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Original article

BPESP as an ergonomic decision-making tool: hybrid assessment, engineering controls, and prospective economic analysis in a manual packaging workstation

BPESP como herramienta de decisión ergonómica: evaluación híbrida, controles de ingeniería y análisis económico proyectado en estación de empaque manual

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Abstract

Introduction**.** Ergonomic assessment has preventive value when its findings are translated into technically justified, documented, and economically assessable control decisions. Objective. To analyze the application of the Business Plan Ergonomic Safety Program in a manual packaging workstation in the manufacturing sector, from quantitative risk identification to the implementation of engineering controls and their ex ante economic assessment, and to identify its preventive, productivity-related, and legal implications. An applied, technical-documentary case study was conducted. The baseline assessment combined task inspection, Rapid Entire Body Assessment, the Revised NIOSH Lifting Equation, biomechanical modeling, and artificial intelligence-assisted postural analysis. Post-implementation follow-up was descriptive. The economic analysis used an adapted break-even approach, while the legal analysis examined the preventive duty, evidence of due diligence, and applicable social protection mechanisms. Results. The original task involved lifting 65-pound boxes 1,040 times per shift, representing an accumulated load of approximately 31.2 metric tons. The assessment identified high ergonomic risk and supported mechanization through conveyors, vacuum-assisted handling, and mechanized palletizing. The documented capital investment was USD 130,045; the break-even analysis indicated that this investment was equivalent to the average direct cost of approximately 4.06 occupational strain claims based on the reference used. **Conclusion.** BPESP can integrate ergonomic assessment, engineering, follow-up, and economic decision-making while also generating traceability relevant to preventive due diligence, although the absence of a quantitative post-intervention reassessment limits estimation of residual risk.

Keywords: ergonomics; occupational safety; artificial intelligence; productivity; risk prevention.

Resumen

Introducción. La evaluación ergonómica adquiere valor preventivo cuando sus resultados se traducen en decisiones de control técnicamente justificadas, documentadas y económicamente evaluables. Objetivo. Analizar la aplicación del Business Plan Ergonomic Safety Program en una estación manual de empaque del sector manufacturero, desde la identificación cuantitativa del riesgo hasta la implementación de controles de ingeniería y su evaluación económica ex ante*, e identificar sus implicaciones preventivas, productivas y jurídicas. Se realizó un estudio de caso aplicado, técnico-documental. La evaluación de línea base combinó inspección de la tarea, Rapid Entire Body Assessment, la Ecuación Revisada de Levantamiento de NIOSH, modelado biomecánico y análisis postural asistido por inteligencia artificial. El seguimiento posimplementación fue descriptivo. El análisis económico utilizó un punto de equilibrio adaptado y el análisis jurídico examinó el deber preventivo, la evidencia de diligencia y mecanismos de protección social aplicables. Resultados. La tarea inicial implicaba levantar cajas de 65 libras 1.040 veces por turno, con una carga acumulada aproximada de 31,2 toneladas métricas. La evaluación identificó riesgo ergonómico alto y sustentó la mecanización mediante transportadores, asistencia por vacío y paletización mecanizada. La inversión documentada fue de USD 130.045; el análisis de punto de equilibrio indicó que esta inversión equivalía al costo directo promedio de aproximadamente 4,06 reclamaciones por distensión laboral según la referencia utilizada.* ***Conclusión.*** *BPESP puede articular evaluación, ingeniería, seguimiento y decisión económica, además de generar trazabilidad útil para la diligencia preventiva, aunque la ausencia de una reevaluación cuantitativa posintervención limita la estimación del riesgo residual.*

Palabras clave: *ergonomía; seguridad en el trabajo; inteligencia artificial; productividad; prevención de riesgos.*

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Introduction

Work-related musculoskeletal disorders remain a persistent occupational health and productivity management concern. Exposure to manual material handling, awkward postures, repetitive movements, force, and prolonged task duration can increase the risk of discomfort and injury, particularly when several factors occur simultaneously within the same task (Hulshof et al., 2021; National Institute for Occupational Safety and Health [NIOSH], 1997). Preventive action, therefore, should not be limited to hazard identification; it requires a verifiable sequence of assessment, prioritization, control selection, implementation, and follow-up.

