'monitor', risking damage to trust among colleagues.

5.6. Psychological Duality when Recognizing Positive Effects

Even if they sympathize with the positive aspects (e.g., reduction in actual safety accidents, resolution of unfair misunderstandings), the burden on signalers or guides remains and causes conflict. They conflict within the contradictory feelings of "It will help safety, but I am afraid I will face disadvantages." The stress from the gap between the purpose of the video system (accident prevention) and the increase in personal burden is significant.

6. Conclusion

The introduction of CCTV and body cams at construction sites clearly has a positive impact on accident prevention (23% reduction in disaster rates). However, the initial behavioral improvement effect ('Hawthorne Effect') caused by workers perceiving surveillance is likely to decrease gradually, and if combined with a 'punitive culture' such as 'One Strike Out' for violations, it can lead to negative side effects like the concealment of risks and silence on near-miss reporting.

Therefore, for these advanced video monitoring systems to become 'sustainable safety management tools' rather than just 'temporary control measures,' 'data-based safety management' is essential. This involves analyzing collected data to derive 'most repetitive unsafe behavior patterns,' warning of risks in real-time, and providing immediate feedback like TBM through customized safety training materials based on post-cause analysis. In other words, the long-term success or failure of accident prevention is determined by the positive way technology is utilized and an open organizational culture where risks can be reported freely, rather than the introduction of smart technology like AI itself.

Summarizing the results of this study, a fundamental paradigm shift in operational purpose and utilization methods is required for video monitoring systems to contribute to long-term accident prevention without staying at a temporary Hawthorne Effect or causing serious adverse effects. Accordingly, specific guidelines for transitioning simple monitoring systems into sustainable safety management tools are suggested as follows:

First, re-establishment of purpose and utilization. The primary purpose of the video monitoring system should not function as a means to 'punish' or 'control' workers. Instead, its purpose should be clearly redefined as a data tool to collect basic materials for 'education' and 'improvement' for safety and disaster prevention. Furthermore, misuse of data for purposes unrelated to safety must be strictly prohibited. For positive utilization, a system should be built to systematically derive 'unsafe behavior patterns' through AI analysis and provide immediate feedback to the site by developing customized training materials (TBM).

Second, worker psychology must be 'externalized' rather than 'silenced'. Workers' psychological concern that the system will be used as 'evidence for disciplinary action' (average 4.51) acts as psychological pressure inducing 'silence,' reducing near-miss reports that identify potential risks. To overcome this side effect, site managers must introduce incentive systems that transition 'near-miss' reporting from a target of discipline to a target of reward.

Near-miss data secured by inducing voluntary reporting can be utilized as core information for improving safety culture.

Third, the manager's role should not be 'over-reliance on technology' but should lead to improvement activities based on data. Over-reliance on technology, such as "AI does it all," can lead to manager negligence in site management, which is a major risk factor.

Managers should perceive AI-based systems as 'supportive tools' rather than simple 'monitors'. The manager's core role should be to judge complex risks that AI might miss and proactively focus on data-based improvement activities to remove fundamental risk factors based on collected data. This can drive the long-term success of technology introduction. In other words, the successful settlement of video monitoring systems depends on the purpose of utilization and efforts to secure transparency, rather than the technology introduction itself. Furthermore, transitioning the system from a tool for punishment or discipline into a tool that promotes education and safety culture is key.

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