

Analysis of personal and work-related factors contributing to construction industry accidents in Peru

Análisis de los factores personales y laborales que contribuyen a los accidentes de la industria de la construcción en el Perú

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ABSTRACT

The purpose of this research is to examine the relationship between individual and occupational risk factors and accidents at road construction sites in Lima, Peru. The research was conducted using a correlational design, analyzing the causes of accidents through safety inspection reports and independent accident investigations. The study population included all employees who suffered lost-time accidents during their workday. Associations between variables were determined using descriptive statistics, inferential statistics, and comparative tables. The results suggest that personal and occupational factors contribute to accidents at road construction sites in Lima, Peru. After the root causes of accidents were identified and addressed, the accident rate decreased significantly in 2017 and 2018. Supervision was found to be the primary means of accident prevention, while leadership is essential to motivate workers to adhere to established standards of conduct.

Keywords: Occupational accident, occurrence, work-related ailment, risky action, hazardous circumstance, immediate trigger, underlying cause, individual factor, work-related factor.

RESUMEN

El propósito de esta investigación es examinar la relación entre los factores de riesgos individuales y laborales y los accidentes en las obras de construcción de carreteras en Lima, Perú. La investigación se llevó a cabo mediante un diseño correlacional, analizando las causas de los accidentes a través de informes de inspección de seguridad e investigaciones independientes de accidentes. Se incluyó en la población de estudio a todos los empleados que sufrieron accidentes con baja durante su jornada laboral. Las asociaciones entre variables se determinaron mediante estadísticas descriptivas, estadísticas inferenciales y tablas comparativas. Los resultados sugieren que tanto los factores personales como los laborales contribuyen a los accidentes en las obras de construcción de carreteras en Lima, Perú. Después de que se identificaron y abordaron las causas raíz de los accidentes, la tasa de accidentes disminuyó significativamente en 2017 y 2018. Se determinó que la supervisión es el principal medio de prevención de accidentes, mientras que el liderazgo es esencial para motivar a los trabajadores a adherirse a las normas de conducta establecidas.

Palabras claves: Accidente de trabajo, ocurrencia, dolencia laboral, acción riesgosa, circunstancia peligrosa, desencadenante inmediato, causa subyacente, factor individual, factor laboral.

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I. INTRODUCTION

Workers are committed to safety from the start of their jobs, and they, along with their employers, take responsibility for preventing work-related injuries and illnesses.

Most construction projects are completed on time, with only a small percentage of total time lost to delays.

The International Labor Organization (ILO) has published new estimates showing that a large number of people die every day as a direct result of occupational accidents and diseases. Around 1.9 million people a year lose their lives as a result of these causes. An estimated 90 million DALYs are lost as a result of exposure to the 19 major occupational risk factors. An additional 360 million people are injured at work each year, and these injuries account for an average of more than four days of sick leave (ILO, 2019)². Occupational accident causes and effects can be identified and reported quickly, but these statistics only tell part of the story because they exclude people who aren't covered by any social security programs. In addition, underreporting is widespread across all nations (PAHO - WHO 2015) As a result of the necessary medical leave that they necessitate, work-related injuries can lead to employee absenteeism (3). These injuries can have a negative impact on a person's life in many ways: professionally, because they prevent them from engaging in their usual duties, and personally, because they mean they can't go about their daily routines as usual until they've fully recovered from their injuries. Because of this absenteeism, execution deadlines are pushed back, and in an effort to meet the agreed upon deadlines, the workload is accelerated, which raises stress levels among employees and, ultimately, causes additional accidents, which disproportionately affect workers who are already injured. There are several ongoing construction projects in Peru, all of which have experienced accidents for a variety of reasons. There is currently an Occupational Safety and Health Law based on nine principles to safeguard employees, but there is no data analyzing accident causes to use as a tool for reducing injuries.