In previous work, Larez and Maribao (2025a) proposed a hybrid approach to ergonomic risk assessment that integrates artificial intelligence-assisted tools with traditional methods and professional validation. This approach seeks to take advantage of the speed and objectivity of computer vision without replacing the ergonomist's professional judgment or the technical legitimacy of established methods such as the Rapid Entire Body Assessment and the Revised NIOSH Lifting Equation. The proposal is consistent with studies on automated detection and motion capture that highlight the usefulness of these technologies in expanding the continuity of measurement while emphasizing the need to maintain methodological validation and expert oversight (Camargo Salinas et al., 2024; Yunus et al., 2021). In a second article, the authors developed the Business Plan Ergonomic Safety Program as a broader management methodology aimed at closing the gap between risk identification, organizational participation, preventive planning, technical evidence, and legal compliance (Larez & Maribao, 2025b).

This third article in the series addresses a different question: what happens after a high ergonomic risk has been identified and quantified? In industrial environments, the response may require engineering controls capable of physically modifying the worker-task interaction, reducing force exposure, or eliminating manual lifting. The literature indicates that the effectiveness of ergonomic interventions depends on the appropriateness of the selected control, its implementation, and the subsequent measurement of outcomes (Bazaluk et al., 2023; Danylak et al., 2024).

The present study uses a real case involving a manual packaging workstation in a manufacturing facility in Texas to analyze the traceability of the decision-making process: operational concern, quantitative assessment, identification of contributing factors, control recommendations, engineering development, implementation, and ex ante economic analysis. The company's identity is kept anonymous for confidentiality reasons. The purpose is not to attribute outcomes to the case that have not been measured, but rather to distinguish rigorously among observed evidence, documented implementation, descriptive follow-up, and quantitative outcomes that remain pending.

The research question guiding the study is: **How can an integrated ergonomic management methodology transform the identification of a high-risk manual material-handling exposure into a technically supported and economically assessable engineering intervention?**

Accordingly, the general objective is to analyze the application of the Business Plan Ergonomic Safety Program in a manual packaging workstation by documenting the transition from hybrid risk assessment to the selection and implementation of engineering controls and their ex ante economic assessment, while identifying the preventive, productivity-related, and legal implications of the process.

This third article does not retroactively redefine the previously published phases of the Business Plan Ergonomic Safety Program. Instead, it focuses on the operational components that connect quantitative assessment with control selection, technical-economic justification, and follow-up. Artificial intelligence is positioned as a measurement and decision-support tool; it does not constitute an engineering control by itself. Engineering control refers to the physical modification of the workstation, equipment, or worker-load interaction.

The operational logic can be summarized in six linked steps: participation and early warning; hybrid assessment; prioritization; engineering design and implementation; ex ante economic assessment; and follow-up with continuous improvement. This sequence is intended to transform ergonomics from a reactive practice into a documented decision-making system that can be audited and replicated.

Materials and methods

An applied, technical-documentary case study was conducted, involving the chronological reconstruction of an ergonomic intervention. The unit of analysis was the preventive decision-making sequence associated with a manual palletizing task involving heavy boxes at a manufacturing facility in Texas, United States. Internal technical documents from 2025, post-implementation photographic

evidence, and scientific and regulatory literature were used as the interpretive framework. No individual medical records or identifiable health data were used.

Documentary sources and timeline

The chronological reconstruction included five milestones: quantitative baseline assessment on March 20, 2025; formalization of the redesign scope on July 7, 2025; engineering technical proposal in July 2025; system commissioning in January 2026; and descriptive operational follow-up from January through August 2026. Internal documentation was kept anonymous.

Ergonomic assessment

The baseline assessment combined four components: (1) task inspection and recording of physical variables; (2) postural scoring using the Rapid Entire Body Assessment method; (3) application of the Revised NIOSH Lifting Equation for manual lifting; and (4) biomechanical modeling and artificial intelligence-assisted postural analysis. The Rapid Entire Body Assessment method allows postural exposure and the need for intervention to be classified (Hignett & McAtamney, 2000), whereas the Revised NIOSH Lifting Equation integrates load, geometry, frequency, duration, and coupling variables to estimate a recommended weight limit and lifting index (Waters et al., 1993).

The hybrid approach retains professional validation as the final component of the assessment process. Artificial intelligence is used to support the recording of angles, postures, and movement patterns; it is not interpreted as a substitute for the Rapid Entire Body Assessment method, the Revised NIOSH Lifting Equation, or the ergonomist's professional judgment (Chatzis et al., 2022; Larez & Maribao, 2025a; Scataglini et al., 2025).

