BALANCING SAFETY AND SURVEILLANCE: OPTIMIZING WEARABLE TECHNOLOGY INTEGRATION IN CONSTRUCTION WHILE ADDRESSING PRIVACY AND TRUST CONCERNS

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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"It is not the technology itself, but

how we choose to use it, that shapes our future."

- *Marshall McLuhan*

Introduction

Construction remains one of the most dangerous industries with employees facing hazards daily. Exposure on-site ranges from hazards such as falls and trips to electrocution and exposure to hazardous materials. In the United Stated in the year 2022, approximately 20% of workplace related deaths happened on construction sites, with 38.4% of those deaths resulting from falls, slips, and trips (U.S. Bureau of Labor Statistics, 2024). Despite advancements to safety regulations and equipment, injuries and fatalities happen too often, emphasizing the need for continuous innovation in workplace safety.

In recent years, promising advancements to mitigate these risks include wearable technologies, such as smart helmets, sensor-equipped vests, and location-tracking devices. These tools monitor workers' conditions in real-time with features like fatigue detection or exposure alerts and are able to notify management personnel when intervention may be necessary. Everyday devices like smartwatches and fitness trackers, which many people wear to stay on top of their health, can track vital signs like heart rate and body temperature to help prevent issues such heat exhaustion and dehydration (American Institute of Contractors, 2024). Construction companies are increasingly prioritizing worker safety; therefore, the adoption of wearable technology has gained momentum as a proactive measure to reduce workplace related incidents.

Figure 1

Examples of Wearable Safety Technologies Used in Construction

Note. This figure shows examples of wearable technologies designed to enhance worker safety in the construction industry, including smart helmets, posture sensors, gas detectors, GPS trackers, and biomedical monitors. Adapted from *Federated Transfer Learning Enabled Smart Work Packaging for Preserving Personal Image Information of Construction Worker* by X. Li, H. Chi, W. Lu, F. Xue, J. Zeng, & C. Z. Li, 2021, *Automation in Construction, 128*, Article 103738. https://doi.org/10.1016/j.autcon.2021.103738. Copyright 2021 by Elsevier.

While these technologies have the ability to enhance worker safety, their integration is not without challenges - among them the most pressing being worker privacy. Many construction

workers express discomfort with constant monitoring, fearing that the data being collected could be used beyond its intended purpose of safety but also for productivity tracking, disciplinary action, or even employment termination. A report by the U.S.Government Accountability Office (GAO) warns that “monitoring devices can store data on employee physiology and movements, which may create privacy concerns” (U.S. Government Accountability Office, 2024). Without the right protections in place, such surveillance can weaken trust and hinder adoption.

Activist groups like *The Yes Men* have explored the conflict between safety and surveillance. In one of their stunts, they impersonated Finnish officials promoting mass surveillance as a solution for global issues, offering an exaggerated but notable critique of how efficiency can be used to justify invasive monitoring (The Yes Men, 2012). Similarly, Andrejevic (2010) argues that the normalization of workplace monitoring can reinforce existing power imbalances, showing how tools meant for protection can easily become mechanisms of control (p. 279). Both the performance and research underscore the need for transparent data policies and trust-building strategies between employers and employees.

Throughout this paper I will examine the intersection of safety, privacy, and technology acceptance in the construction industry. Using the Technology Acceptance Model (TAM) as a framework, this study analyzes how perceived usefulness, ease of use, and privacy concerns influence workers’ willingness to adopt wearable safety devices. Through case studies and interviews, this study will explore strategies for fostering trust and privacy concerns, arguing that the successful integration of wearable technology is dependent on ethical data management and worker engagement. Addressing these sociotechnical barriers is essential for construction firms to optimize wearable technologies to achieve their safety capabilities without sacrificing worker privacy and trust.

Problem Definition

What We Know: The Benefits of Wearable Technology for Safety

As we now know, the construction industry remains one of the most dangerous work environments with consistently reported high rates of injuries and deaths. Despite the ever changing safety regulations and protocols, traditional measures often fail to prevent accidents in real time. As a response to address this gap, engineers and safety officials have collaborated to introduce wearable technologies such as smart helmets, sensor-equipped vests, and GPS-tracking wristbands that provide real-time monitoring, hazard detection, and automated alerts (Awolusi et al., 2018).