Workplace accidents, dangerous incidents, and occupational diseases affect the progress of many Lima construction projects. A direct result of these occurrences is an increase in the urgency with which the aforementioned projects or works must be completed to meet delivery deadlines and avoid paying penalties outlined in the contract for not meeting the agreed-upon delivery date. On the other hand, the construction sector activity is subject to public and private investment directed to works such as hospitals, public offices, schools, and urban improvement (Del Águila, 2021)⁴. The construction sector is one sector in

which workers and visitors to construction sites are particularly vulnerable to injury. (Duarte, 2018).⁵

Studies by Frank Bird (1986) suggest that a lack of control is the root cause of accidents. From this lack of control, two other factors come into play: the worker's characteristics and the nature of the work itself. It is a basic human right to be able to leave work without fear of harm, and no one should ever lose their life or be seriously injured at work. However, to reach this ideal state, much more work needs to be done around accident prevention than is currently being done. (Saravia, 2018)⁶.

A practice recommended by the Ministry of Labor and Employment Promotion in the investigation of accidents is using the TASC method (Table of Systematic Analysis of Causes); the TASC is a complementary method to the management systems that formalize the analysis of causes based on the ISO 45001 standard. To do so, it provides a set of interconnected standardized scenarios that lead to a causal link between a risk event identified in practice and the severity of the incident or nonconformity caused by it (Baylón, 2019)⁷. The Behavioral Observation Model can be applied to safety to understand better the causes of accidents and unsafe behaviors in the workplace. (OCAS) to modify unsafe behaviors of workers (Rodríguez 2020)⁸, so it should be taken into account that the organization of the work area through the implementation of the 5S' technique allow the comprehensive training of industrial training centers since it is the work environments that influence the occurrence of accidents (Rosales, 2019)⁹.

The Ministry of Labor and Employment Promotion compiles monthly reports on work-related accidents and incidents in Peru. These reports contain information on the total number of accidents, the number of fatal accidents, the total number of accidents resulting in lost time, occupational diseases, and incidents that occurred during the specified month. accidents, fatal accidents, lost time accidents, occupational diseases, and incidents that occurred in the month preceding publication; only reference tables are presented as occurrences by regions, economic sectors, sex of injured party, injured body part, causing agent, occupational category of injured party, and type of accident (aggression with weapons, entrapment, running over, falls, etc).

This lack of investigation into the causes of accidents is compounded by the fact that companies rarely report accidents and even less often determine their causes.

2 International Labour Organization, Occupational Safety and Health, <https://www.ilo.org/global/topics/safety-and-health-at-work/lang-es/index.htm>

3 Pan American Health Organization - World Health Organization, Plan of Action on Workers' Health 2015- 2025 67th Session of the WHO Regional Committee for the Americas.

4 Edson Del Águila G., 2021, Influence of the application of the G050 standard on the safety climate of construction sites in the Surquillo district.

5 Pedro M. Duarte K., 2018, Improvement of the G050 Standard to Decrease Accidents During Construction Peru.

6 Miguel A. Saravia L, 2018, Relationship between psychological profile and accident rate in an industrial factory.

7 José Baylón M. - Patricia Santillán G, 2019, Determinants of accidents in large-scale projects in the construction sector.

8 Pavel Rodríguez P., 2020, Implementation of the behavioral observation model applied to safety (OCAS) to increase safe behaviors and reduce unsafe behaviors in polymetallic mining workers.

9 Víctor G. Rosales U., 2019, Implementation of the 5S's program for the improvement of training in industrial training centers.

Occupational illness and injury rates have risen because of service liberalization and privatization. And some signs suggest the rate of workplace injuries and illnesses is rising again, even though prevention efforts have regressed since 1983. (Draft Law on Occupational Safety and Health 2010) Factors at both the worker and the job site level were found to play a role in the ten most common causes of accidents on road construction sites in Lima, Peru, between 2017 and 2018.

II. METHODS

During the 18th and 19th centuries, the industrial revolution took place across Europe, the United States, and some European colonies, there was a dramatic increase in awareness of the problem of workplace injuries and fatalities (ILO 2019). According to this information, workers' practices changed during the industrial revolution, which coincided with the rise of steam-powered machinery, the mechanization of previously manual tasks, and the development of new methods of organization in the workplace. That's because, prior to the revolution, humans used all their strength to combat machines.