Post-implementation follow-up

Follow-up after system commissioning was descriptive. Photographs of the modified workstation and the operational report provided by the technical project lead were used. The presence of conveyors, vacuum-assisted handling, and a palletizing system was documented, together with the reported absence of task-related incidents and absenteeism and the absence of worker complaints of discomfort or fatigue during the initial follow-up period. These findings were not considered equivalent to a quantitative reassessment of residual ergonomic risk.

Ex ante economic analysis

The break-even point in equivalent events was estimated through an adaptation of conventional break-even analysis. In managerial accounting, the break-even point in units is calculated by dividing fixed costs by the contribution margin per unit (Franklin et al., 2019). Based on this principle, the authors adapted the calculation to the preventive context to express how many average direct workers' compensation claim costs would be economically equivalent to the initial investment in engineering controls. The expression used was:

$$QBE = I / Cd$$

where **QBE** represents the number of equivalent claims at the break-even point, **I** represents the documented capital investment, and **Cd** represents the average direct cost of a reference claim. This formula is an analytical adaptation developed by the authors and is not a formula developed by the Occupational Safety and Health Administration. OSHA Safety Pays was used exclusively as the source of the average direct claim cost used as the economic reference.

Legal criteria

The legal analysis was limited to the relationship among the preventive duty, ergonomics, documentation of controls, preventive due diligence, and social protection mechanisms. The analysis reviewed the General Duty Clause of the Occupational Safety and Health Act; the effects of the Congressional Review Act on the 2000 federal ergonomics standard; the Field Operations Manual and

OSHA policy on ergonomic hazards; the decision of the Occupational Safety and Health Review Commission in *Pepperidge Farm*; the Texas Labor Code provisions governing workers' compensation; and the coordination mechanisms between SSDI and certain workers' compensation or public disability benefits. This framework was used to interpret the preventive function of BPESP and the value of documentary traceability; it does not constitute a determination of regulatory compliance or legal liability, nor does it convert the economic analysis into a mandatory legal standard.

Results

Characterization of the task and exposure

The March 2025 assessment documented a manual palletizing task in which the operator handled boxes weighing approximately 65 lb (30 kg) (Table 1). Twenty boxes were required to complete one pallet, and the production target was 52 pallets per shift, equivalent to 1,040 lifts. The approximate frequency was two lifts per minute, and the accumulated weight handled was estimated at 31,200 kg per shift, or approximately 31.2 metric tons.

Table 1. *Characterization of exposure and multimethod baseline ergonomic assessment*

Indicator	Documented result	Technical interpretation
Weight per box	65 lb (≈30 kg)	High individual load in a repetitive task.
Boxes per pallet	20	Defines the production unit and repetition.
Pallets per shift	52	Documented operational target.
Lifts per shift	1,040	Repetitive and cumulative exposure.
Frequency	≈2 lifts/minute	Relevant variable for NIOSH assessment and cumulative load.
Accumulated load	≈31.2 metric tons/shift	Magnitude of manual material handling.
Initial destination height	≈5 inches above the floor	Promotes deep flexion when placing boxes on lower pallet layers.
REBA	≈8	High-risk level in the baseline assessment; action required.
NIOSH Lifting Index	>3	Exposure above the recommended level in the internal assessment.
Internal segment assessment	Back 8; shoulder 8; legs 8; hand/wrist 6; elbow and neck 4	Prioritizes the back, shoulders, and legs.
Biomechanical model	45° trunk flexion; 60° knee flexion; 65-lb load	Identifies overload in the lumbar region, hips, and ankles.
Artificial intelligence-assisted postural modeling	Very high at destination levels 1–3; low/moderate from level 4 onward	Identifies the greatest exposure at the lower pallet levels.

Biomechanical and postural modeling findings

The assessment identified trunk flexion, knee flexion, shoulder adduction, and handling of the load from a conveyor to pallets positioned at a low height. The biomechanical model documented a trunk posture of approximately 45° and knee flexion of approximately 60° while handling a 65-lb load, with an estimated elevated risk to the lumbar region, hips, and ankles. Artificial intelligence-assisted postural modeling classified the risk levels for the legs, back, and arms as very high when boxes were placed at destination levels 1 through 3. At higher destination levels, exposure decreased to low or moderate categories (Figure 1).

