*Original Article*

# Digital transformation in accident prevention: Enhancing efficiency using the VICTORIA 4.0 digital form in the construction sector in Barranquilla

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## ABSTRACT

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**Introduction:** Occupational safety in the construction sector is a critical challenge, especially in high-risk tasks. In this context, digital transformation offers new tools, such as the VICTORIA 4.0 form, designed to improve accident prevention. The objective of the research is to determine the potential efficiency of using the VICTORIA 4.0 digital form in accident prevention during high-risk tasks in the construction sector in Barranquilla.

**Methods:** A quantitative, descriptive, and correlational study was conducted using a non-experimental, cross-sectional design. Data were collected in May 2024 from 15 construction workers in Barranquilla, Colombia, through a structured questionnaire of 29 items. Reliability was assessed with Cronbach's alpha. Statistical analyses included chi-square tests and linear regression using IBM Statistical Package for the Social Sciences (SPSS) version 24.

**Results:** Linear regression analysis showed that variables such as the understanding of accident sequences ($\beta = 0.650$, $p = 0.009$), the effectiveness of corrective measures ($\beta = 0.650$, $p = 0.009$), and the promotion of safety culture ($\beta = 0.747$, $p = 0.001$) were significantly associated with an improved perception of work place safety. Fisher's Exact Tests revealed significant associations between educational level and key safety perceptions, including error reduction, effectiveness of corrective measures, and injury documentation features of the VICTORIA 4.0 form ($p < 0.05$).

**Conclusion:** The VICTORIA 4.0 digital form proved to be a useful tool for enhancing occupational safety in the construction sector. Its effectiveness, however, may vary depending on educational background and previous accident experience. These findings support the integration of digital tools in occupational safety strategies and highlight the importance of adapting their implementation to workers' contexts.

**Keywords:** Accidents, Occupational, Occupational Health, Occupational Injuries, Risk Management.

## Introduction

Digital transformation has emerged as a key factor in the modernization of various industrial sectors, including construction. In this context, the digitalization of critical processes not only

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optimizes operational efficiency but also enhances workplace safety, a fundamental aspect in high-risk environments such as construction sites. Additionally, it offers advantages in the surrounding environment and opens up possibilities for sustainable growth in decent employment.[1,2] This document focuses on the implementation of the VICTORIA 4.0 digital form, a tool designed for accident prevention in the construction sector in Barranquilla.

Digital transformation is driving a profound change in numerous industrial sectors. In Colombia, and particularly in Barranquilla, the adoption of digital technologies in occupational safety management promises to revolutionize accident prevention, a constant challenge in this sector[3]. Despite technological advancements, accident rates in the construction sector remain alarming, reflecting the urgent need to improve safety strategies.

The construction sector in Barranquilla faces various challenges in accident prevention, such as inadequate tracking of safety measures, delayed reporting of incidents, and insufficient training of workers.[4] The causes of these problems are multiple: from resistance to change and lack of investment in technology, to a shortage of specialized personnel in digital safety.[5,6]These deficiencies not only endanger the lives and health of workers but also negatively impact the productivity and sustainability of construction companies.

Recent literature has emphasized the transformative potential of digital technologies in enhancing occupational risk management, especially in the construction industry. Qiu and Li proposed a blended analytical approach combining risk modeling and data mining to assess injury reports and standard operating procedures. Their model enables real-time risk evaluation and could be integrated into digital twin systems to optimize decision-making in dynamic work environments. [7]Similarly, Lopes and Silva Filho examined the adoption of Fourth

Industrial Revolution (4IR) technologies in construction and identified several implementation challenges, including limited digital maturity and resistance among traditional firms. They proposed a stage-based framework for aligning technologies with safety goals throughout the construction lifecycle. [8] These studies highlight the potential and limitations of digitalization for safety improvement.

Furthermore, Osorio-Gómez et al. explored the use of digital safety tools in public construction projects in Colombia and noted that contextual adaptation and worker involvement are critical for successful implementation. [4] Collectively, these contribution suggest that while technological tools can optimize processes, their integration with local safety culture and work force characteristics remains essential.

In this context, a crucial question arises: can the implementation of digital tools like the VICTORIA 4.0 form significantly reduce the accident rate in construction in Barranquilla? This study aims to explore this question by analyzing the impact of digitalization on improving safety procedures and reducing workplace incidents. The use of the VICTORIA 4.0 digital form represents an innovation in risk management, enabling real-time monitoring and immediate responses to hazardous situations. Its implementation is expected not only to improve operational efficiency but also to positively transform the safety culture among workers.[9]

This article aims to capture the reader's interest by demonstrating how digitalization can become a powerful tool for improving workplace safety in construction, providing a solid foundation for future research and practices in the sector. It is expected to contribute to the existing knowledge on digital transformation in occupational safety management, offering a practical tool that enhances efficiency and reduces risks in the construction sector.