The International Labor Organization (ILO) is a tripartite United Nations agency that was founded in the early 20th century due to rising concerns about worker safety and health. The International Labor Organization (ILO) brings together 187 countries' governments, businesses, and workers to set minimum wage, hours worked, and other labor standards, as well as to create policies and programs to ensure that all workers, regardless of gender, are treated fairly in the workplace. As part of its mission to protect workers around the world, the International Labor Organization (ILO) has issued a set of standards for doing so. These standards are binding for all ILO members, including Peru, and have been ratified by the appropriate authorities in accordance with Peruvian law.

When it comes to evaluating the efficacy of a business' loss prevention services, all eyes should be on the Accident Ratio (Figure 1), first introduced in Practical Leadership in Loss Prevention (Bird & Germain, 1986).

It is important to remember that the 1-10-30-600 ratio shown in Figure 1 only accounts for the reported accidents and incidents and not the actual number of accidents that occurred. (Bird, 1986)¹⁰. Most workplace accidents result in relatively minor injuries due to worker carelessness, laziness, poor posture leading to back injuries, lack of economic incentives or recognition, defective or outdated safety equipment, and exposure to corrosive chemicals. However, companies have a safety plan and workers face hazardous conditions when performing specific tasks, so it is imperative that they implement mechanisms and use protective equipment to minimize and eliminate occupational accidents (Garay 2020).¹¹

The Peruvian government passed its first occupational safety and health law, the Industrial Safety Regulation (D.S. 42-F), in 1964, and its second, the Regulation for the Opening and Sanitary Control of Industrial Plants (D.S. N° 29/65 D.G.S.), in 1965. Occupational Safety and Health Regulations, published in 2005, were revised in D.S. 007-2007. Permissible Values for Chemical Agents in Work Environments, originally published in 2005, was also revised in 2015.

The International Labor Organization (ILO) published "Guidelines concerning the management of safety and health at work ILO-OSH 2001" in response to the increasing incidence of workplace injuries and illnesses. This document is therefore intended to serve as a guide for nations that wish to voluntarily apply these guidelines and manage safety and health at the national level. With suggestions from the principles that the national policy should include and moving on to the organization, planning and application, evaluation, and actions for improvement—

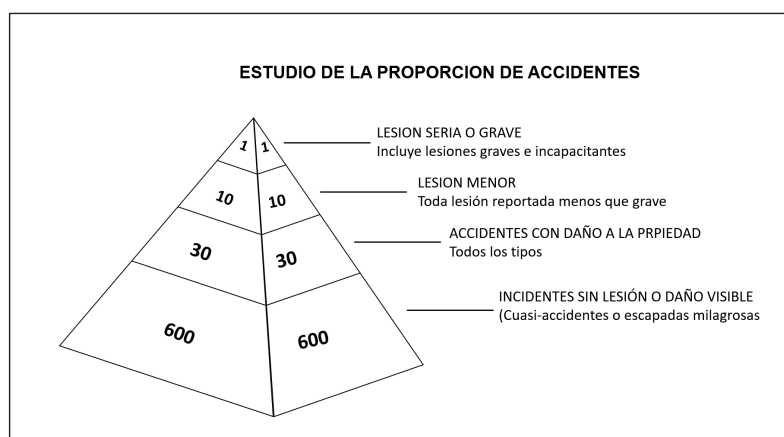


Figure 1. Study of Bird's accident rate
Source: Loss Prevention Expertise at the Head of the Pack

¹⁰ Frank E. Bird, Jr - George L. Germain, 1986, Practical Leadership in Loss Control p. 21.

¹¹ Juana Garay T., 2020, Risk factors and occupational accidents in construction companies, Lima 2019.

the “continuous improvement” cycle used in the OHSAS 18001:2007 and ISO 45001:2018 model management systems—this document establishes implementation guidelines for a national management system. Guidelines at the international, national, and even organizational levels should be consistent with one another and sufficiently adaptable to permit either direct or specific application. (ILO-OHS, 2001)¹² Also a recommendation for national guidelines is number 13, as indicated in Figure 2.