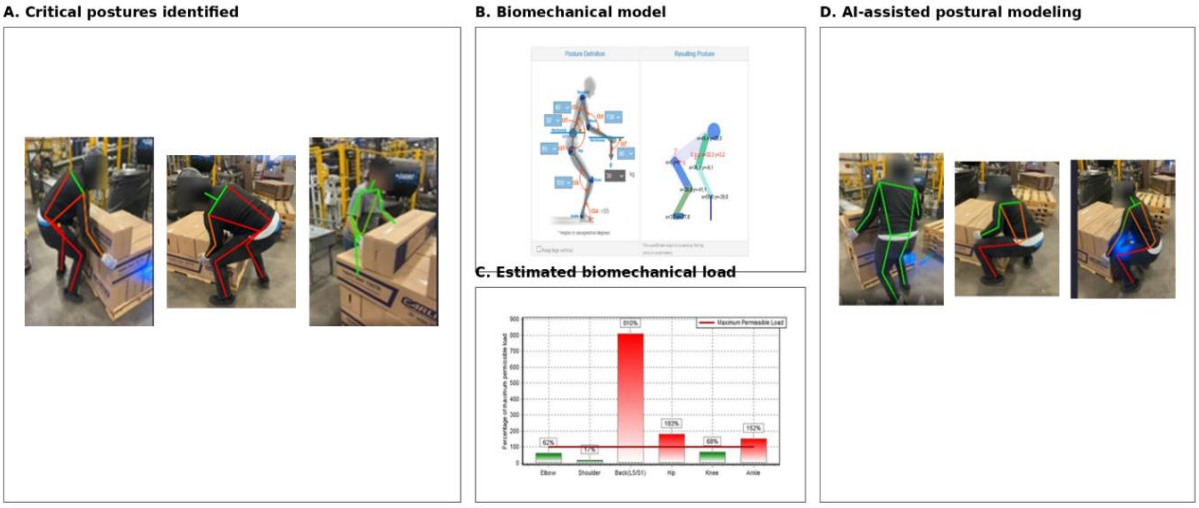


Figure 1. *Baseline evidence: critical postures, biomechanical modeling, and artificial intelligence-assisted postural analysis. Source: internal ergonomic assessment, March 2025; reproduced in anonymized form.*

From diagnosis to engineering control

The internal assessment concluded that the combination of an individual load exceeding 50 lb and an accumulated load exceeding 30 metric tons per shift justified the implementation of engineering controls. Recommendations included lifting-assistance devices, control of destination height, modification of the workstation layout, and formal worker rotation as a complementary administrative measure. The purpose of the control strategy was to reduce the need for manual lifting and minimize deep flexion when placing boxes on the lower layers of the pallet.

The subsequent project developed a broader solution for the production line, including conveyors, a vacuum-assisted handling system, and mechanized palletizing. The documented capital investment in the engineering proposal amounted to USD 130,045, distributed among conveyor materials, end-of-line equipment, mechanical installation, field wiring, and controls. For confidentiality purposes, the names of the company, supplier, and commercially identifiable elements are omitted (Table 2).

Table 2. *Documented capital investment and ex ante break-even analysis*

Concept	Value	Interpretation
Conveyor materials	USD 33,400	Conveyance system.
End-of-line materials	USD 38,600	Material-handling assistance and palletizing.
Mechanical installation	USD 25,685	Installation of equipment and conveyors.
Field wiring and controls	USD 32,360	Electrical installation and control systems.
Total documented investment	USD 130,045	Subtotal of the technical proposal, subject to contractual exclusions.
Average direct cost of an occupational strain claim	USD 32,023	General OSHA Safety Pays reference for lost-time claims.
Direct break-even point	4.06 equivalent claims	Ratio between the documented investment and the average direct reference cost.
Indirect costs and productivity benefits	Not monetized	Conservative criterion; reproducible cash flows were not available.
Financial return indicators	Not calculated	ROI, NPV, IRR, and payback period are not reported in the absence of actual post-implementation cash flows.

Post-implementation status and descriptive follow-up

The system was reported as commissioned in January 2026. Subsequent photographs show the implemented configuration (Figure 2), including conveyors and vacuum-assisted handling used to transfer the boxes, thereby reducing the need to perform the manual lifting observed at baseline.