## Methods

This study followed a quantitative, descriptive, and correlational approach to evaluate the potential effectiveness of the VICTORIA 4.0 digital form in preventing occupational accidents during high-risk construction activities. The VICTORIA 4.0 form contains structured fields to record personal data, risk identification, accident circumstances, type of injuries, corrective measures, and follow-up actions. The choice of a quantitative method was justified by the need for objective measurement and statistical analysis of the relationships between the variables, enabling a structured understanding of how digital tools impact work place safety.[10,11]

A non-experimental, cross-sectional design was applied, which allowed for the observation and analysis of workers' perceptions at a single point in time, specifically in May 2024, after the implementation of the VICTORIA 4.0 form. This design was appropriate for capturing a snapshot of the real-world application and acceptance of the digital tool in a natural setting, without manipulating the conditions under study. [12]

Data were collected through a structured questionnaire composed of 29 items, combining closed-ended and Likert-scale questions. The instrument was designed to explore four key components: sociodemographic characteristics (such as age, educational level, and work experience), the use and perceived usefulness of the VICTORIA 4.0 form, aspects of digital transformation in the workplace, and factors related to accident prevention in high-risk tasks. The questionnaire aimed to provide a comprehensive overview of the relationship between digitalization and safety perception in the construction sector.

The internal consistency of the questionnaire was evaluated using Cronbach's alpha. The digital transformation dimension, consisting of six items, yielded a reliability coefficient of 0.940, while the accident prevention dimension, with eleven items, produced a coefficient of 0.826.

These values demonstrate high internal reliability and support the validity of the instrument used in the study. [13]

The study population consisted of construction workers in the city of Barranquilla, specifically those involved in high-risk operational tasks. A non-probabilistic convenience sampling strategy was used to select 15 participants who had direct exposure to and experience with the VICTORIA 4.0 form. Although this sampling technique does not allow for broad generalization, it enabled the inclusion of relevant respondents for the exploratory nature of this research.[14]

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 24. Two statistical techniques were employed. First, Fisher's Exact Test was used to identify associations between categorical sociodemographic variables and workers' perceptions regarding the effectiveness of the VICTORIA 4.0 form, due to the small sample size and low expected cell counts.[15] Second, linear regression analysis was conducted to determine the influence of independent variables—specifically workers' experiences and perceptions of the form—on the dependent variable, defined as the perceived level of job safety following the form's implementation.[16,17] These techniques were selected for their appropriateness in assessing both associative and predictive relationships within the framework of the research objectives. Specifically, chi-square tests were suited for exploring relationships between nominal variables, while linear regression allowed for estimating the predictive power and relative contribution of continuous or ordinal variables in determining safety perception outcomes. Their combined use provided a comprehensive analytical framework for the study. An ordinal variable is a type of categorical variable where the categories have a natural, meaningful order or rank, but the differences between the categories are not necessarily equal. [16,17] Participation was voluntary, and informed consent was obtained from all participants prior to data collection. The

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consent section, included within the same questionnaire, explained the purpose of the study, ensured confidentiality and anonymity, and complied with the Colombian Personal Data Protection Law.

## Results

This section presents the findings derived from the quantitative analysis conducted to evaluate the impact of the VICTORIA 4.0 digital form on workplace accident prevention in high-risk tasks within the construction sector in Barranquilla. The results from both linear regression Fisher's Exact Tests offer insight into the relationships between sociodemographic variables, usage of the digital form, and workers' perceptions of occupational safety.

The linear regression analysis was conducted to evaluate how different elements of the VICTORIA 4.0 form influence workers' perception of safety. The model yielded several statistically significant predictors, as shown in Table 1. High standardized beta coefficients indicate a strong relationship between the independent variables and the perception of safety after implementing the form.

**Table 1**: Linear regression of the variables related to digital transformation and accident prevention

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | StandardError | Beta | | |
| (Constant) | 1.333 | .982 | | 1.358 | .198 |
| 1   The form has helped me understand how accidents occur and recognize the series of events that could lead to injuries | .750 | .244 | .650 | 3.080 | .009 |
| The VICTORIA 4.0 form has influenced my acceptance and control over my personal occupational health and safety. | .750 | .244 | .650 | 3.080 | .009 |
| The VICTORIA 4.0 form has improved the safety culture in my workplace | .893 | .220 | .747 | 4.051 | .001 |
| I have noticed a reduction in worker errors since the VICTORIA 4.0 form began to be used | .909 | .276 | .674 | 3.291 | .006 |
| The form facilitates the identification and mitigation of mechanical and physical risks | .474 | .189 | .571 | 2.507 | .026 |
| The corrective measures suggested by the VICTORIA 4.0 form are effective in preventing similar accidents. | .750 | .244 | .650 | 3.080 | .009 |
| The VICTORIA 4.0 form includes a specific section to record the type of injuries and damages caused by workplace accidents | .750 | .244 | .650 | 3.080 | .009 |

For instance, understanding how accidents occur and recognizing the sequence of events leading to injuries showed a Beta = 0.650 (p = 0.009), implying a moderate-to-strong positive effect. Similarly, the perceived improvement in safety culture exhibited the strongest relationship (Beta = 0.747, p = 0.001), highlightingthattheformnotonlysupportsoperationaltasksbutalsoreinforces safety-oriented values in the workplace.