These technologies are designed to reduce risk by collecting biometric and locational data that can be used to anticipate and prevent accidents. Choi et al. (2017) demonstrate how smart vests embedded with physiological sensors and GPS tracking can help reduce risks associated with falls, fatigue, and wheat exposure. Similarly, Kim et al. (2024) conducted a study and found that wearable devices enhance safety compliance by allowing for early intervention in cases of stress or exhaustion. Their review of many scholarly studies concludes that "physiological responses offer unique insights into human perception, cognition, and intention, which have been found to make significant contributions to accidents in construction job sites" (Kim et al., 2024). These findings directly support the argument that wearable safety technologies have life-saving potential in the construction sector.

What We Do Not Know: Gaps in Understanding Worker Hesitation and Privacy Concerns

Despite strong evidence from research supporting their benefits, wearable technologies have not been widely adopted across the construction industry. A major factor of this reluctance

is worker concern over privacy and data misuse. Employees worry that biometric and locational data, although collected for safety, may be leveraged by their employers for performance tracking, disciplinary action, or even termination (Choi et al., 2017). One peer-reviewed study warns that "workers are hesitant to adopt technology due to identity disclosure and related data privacy issues" (Tabatabaee et al., 2022, p. 5).

Intensifying the issue is the lack of consistent data governance across the industry. While some companies offer clear and transparent policies outlining how wearable data is collected, used, and stored, many do not, which leaves workers uncertain of their rights and protections. Moreover, trust between employers and their employees plays an important role in shaping attitudes toward wearable technology and its acceptance in the workplace. During a study conducted on the Nigerian construction industry, Ibrahim et al. (2023) found that "professionals in the Nigerian construction industry are aware of the inherent advantages of using technologies; however, they rarely adopt technologies that could enhance performance" (p. 18). This gap in trust shows that developing and distributing these devices are not enough; however, construction firms must address the sociotechnical challenges that surround them.

Gap in Knowledge: Balancing Privacy Concerns and Safety Benefits

Many studies acknowledge both the safety benefits and ethical barriers to wearable technology adoption, yet few offer concrete solutions to understand how privacy concerns should be addressed without compromising safety goals. This gap in research is especially relevant in construction, where jobsite risks coexist with deeply rooted concerns about privacy and constant surveillance.

The Technology Acceptance Model (TAM) provides a useful framework for analyzing the factors that influence workers' willingness to accept and use new technologies. TAM was

originally developed by Davis (1987) to understand an individual's likelihood to adopt new technologies. The model has two core components which are perceived usefulness (PU) and perceived ease of use (PEOU). However, Keil et al. (1995) point out that "no amount of PEOU will compensate for low usefulness" and in this case, fears of surveillance and data exploitation could compromise the use of wearable tech (Lee et al., 2003, p. 759). This study builds upon the Technology Acceptance Model (TAM) by incorporating trust, transparency, and data ethics as factors that influence technology acceptance and adoption in high-risk industries.

Further research is necessary to identify how companies can implement wearables while also protecting worker privacy and fostering trust. Exploring trust-building like transparent data policies, clear opt-in procedures, and worker participation in decision-making may bridge the gap between innovation and implementation.

This paper uses TAM as a foundational framework, while also addressing its limitations in the context of wearable safety devices. Through case studies and qualitative research, this study examines how perceived usefulness, perceived ease of use, and privacy concerns intersect in shaping the adoption of wearable safety technology. The overarching goal is to improve workplace safety without sacrificing worker morale, trust, and autonomy.

Research Approach

This research applies the TAM as the foundational theoretical framework to analyze how construction workers adopt or resist wearable safety technologies. TAM was originally developed by Davis (1987) to identify two core components that influence user acceptance: perceived usefulness (PU) and perceived ease of use (PEOU). PU refers to whether workers believe wearable devices enhance their personal safety on the job, whereas PEOU regards how easily and intuitively workers can incorporate the technology into daily activities. However, Lee

et al. (2003) states that these factors alone are not sufficient enough in cases where ethical concerns and trust play central roles in adoption. In response, this study expands TAM by integrating privacy concerns as an additional aspect to allow for a deeper exploration of the sociotechnical barriers that influence workers' decisions.