According to the technical project lead, during the initial follow-up period through the manuscript review in August 2026, no task-related incidents or absenteeism were reported, and operators did not report discomfort or fatigue. These findings are presented as descriptive operational follow-up and not as quantitative evidence of reductions in REBA or NIOSH scores.

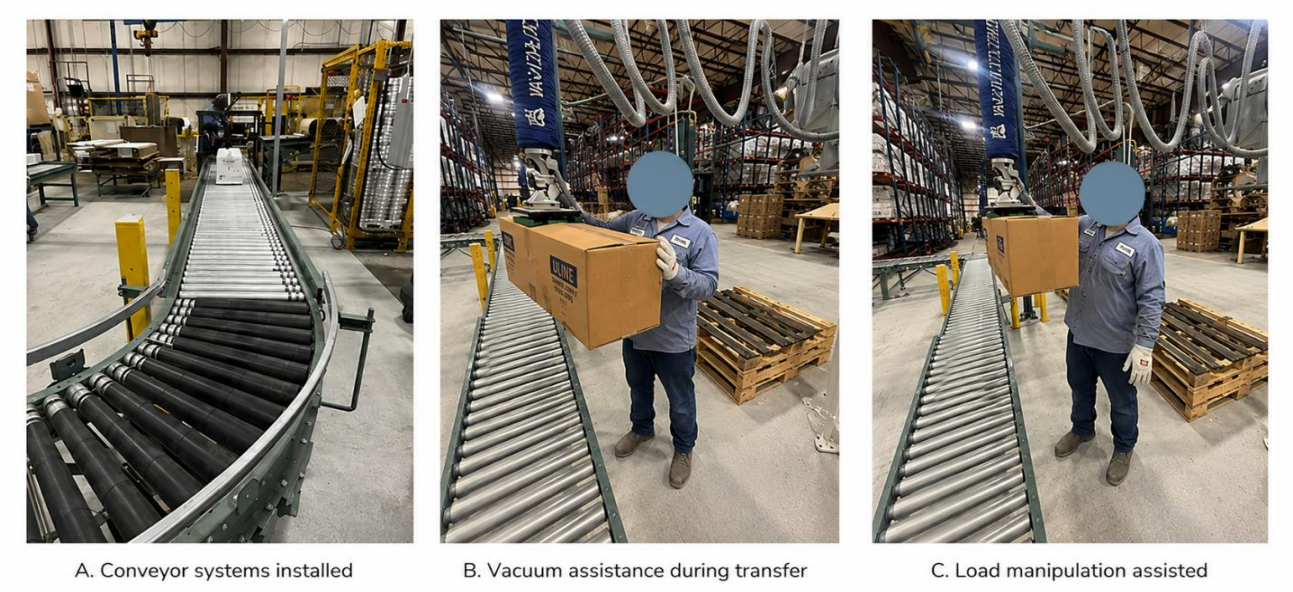


Figure 2. *Post-implementation status of the workstation: conveyors and vacuum-assisted handling. Anonymized photographs; January–August 2026.*

Ex ante economic analysis using the break-even point

OSHA Safety Pays reports an average direct cost of USD 32,023 for claims classified as *strain*. These values are derived from lost-time workers' compensation claims provided by the National Council on Compensation Insurance and correspond to policy years 2015–2017; therefore, they are used solely as a general economic reference and not as a company-specific cost estimate (OSHA, n.d.).

Using the documented capital investment of USD 130,045 and the average direct cost of USD 32,023, the break-even point is: **130,045 / 32,023 = 4.06 equivalent claims.** In interpretive terms, the initial capital cost is approximately equivalent to the average direct cost of four occupational *strain* claims. This calculation does not predict that such injuries would occur, nor does it causally attribute their avoidance to the project; it expresses only the relative economic magnitude of the investment.

Discussion

From risk identification to an engineering decision

The main contribution of this case is not an isolated percentage of risk reduction, but rather the traceability of the decision-making process. The operational concern was followed by a quantitative assessment, identification of load- and posture-related factors, recommendation of controls, formalization of the project, and implementation of an engineering solution. This sequence is consistent with a systemic approach to ergonomic management, which requires moving from diagnosis to modification of the source of risk (Bazaluk et al., 2023).