Other important predictors include the reduction of worker errors (Beta = 0.674, p = 0.006) and the

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perceived effectiveness of corrective measures (Beta = 0.650, p = 0.009), both of which suggest the tool contributes meaning fully to incident prevention and operational discipline.

The inclusion of a specific section to record injuries and damages (Beta = 0.650, p = 0.009) also proved significant, under lining the importance of documentation in accident analysis and prevention planning. These findings demonstrate that the VICTORIA 4.0 form fosters a comprehensive safety framework that integrates technical reporting with cultural awareness and worker engagement.

Table 2 shows a significant relationship between educational level and the perceived reduction of worker errors (Fisher's Exact Test, p = 0.020). This suggests that workers with higher educational attainment may be more receptive to the form's guidance and structure, resulting in fewer operational mistakes. However, no linear trend was detected (p = 0.439).

Table 3 shows a significant relationship between educational level and the perceived effectiveness of corrective measures suggested by the VICTORIA 4.0 form to prevent similar accidents (Fisher's Exact Test, p = 0.023)

Table 4 shows a significant relationship between educational level and the perception that the VICTORIA 4.0 form includes a specific section to record the type of injuries and damages caused by workplace accidents (Fisher's Exact Test, p = 0.023). This suggests that workers with higher educational attainment are more likely to recognize the documentation features of the digital form. However, no linear trend was detected (p = 0.155)

**Table 2:** Association between educational level and the perception of error reduction after the implementation of the VICTORIA 4.0 form

|  |  |  | Neither agree nor disagree | Agree | Strongly agree | Total |
|---|---|---|---|---|---|---|
| Highest educational level attained | Technical/Technological | Count | 0 | 3 | 0 | 3 |
|  |  | Expected count | 0.2 | 2.4 | 0.4 | 3.0 |
|  | University | Count | 0 | 8 | 0 | 8 |
|  |  | Expected count | 0.5 | 6.4 | 1.1 | 8.0 |
|  | Postgraduate | Count | 1 | 1 | 2 | 4 |
|  |  | Expected count | 0.3 | 3.2 | 0.5 | 4.0 |
| Total |  | Count | 1 | 12 | 2 | 15 |
|  |  | Expected count | 1 | 12 | 2 | 15 |
| Chi-Square Tests |  |  | Exact Significance (two-sided) | | | |
| Pearson Chi-Square |  |  | 0.033 | | | |
| Fisher's Exact Test |  |  | 0.020 | | | |

**Table 3:** Association between educational level and the perceived effectiveness of corrective measures suggested by the VICTORIA 4.0 form

|  |  |  | Neutral | Effective | Very effective | Total |
|---|---|---|---|---|---|---|
| Highest educational level attained | Technical/Technological | Count | 1 | 2 | 0 | 3 |
|  |  | Expected count | 0.4 | 2.2 | 0.4 | 3.0 |
|  | University | Count | 0 | 8 | 0 | 8 |
|  |  | Expected count | 1.1 | 5.9 | 1.1 | 8.0 |
|  | Postgraduate | Count | 1 | 1 | 2 | 4 |
|  |  | Expected count | 0.5 | 2.9 | 0.5 | 4.0 |
| Total |  | Count | 2 | 11 | 2 | 15 |
|  |  | Expected count | 2.0 | 11.0 | 2.0 | 15.0 |

| Chi-Square Tests | Exact Significance (two-sided) |
|---|---|
| Pearson Chi-Square | 0.043 |
| Fisher's Exact Test | 0.023 |

**Table 4:** Association between educational level and the perception of whether the VICTORIA 4.0 form includes a section to record injuries and damages caused by workplace accidents

| | | | Neither agree nor disagree | Agree | Strongly agree | Total |
|---|---|---|---|---|---|---|
| Highest educational level attained | Technical/Technological | Count | 1 | 2 | 0 | 3 |
| | | Expected count | 0.4 | 2.2 | 0.4 | 3.0 |
| | University | Count | 0 | 8 | 0 | 8 |
| | | Expected count | 1.1 | 5.9 | 1.1 | 8.0 |
| | Postgraduate | Count | 1 | 1 | 2 | 4 |
| | | Expected count | 0.5 | 2.9 | 0.5 | 4.0 |
| Total | | Count | 2 | 11 | 2 | 15 |
| | | Expected count | 2.0 | 11.0 | 2.0 | 15.0 |

| Chi-Square Tests | Exact Significance (two-sided) |
|---|---|
| Pearson Chi-Square | 0.043 |
| Fisher's Exact Test | 0.023 |