Many scholars suggest that trust and transparency are pivotal in determining whether surveillance-related technologies are accepted in workplace environments. For example, Andrejevic (2010) explains that "privacy debates thus come to stand in for discussions that might more directly address the question of who controls the information infrastructure and for what ends" (p. 279). This research utilizes that insight by analyzing how ethical data policies, communication strategies, and privacy assurance affect the recognized validity of wearable tech in construction.

To accomplish this analysis, the research combines case studies, interviews, and reviews of academic literature to identify both barriers and solutions to adoption. Case studies of construction firms currently implementing wearable safety devices will be used to assess how companies establish their data policies, manage ethical considerations, and communicate with workers. Ibrahim et al. (2023) show that companies who clearly articulate how data is collected and used experience higher acceptance among workers compared to those who fail to do so. These cases will be used to examine organizational practices related to policy transparency, data protection, and worker engagement.

Additionally, this study includes interviews with construction industry professionals, ranging from small residential operations to large commercial firms. To gain unique perspectives and comprehensive insights from both ends of the spectrum, participants include Melissa Colbert and an employee from a small-scale firm, as well as multiple employees, managers, and safety

personnel from the Whiting-Turner Contracting Company, a national commercial contractor. These interviews will explore workers' experiences with safety technology, including their perceptions of safety benefits, concerns about surveillance, and trust in employer intentions. Awolusi et al. (2018) note that "wearable technologies offer a non-intrusive solution that provides objective, real-time data that can be used to make efficient and proactive decisions" (p. 98), which is an idea this research aims to explore through qualitative analysis of participants' responses.

Interview responses along with academic literature on surveillance, data privacy, and workplace technology adoption will apply the triangulation method to this research. Conducted studies suggest that workers' uncertainty surrounding wearable tech is often grounded in worry of constant monitoring and a lack of control over personal data (Choi et al., 2017). If evidence stands true, the personal interviews will show some of the same concerns from individuals. This study will test whether such concerns are present on current job sites and investigate how different approaches to implementation affect employee response.

Ultimately, this approach aims to create practical, ethically sound recommendations for construction firms that intend to introduce wearable safety technology. By utilizing these research methods, this study calls attention to how important sociotechnical considerations are to the success or failure of technological innovation in high-risk industries.

Results

This study builds on existing literature by analyzing how construction professionals perceive the implementation of wearable safety technology. Two key findings emerged from the interviews. The first is that transparent data policies significantly reduce worker resistance to these wearable devices, and the second is that training programs emphasizing safety benefits can

encourage increased acceptance and trust. These themes were consistent across both field and managerial-level participant responses.

A common concern raised by participants was data privacy specifically pertaining to how the collected information from wearables would be stored, how it would be used, and who would access it. Many of the participants emphasized that transparency is essential for worker buy-in. One project engineer, Molly Lee, noted “100% transparency. A worker shall be able to view the entirety of the data taken for that specific person and must be “entitled to review and ask questions about any specific data with those who are collecting it.”

Others highlighted the necessity for ethical data practices. An Environmental, Health, and Safety (EHS) Manager, David Lagueux, stated, “Transparency is paramount. If the employee feels you are being untruthful, good luck regaining their trust.” This thought aligns with Tabatabaee et al. (2022), who discovered that a lack of clear data policies significantly lowers adoption rates in construction safety programs.

Another consistent trend was concern over continuous monitoring outside of work hours. Superintendent Michael Mitchell warned “Tracking software would be a concern as the PPE (Personal Protective Equipment) used onsite is generally taken home with the workers on a daily basis. How is that information not being tracked during personal times?” Such insights show the importance of establishing off-hours boundaries and clear consent protocols which allows firms to proactively build trust.

Workers' perceptions shift from surveillance to protection when they are knowledgeable and understand to the full extent how wearable technologies directly improve safety. One participant explained that these tools should not be framed as a replacement for hazard awareness but rather “a tool…that may be used to supplement their tasks” and reduce risk in real-time.

Several participants cited scenarios that wearables could be particularly valuable in addressing OSHA's "Fatal Four" hazards - falls, struck-by incidents, electrocutions, and caught-in-between accidents - which together account for 60% of construction worker fatalities (Texas Department of Insurance, 2024).

One field engineer emphasized the need for trial period and proof-of-concept demonstrations by stating "an onsite trial process to test out the technology." Others suggested worker consent forms and opt-in programs, so workers could understand what data is being collected and for what purposes.