Administrative measures—such as training, operating procedures, breaks, or worker rotation—play an important role, but they do not necessarily eliminate the exposure associated with handling a 65-lb load more than one thousand times per shift. In the case analyzed, mechanization through conveyors, vacuum-assisted handling, and palletizing physically modifies the worker-load interaction and constitutes the core of the engineering control. Worker rotation retains value as a complementary measure when residual manual tasks remain.

AI, traditional methods, and human validation

The hybrid approach retains an important methodological advantage. Artificial intelligence tools can increase the continuity of observation and reduce variability associated with manual recording; however, interpreting the results requires an understanding of the task, its context, the force applied, process constraints, and the feasibility of the control (Chatzis et al., 2022; Scataglini et al., 2025).

The literature also warns that incorporating artificial intelligence into occupational safety and health requires attention to bias, privacy, data quality, equity, and human oversight, as well as individual factors that may modify exposure and musculoskeletal response, including workforce aging (El-Helaly, 2024; Fisher et al., 2023; Nygaard et al., 2022). REBA and NIOSH, in turn, provide established interpretation criteria and allow comparability with the scientific literature and professional practice.

The BPESP sequence can therefore be expressed as:

AI + validated method + professional judgment + engineering + follow-up

This formulation is more robust than a narrative in which software independently determines the solution or clinically predicts which worker will develop a work-related musculoskeletal disorder.

Economic analysis as decision support

Economic analysis can contribute to transforming an ergonomic recommendation into a capital investment. OSHA Safety Pays recognizes that injuries generate both direct and indirect costs and that their impact can be expressed in terms of profitability and the sales required to absorb losses. However, OSHA itself cautions that the tool is intended to increase business awareness and does not replace a detailed analysis of company-specific costs (OSHA, n.d.).

For this reason, the present study does not use probabilistic percentages or ROI, NPV, or IRR indicators, but instead adopts a transparent break-even approach based on a documented investment and a verifiable external average cost. The comparison shows that an investment of USD 130,045 is approximately equivalent to the average direct cost of four occupational *strain* claims, without incorporating indirect costs or productivity gains. The estimate is deliberately conservative and should be interpreted as ex ante decision support rather than a realized economic benefit.

Legal implications: preventive duty and evidence of due diligence

From a U.S. legal perspective, the absence of a general federal ergonomics standard does not imply the absence of a preventive duty. OSHA promulgated an *Ergonomics Program Standard* on November 14, 2000 (65 Fed. Reg. 68262), which was nullified through a joint resolution of disapproval adopted under the *Congressional Review Act* and enacted as Public Law 107-5 on March 20, 2001. As a consequence, OSHA removed the standard from the *Code of Federal Regulations* effective April 23, 2001 (Occupational Safety and Health Administration [OSHA], 2001). The *Congressional Review Act* further provides that a disapproved rule may not be reissued in substantially the same form, nor may a new rule that is substantially the same be issued, unless specifically authorized by a subsequently enacted law (5 U.S.C. § 801(b)(2)).

Section 5(a)(1) of the *Occupational Safety and Health Act*—the *General Duty Clause*—requires each employer to provide employees with employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm (29 U.S.C. § 654(a)(1)). According to OSHA's *Field Operations Manual*, establishing a violation of this clause requires showing that

the employer failed to keep the workplace free from a hazard to which employees were exposed; that the hazard was recognized; that it was causing or was likely to cause death or serious physical harm; and that a feasible and useful method existed to eliminate or materially reduce the hazard (OSHA, 2020).

The *Occupational Safety and Health Review Commission* has recognized the potential applicability of the *General Duty Clause* to ergonomic hazards. In *Secretary of Labor v. Pepperidge Farm, Inc.* (OSHRC Docket No. 89-0265, 1997), the Commission held that the clause could be applied to hazards arising from lifting and repetitive-motion activities. With respect to lifting, the Commission affirmed violations classified as *willful* and found that recognition of the hazard was supported, among other evidence, by memoranda from the company's corporate ergonomist, medical records, and communications from its insurer. By contrast, with respect to repetitive-motion allegations, the Commission upheld dismissal because the Secretary had not sufficiently demonstrated that the additional measures proposed were feasible and that their effectiveness justified requiring them in light of the measures the employer had already implemented.