The explanatory memorandum references Law 29783, also known as the Law on Safety and Health at Work, which was passed in Peru in 2011 when discussing the national regulatory framework. While occupational safety and health regulations have been expanding in individual industries, there is currently no overarching legal or policy framework controlling their scope. Article 168-A of the Criminal Code, titled “Attempt against the conditions of safety and health at work,” was added in 2013 by Law 30222, which amends Law 29783¹³, and was further modified in 2019 by Emergency Decree No. 044-2019, expanding its scope of application. The article describes the punishment for those who deliberately violate occupational safety and health standards and put their workers’ lives, health, or physical integrity in imminent danger. If death or serious injury occurs as a result of the agent’s deliberate disregard for occupational health and safety regulations and the agent could have foreseen this outcome, the agent will be sentenced to between four and eight years in prison for death and between three and six years for serious injury.

The Occupational Safety and Health Regulation for the Construction Sector was approved by the Supreme Decree D.S. 011-2019-TR in 2019, which established a Sectoral Standard for the construction industry. In 2012,

the D.S. 005-2012-TR Regulation of Law 29783 provided guidelines for complying with the Law of Safety and Health at Work, serving as a reference for its implementation. The Ministry of Labor, not the Ministry of Housing, issued this sector-specific regulation through a Supreme Decree with Supra-sectorial characteristics, meaning it applies to construction activities regardless of the industry or sector. Despite this trend, there has been no decrease in the number of accidents at construction sites over the past five years, as demonstrated in the Figure 3. In 2019, the Ministry of Labor and Employment Promotion received the highest number of accident reports on record, in addition to this, Figure 4 shows the accidents that occurred in the construction and real estate sector.

III. RESULTS AND DISCUSSION

This study was conducted in the context of a road construction site in Lima, Peru, and is an applied, rather than experimental, study of the causes of accidents at the site.

The contribution of individual and workplace variables to occupational accidents is a fundamental research question. The objective of this project is to investigate the potential correlation between individual and workplace risk factors, which will be the independent variables, and the dependent variable. The main focus of this research is to determine whether or not there is a connection between these factors.

This study used a correlational design, analyzing the causes of accidents based on the results of separate accident investigations and examining safety inspection reports.

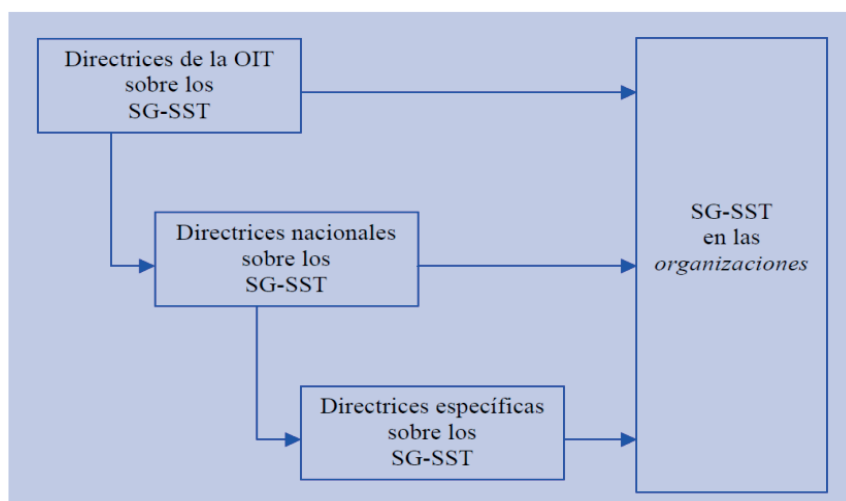


Figure 2. Components of the Federal Regulations Establishing Requirements for Occupational Health and Safety Management Systems
Source: OLO-OHS 2001

12 ILO-OHS, 2001. Guidelines on occupational safety and health management systems.
13 Law 29783, Occupational Health and Safety Law