## Discussion

The findings of this study reinforce the growing relevance of digital transformation in occupational safety management, particularly within high-risk sectors such as construction. The results from the linear regression analysis demonstrated that key features of the VICTORIA 4.0 form—such as the ability to document incidents, promote safety culture, and guide corrective actions—significantly improved workers' perceptions of safety. These findings are aligned with previous studies showing that digital tools can enhance safety practices by enabling structured data collection, faster response to hazards, and better-informed decision-making.[4,18]

The additional results obtained through Fisher's Exact Test further strengthen these conclusions by identifying significant associations between workers' educational level and their perceptions

of the form. Specifically, higher educational attainment was associated with a greater perception of error reduction (p = 0.020), the recognition of corrective measures as effective (p = 0.023), and the acknowledgement of a specific section for documenting injuries and damages (p = 0.023). These findings suggest that the effectiveness of digital safety tools may be influenced by workers' educational background, with more educated individuals demonstrating higher receptivity to structured guidance and preventive documentation. This aligns with research in healthcare and industrial contexts, where digitalization not only improved operational efficiency but also reinforced organizational values and safety culture.[2,19]

However, not all effects may be uniformly positive. As highlighted by Bobillier, digital transformation can also produce psychosocial

strain, such as information overload or increased pressure to comply with automated systems.[20] While the results show an overall positive perception of safety, it is also evident that personal experiences, such as prior accidents, shape workers' views toward digital interventions. The significant associations between accident history, occupational psychology, and safety perceptions underscore the emotional and cognitive dimensions of accident prevention—an aspect often overlooked in strictly procedural interventions.

Methodological limitations must also be acknowledged. The small sample size (n = 15) restricted the statistical power of the tests and the generalizability of the findings. The violation of chi-square assumptions due to low expected cell counts required the use of Fisher's Exact Test, which, despite providing more accurate results, limits the robustness of broader inferences. Nevertheless, the consistency of the findings across both regression and Fisher's tests strengthens the preliminary validity of the observed trends. Future studies should replicate this analysis with larger samples and incorporate mixed methods to capture the complex interplay between digital transformation, safety culture, and human factors.

Overall, this study highlights that the VICTORIA 4.0 digital form contributes meaningfully to accident prevention and the promotion of safety culture in construction. Its implementation supports not only risk documentation but also behavioral and perceptual changes among workers. However, successful digitalization must integrate human considerations—such as workers' educational background, psychological responses, and prior accident experiences—to ensure sustainable and inclusive improvements in occupational safety.

However, it is important to recognize the limitations of this research. The small sample size (n = 15) restricts the generalizability of the findings, and some chi-square assumptions were violated due to low expected counts. Despite these limitations, the consistency across regression and Fisher's test results suggests a robust trend. Future research with larger and more diverse samples should further validate these findings and explore how factors such as prior accident experience, organizational policies, and psychosocial conditions influence the adoption and effectiveness of digital safety tools.

## Conclusion

This study provides evidence that the VICTORIA 4.0 digital form is a relevant and effective tool for strengthening occupational safety practices in the construction sector of Barranquilla. By integrating structured fields for personal data, accident circumstances, risk identification, injuries, corrective measures, and follow-up actions, the form not only standardizes reporting but also supports the development of a stronger safety culture.

The results obtained through Fisher's Exact Test highlight that educational level plays a decisive role in shaping workers' perceptions of the form's effectiveness. Significant associations were observed between higher educational attainment and the perceived reduction of worker errors (p = 0.020), the recognition of corrective measures as effective in preventing accidents (p = 0.023), and the ability to document injuries and damages (p = 0.023). These findings suggest that more educated workers are more receptive to the structure and guidance provided by digital tools, which can enhance their impact on accident prevention strategies.

The regression analysis further reinforced these conclusions, showing that the VICTORIA 4.0 form significantly improves perceptions of safety culture ($\beta$ = 0.747, p = 0.001), reduces worker errors ($\beta$ = 0.674, p = 0.006), and enhances awareness of accident sequences and corrective actions ($\beta$ = 0.650, p = 0.009). Together, these results demonstrate that the form contributes not only to documenting risks but also to shaping preventive behaviors, increasing awareness, and fostering organizational learning.

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From a broader perspective, the study confirms that digital transformation initiatives in occupational safety can generate measurable improvements when adequately implemented. The VICTORIA 4.0 form represents a practical example of how technological solutions can integrate procedural control with cultural reinforcement, thus supporting both operational efficiency and the human dimension of safety management.

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