The implications for BPESP are twofold. Economic justification does not replace the preventive duty; rather, it complements it. At the same time, documentation can operate in both directions: a technical assessment that identifies and quantifies a hazard may constitute evidence of the employer's recognition of that hazard, while documentation of feasible controls, their implementation, and subsequent follow-up may demonstrate the organization's preventive response. Accordingly, the protective value of traceability depends on whether risk identification is translated into effective action. An organization that identifies a hazard, documents its level using technically defensible methods, selects feasible controls, implements them, and preserves evidence of the process strengthens its preventive due diligence and internal risk governance. Technical documentation alone, however, does not guarantee legal compliance and must correspond to actions actually implemented. This interpretation is consistent with OSHA's policy for follow-up of ergonomic hazards through *Ergonomic Hazard Alert Letters* (OSHA, 2007).

Because the facility analyzed in this study is located in Texas, the legal framework governing compensation for occupational injuries and illnesses presents an additional characteristic. In Texas, subject to certain statutory exceptions, private employers may elect whether to obtain workers' compensation coverage (Tex. Lab. Code § 406.002(a)). When an employer does not have coverage under the workers' compensation system authorized by law, it may not assert, in an action brought by an injured employee, the defenses of contributory negligence, assumption of risk, or negligence of a fellow employee. Nevertheless, the claimant remains responsible for proving negligence by the employer or by an agent or employee acting within the general scope of employment (Tex. Lab. Code § 406.033(a), (d)).

This distinction should be kept separate from the economic analysis developed in the present study. OSHA Safety Pays uses average costs of lost-time workers' compensation claims supplied by the National Council on Compensation Insurance and corresponding to policy years 2015–2017. Accordingly, those values are used exclusively as a general economic reference and do not permit inferences regarding the organization's coverage status or its actual claim costs (OSHA, n.d.).

Finally, the existence of separate legal regimes does not imply a complete absence of coordination with federal social security protections. When an individual receives Social Security Disability Insurance (SSDI) together with certain workers' compensation benefits or public disability benefits, SSDI benefits may be reduced when the combined amount exceeds 80% of the individual's average current earnings before disability. The reduction continues until the month in which the worker reaches full retirement age or until the other benefits cease, whichever occurs first (Social Security Administration [SSA], 2024). It is therefore more accurate to describe a fragmented architecture with partial coordination mechanisms than to characterize these systems as entirely disconnected. Table 3 summarizes the main legal and institutional instruments discussed above and their implications for the preventive and economic interpretation of BPESP.

Table 3. *Legal and Institutional Framework Relevant to the Preventive and Economic Interpretation of the Case*

Instrument / institution	Relevant content	Implication for BPESP
OSH Act § 5(a)(1), 29 U.S.C. § 654(a)(1)	Duty to maintain a workplace free from recognized hazards that cause or are likely to cause death or serious physical harm.	Supports the preventive dimension and the need to identify and control recognized hazards.
OSHA *Field Operations Manual* (2020); *Pepperidge Farm* (OSHRC, 1997)	Defines the elements of a *General Duty Clause* violation and recognizes its applicability to lifting and repetitive-motion hazards.	Documented assessment may evidence recognition of the hazard; the response should include feasible and effective measures.
Congressional Review Act, 5 U.S.C. § 801(b)(2); Pub. L. 107-5	Nullified the 2000 federal ergonomics standard and restricts reissuance of a substantially similar rule.	Explains why ergonomic risk management does not currently rest on a specific general federal ergonomics standard.
Tex. Lab. Code §§ 406.002, 406.033	Workers' compensation coverage is generally elective for private employers; an employer without coverage loses certain traditional defenses.	The economic and legal consequences of an occupational injury may vary according to the applicable coverage status.
SSA – WC/PDB offset	Certain workers' compensation or public disability benefits may result in a reduction of SSDI benefits.	Demonstrates partial coordination among protection mechanisms.
OSHA – Safety Pays	Economic awareness tool based on average claim costs; it does not create legal obligations or estimate company-specific costs.	Provides an external reference for the ex ante economic analysis.

Primary prevention, productivity, and social protection

The prevention of work-related musculoskeletal disorders (WMSDs) has effects that extend beyond the workstation. An occupational injury may generate costs for both the employer and the worker and, depending on the applicable coverage framework, may involve workers' compensation mechanisms, healthcare services, and certain disability benefits. The way in which those costs and benefits are distributed depends on the specific case, the jurisdiction, and the coverage in place. In Texas, where workers' compensation coverage is generally elective for private employers, a uniform distribution of those costs cannot be assumed (Tex. Lab. Code §§ 406.002, 406.033). Likewise, certain workers' compensation or public disability benefits may interact with Social Security Disability Insurance (SSDI) benefits through offset mechanisms established under federal social security rules (SSA, 2024). From a preventive perspective, reducing exposure before harm occurs may decrease the need to activate these mechanisms and help preserve work capacity.