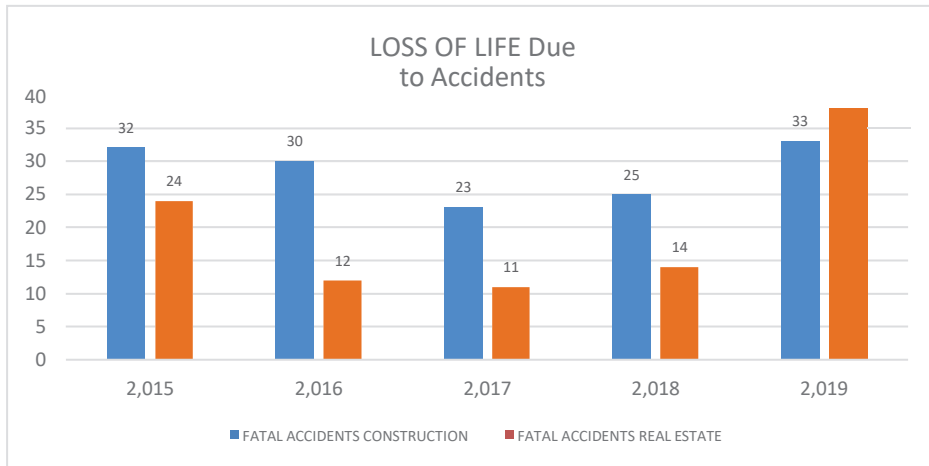


Figure 3. Mishaps in the building and housing industries that claim lives

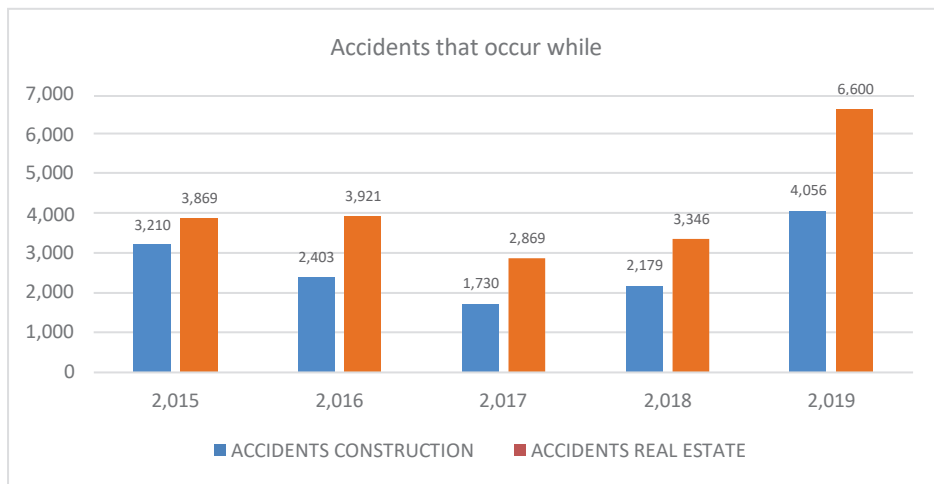


Figure 4. Incidents at work in the building and housing industries

Since all workers who experienced lost-time accidents within the study’s time frame are of interest, all such workers constitute the study’s intended population.

Descriptive statistics, inferential tables, and comparative tables were used to establish associations between variables.

The data for this study was collected from a road construction project in Lima, Peru, spanning from January 2017 to July 2018. Accidents during the project’s development since 2013 were taken as a reference point. The project had an accumulated frequency rate of 2.62 during the period under consideration. In 2017 and 2018, the frequency rates were 1.26 and 1.08, respectively. Table 1 presents the relevant information regarding the frequency rates of accidents during the study period.

These tables show that the project has an initial accident rate of over three workers per million man hours, rising to over four workers per million hours in 2015 and 2016, and then dropping to one worker per million

man hours in 2017 as a result of permanent inspections. They also show the correlation between ASTP (accidents involving only minor damage), ACTP (accidents involving major damage), and fatal accidents.