Training is central to any safety protocol that is implemented on the jobsite. These devices are no different and such programs have the potential to change the narrative. Tabatabaee et al. (2022) state that "proper technical training for workers and owner involvement are essential to prudently work with sensors functionalities (both workers and supervisors)." (p. 5) Interview responses strongly agreed with this. Participants indicated that highlighting the contributions to safety of wearable devices, such as preventing overexposure to heat, alerting to unsafe oxygen levels, or determining appropriate levels of hearing protection, would make workers more receptive to adoption.

Summary of Results

The results in Table 1 indicate that wearable safety technology is most effective when companies prioritize implementing clear, ethical, and transparent data policies that focus on educating workers about how the technology enhances their personal safety on the job.

Table 1

Summary of Interview Results: Themes and Participant Quotes

Theme	**Participant Quotes**	**Sources' Job Position**
Data Transparency and Access	"Whoever is wearing the technology should be aware of the information that others are gathering from them."	Judd Garner (Field Engineer)
Consent and Opt-in Expectations	"The worker themselves would have to consent…HIPAA references to confirm confidentiality."	Molly Lee (Project Engineer)
Importance of Context	"...Make the technology a 'normal' accessory that doesn't require any additional time or effort to set up…"	Matt Sharp (Project Manager)
Physical Discomfort	"Added technology generally adds weight and bulk…added burden on workers."	Michael Mitchell (Superintendent)
Need for Trials and Tests	"A small pilot program showing a positive cost/benefit analysis."	Greg Stiles (Project Manager)
Worker Education	"...Explanation for each tracking item, so they comprehend the functionality of the device fully."	Molly Lee (Project Engineer)

Note. Table summarizes recurring themes identified through interviews with construction professionals regarding the adoption of wearable safety technology. Participant quotes highlight key perceptions and concerns influencing technology acceptance. Data derived from *STS 4600 Interview Responses* (Colbert, 2025).

These qualitative results strengthen the findings in existing literature by offering a more refined view of how trust, education, and practical implementation strategies impact workers' perception and probability of adoption of wearable safety technologies.

Conclusion

These findings suggest that addressing privacy concerns through transparents data policies and effective worker engagement is essential for the successful adoptions of wearable technology in the construction industry. Existing research shows that when companies implement and clearly communicate how worker data will be collected, used, and protected, hesitation of adoption around using these technologies significantly decreases. Interviews with construction professionals confirmed that trust and transparency are key drivers of acceptance especially in an industry where workers already face risks to their physical well–being daily.

This study reinforces the importance of aligning technological innovation with ethical considerations. Construction firms that aim to implement these technologies on-site must go above and beyond simply providing the equipment. They must prioritize educating workers on how these tools work, what safety risks they help mitigate, and how the data being collected will remain secure and confidential. The likelihood of workers viewing wearables as supportive safety tools rather than invasive surveillance devices significantly increases when provided with the knowledge surrounding them.

Moreover, practical implementation measures can further improve adoption outcomes. Some examples of these measures include piloting small-scale programs, offering opt-in participation, anonymizing data collection, and ensuring compatibility with existing safety equipment. This research also shows the importance of framing wearables as supplements to the traditional required gear and protocols rather than replacements for it. Workers emphasized the

continued need for personal hazard awareness which suggests that technology must enhance their personal judgements on the job site instead of overriding or hindering it in any way.

Like most research, this study has limitations. The interview pool included candidates in diverse roles and company sizes; however, it was limited to a specific set of professionals that were primarily from one large construction company. This research could be expanded upon to include more subcontractors, unionized workers, and non-commercial sectors in order to provide a broader understanding of worker insights across the industry. Additionally, while this study focuses on trust, transparency, and worker engagement, it does not extensively address the role of workplace privacy laws or corporate governance policies. Future studies could explore how evolving legal frameworks influence technology acceptance and ethical implementation on construction sites. As wearables and technology in general continue to evolve, future studies should also consider how generational differences and cultural norms may change perspectives over time.

In the construction world, a common phrase heard on many job sites is that *everyone should go home at the end of the day the same way they arrived* - meaning safe, healthy, and ready to see their family and loved ones. Wearable safety technologies can play a critical role in making that goal a reality. These tools enhance daily safety by providing real-time support for monitoring falls, heat, hazardous materials, and other risks. Implementing these tools in an ethical manner offers a promising course of action in protecting the lives of the people who build our communities.

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