The added value of BPESP lies in making visible, before an injury occurs, the physical risk, the need for feasible controls, and the economic dimension of the decision. In this case, post-implementation follow-up provides favorable operational signals, but the absence of a quantitative reassessment requires continued caution regarding causal interpretation. Even so, the combination of technical assessment, implementation evidence, and transparent economic analysis makes it possible to present ergonomics as a preventive and productive investment without overstating the available results. OSHA Safety Pays is used solely as an external economic reference and not as an estimate of the organization's actual costs or its specific coverage status (OSHA, n.d.).

Study limitations

- The study is limited to a single workstation case; its findings are not automatically generalizable to other facilities or sectors.
- No quantitative post-intervention reassessment using REBA, NIOSH, or biomechanical modeling was available. Therefore, the reduction in residual risk is not numerically estimated, and no confirmed transition to a specific color-coded risk category is claimed.

- Post-implementation follow-up is descriptive and is based on photographic evidence and the technical project lead's report. The reported absence of incidents, absenteeism, discomfort, or fatigue was not independently verified in this manuscript through clinical or administrative records.
- The economic analysis uses average OSHA Safety Pays costs based on lost-time claims from policy years 2015–2017. These values constitute a general economic reference and do not necessarily reflect current or organization-specific costs.
- Operational benefits such as reduced downtime, changes in headcount, throughput, overtime, productivity, or indirect costs were not monetized; therefore, ROI, NPV, IRR, and payback period were not calculated using actual post-implementation economic flows.
- The legal analysis is interpretive and contextual in nature; it does not constitute a determination of regulatory compliance or legal liability on the part of the organization. The specific workers' compensation coverage status of the employer analyzed was also not verified; therefore, no specific conclusions are drawn regarding coverage, claim costs, or litigation exposure.
- The identity of the company and its suppliers remains anonymized, and the images included were edited to reduce personal and commercial identifiers.

Final considerations

The case provides documentary evidence that BPESP can function as a decision-making architecture rather than merely as an assessment tool. The observed sequence—operational alert, quantitative analysis, identification of contributing factors, control recommendations, project formalization, implementation, and follow-up—demonstrates preventive traceability that can be audited and methodologically replicated.

The baseline assessment identified significant exposure: 65-lb boxes, 1,040 lifts, and approximately 31.2 metric tons handled per shift, with a REBA score of approximately 8, a NIOSH Lifting Index greater than 3, and biomechanical and postural findings that justified intervention at the source of the risk. The implemented solution incorporated conveyors, vacuum-assisted handling, and mechanized palletizing, thereby physically modifying the worker-load interaction.

Initial operational follow-up after system commissioning reported no task-related incidents or absenteeism and no complaints of discomfort or fatigue, although these findings are descriptive and do not substitute for a quantitative reassessment. From an economic perspective, the break-even analysis shows that the documented capital investment is approximately equivalent to the average direct cost of 4.06 occupational strain claims according to OSHA Safety Pays, without including indirect costs or productivity gains. This equivalence constitutes an ex ante economic reference and is not an estimate of injuries avoided, realized savings, or organization-specific costs.

From a legal perspective, the economic incentive does not replace the preventive duty. The General Duty Clause remains relevant to recognized ergonomic hazards when its requirements are met, and the traceability generated through a methodology such as BPESP may help document both recognition of the hazard and the preventive response adopted. Its value as evidence of due diligence depends on risk identification being followed by the selection and implementation of feasible controls and by effective follow-up. Technical documentation alone does not guarantee legal compliance.

The main direction for future research is to incorporate a quantitative post-intervention reassessment and actual economic flows in order to complete a longitudinal evaluation of the technical and financial performance of the intervention.

Acknowledgments

To our collaborators.

Conflict of Interest

Felipe Larez is the author and developer of the BPESP methodology evaluated in this study; this role is disclosed as a potential intellectual interest. The article does not attribute promotional outcomes to any brands, suppliers, or commercial platforms.

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