Calculating man-hours worked and the number of accidents that occurred during the period is essential for determining the IF:

$$IF = \frac{N}{H} \times 1'000,000$$

H- man

Where:

IF: Accident Frequency Index

N: Number of accidents occurring in the period

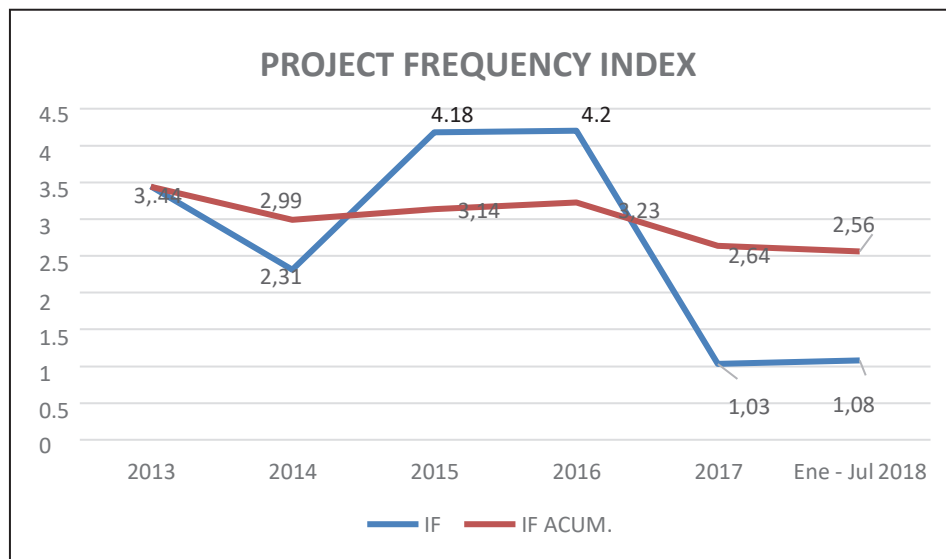
H-man: Number of man-hours worked during the period

Using the data presented in the aforementioned graphs and the results of the accident frequency rate calculation, we can trace the rate’s development as the project progressed, which we can see in Figure 5.

Table 1. Yearly and cumulative frequency and severity rates for the project

Año	Prom. trab.	Max. working hours	H -malee	ASTP	ACTP	Fatal	Days lost	Total accid.	IF	IF accumulated	IS	IS accumulated
2013	2.839	3.159	11.625.873	0	40	0	238	40	3,44	3,44	20,47	20,47
2014	2.633	3.697	7.778.739	3	18	0	167	21	2,31	2,99	21,47	20,87
2015	1.321	1.701	2.869.654	1	11	1	10.145	13	4,18	3,14	3,535,27	473,64
2016	714	1.397	1.903.464	4	8	0	127	12	4,20	3,23	66,72	441,60
2017	3.071	4.597	8.732.028	11	9	0	125	20	1,03	2,64	14,32	328,23
Jan - Jul 2018	1.051	2.289	1.850.978	1	2	0	0	3	1,08	2,56	0,00	310,75
Totals	1.938	4.597	34.760.735	20	88	1	10.802	109		2,55		310,75

Figure 5. Evolution of the Frequency Index



3.1 Numerical Outcomes

HG: In the Road Works industry in the city of Lima during the years 2017 and 2018, accidents are influenced by both individual and workplace factors.

HO: During the period of 2017-2018, accidents in Road Works in the city of Lima are not influenced by either personal or work factors.

As shown in Table 2, there is a moderate amount of correlation between the independent variables and the dependent variable (0.620), as indicated by the coefficient of determination (R).

According to Table 3, when the p-value of a hypothesis test (0.38) is greater than 0.05, it means that the null hypothesis is not rejected and the model is not significant.

Based on the coefficient results from Table 4, it appears that the personal factor is not a significant part of the model (p-value > 0.05), while the work factor is (p-value 0.05), suggesting that the personal factor is a moderating one (indicating that it is a significant part of the research).

According to Table 5, the low value of R (0.252) indicates that only 25.2% of the variation in the independent variables can be accounted for by changes in the dependent variable.

As indicated in Table 6, the model is not significant in general, as the p-value (0.585) is greater than 0.05, indicating that the null hypothesis is not rejected.

The coefficient results in Table 7, that the personal factor is not significant in the model because its associated p-value (0.585) is larger than 0.05.

The rate of accidents during Road Works in Lima, Peru, was affected by work-related factors between 2017 and 2018.

HO: During the period of 2017-2018, work factors do not influence the occurrence of accidents in Road Works in the city of Lima.

According to the results shown in Table 8, low levels of explanatory power (R = 0.48) suggest that only about half of the variation in the dependent variable can be accounted for by the variation in the independent variable.

Table 2. Summary of the model

Model	R	R square	Adjusted R-squared	Standard error of the estimate
1	,620 ^a	,384	,076	5,62884

Table 3. Analysis of variance

ANOVA ^a						
	Model	Sum of squares	gl	Root mean square	F	Sig.
1	Regression	78,979	2	39,490	1,246	,380 ^b
	Waste	126,735	4	31,684		
	Total	205,714	6			

Table 4. Coefficients

	Modelo	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Error estándar	Beta		
1	(Constant)	6,018	3,916		1,537	,199
	PERSONAL FACTOR	-,614	,616	-,406	-,998	,375
	WORK FACTOR	1,374	,953	,586	1,442	,023

Table 5. Summary of the model

Model	R	R square	Adjusted R-squared	Standard error of the estimate
1	,252 ^a	,064	-,124	6,20663

Table 6. Analysis of variance

ANOVA ^a						
	Model	Sum of squares	gl	Root mean square	F	Sig.
1	Regression	13,103	1	13,103	,340	,585 ^b
	Waste	192,611	5	38,522		
	Total	205,714	6			

Table 7. Coefficients^a

	Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Standard error	Beta		
1	(Constant)	9,739	3,248		2,998	,030
	PERSONAL FACTOR	-,382	,655	-,252	-,583	,585

Table 8. Summary of the model

Model	R	R square	Adjusted R-squared	Standard error of the estimate
1	,480 ^a	,231	,077	5,62607

According to what is indicated in Table 9 of Analysis of Variation, given that 0.275 is greater than 0.05, it is not possible to reject the null hypothesis and declare the model to be statistically insignificant.

From the result of coefficients shown in Table 10, the p-value (0.025) associated with the individual component in the model is less than 0.05, as shown by the coefficient results.

IV. CONCLUSIONS

There are only two true causes of accidents: carelessness on the part of those involved and the presence of unsafe conditions. This means that there have never been any accidents where the employee’s own carelessness was the sole cause of harm, as the workplace was always completely risk-free.

Unsafe behaviors and settings can be reduced significantly if the proper precautions are taken. According to the “pyramid of accident proportions,” the most common type of accident is one that causes no noticeable damage or injuries. Unsafe behaviors and environments are the direct causes of accidents, so they provide a solid base for understanding the causes of accidents. After identifying and addressing their root causes, accidents decreased significantly in 2017 and 2018, as demonstrated by this study.

Leadership is the cornerstone of accident prevention; a leader’s inspiration to his or her employees serves as a roadmap for doing things correctly, adhering to established work standards and, most importantly, inspiring followers to emulate their leader.

Supervision is the primary method of accident prevention because it is so useful for eradicating immediate causes.

Workers’ decisions to engage in unsafe behavior are influenced less directly by factors external to the workplace and more by those internal to the worker themselves.

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Law 29783, *Ocupacional Health and Safety Law, Perú*

Table 9. Analysis of variance

ANOVA ^a						
	Model	Sum of squares	gl	Root mean square	F	Sig.
1	Regression	47,451	1	47,451	1,499	,275 ^b
	Waste	158,263	5	31,653		
	Total	205,714	6			

Table 10. Coefficients

Coefficients ^a						
	Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Standard error	Beta		
1	(Constant)	4,729	3,695		1,280	,257
	WORK FACTOR	1,126	,920	,480	1,224	,025

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Conflict of interests

The author declares no conflicts of interest.