

## The delay of consequences and perceived risk: an analysis from the workers' view point

### La demora de las consecuencias y el riesgo percibido: un análisis desde el punto de vista del trabajador

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#### Abstract

This paper addresses the question of how construction workers perceive occupational risks. It is a question that has not been addressed in scientific research. Specifically, we answer the following research questions: what is the perception of risk of construction workers?; what aspects of risk significantly influence the formation of the overall perception of risk?; are there sociodemographic variables that help to understand the perception of risk of construction workers? and if this were the case, then what are these variables and how do they influence them?. Ultimately, it examines the profile of perceived risk, its relation to the delay of consequences and the influence of socio-demographic variables.

Respondents filled out a questionnaire in the presence of the survey-taker. The questionnaire was based on the psychometric paradigm, and was comprised of: (a) nine questions, each exploring a perceived risk attribute or dimension rated on a Likert 7-point scale, (b) a question on global risk perception, and

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(c) categorical questions about socio-demographic issues. The survey was conducted in the city of Granada (Spain).

A profile of the construction workers' perceived risk was obtained. Answers to each attribute were above the neutral line (scores above four). The profile shows the risk dimension with the highest score was the delayed consequences of exposure to risk conditions, a dimension that can be related to ergonomics and occupational hygiene. This is a new outcome since traditionally this dimension was given a lower score in the worker's perception. A simple linear regression showed global risk may be explained in terms of the delayed consequences dimension ( $R^2=0.29$ ). Finally, a variance analysis (ANOVA) and several t-tests explored the relationship between this dimension and the sample's socio-demographic variables.

To conclude, the delay of consequences is the risk dimension workers perceived as the most critical in their daily chores. In addition, this risk dimension is decisive in creating a high global risk perception. Parenthood, a higher worker category and training are the only socio-demographic variables having an impact on this dimension of perceived risk. Hence, there is a direct relationship between these two variables.

-----**Keywords:** perceived risk, occupational hygiene, ergonomics, prevention

## **Resumen**

Este artículo aborda el problema del desconocimiento por parte de la ciencia de cómo perciben el riesgo laboral los trabajadores de la construcción. Específicamente, se da respuesta a las siguientes cuestiones de investigación: ¿cuál es el riesgo que perciben los trabajadores de la construcción?; ¿qué aspectos del riesgo influyen de forma significativa en la formación del riesgo percibido global?; ¿existen variables sociodemográficas que ayuden a entender la percepción del riesgo de los trabajadores de la construcción?, y en caso afirmativo, ¿cuáles son estas variables y de qué forma influyen? En definitiva, se examina el perfil del riesgo percibido, su relación con la demora de las consecuencias y la influencia de las variables socio-demográficas.

Los participantes rellenaron un cuestionario en presencia del encuestador. El cuestionario se basaba en el paradigma psicométrico, y se componía de: (a) nueve cuestiones, donde cada una de ellas exploraba un atributo o dimensión del riesgo en una escala Likert de 7 puntos, (b) una pregunta global de la percepción del riesgo, y (c) preguntas sociodemográficas acerca de ellos mismos. La muestra se consiguió en Granada (España).

Como resultado se obtuvo un perfil del riesgo percibido para el trabajador de la construcción. Las respuestas a cada atributo siempre estuvieron por encima de la línea neutral (puntuaciones superiores a cuatro). El perfil muestra que el atributo con mayor puntuación fue el atributo relacionado con la demora de las consecuencias en la exposición al riesgo, una dimensión que puede estar

relacionada con la ergonomía y la higiene. Esto es un resultado novedoso ya que tradicionalmente esta dimensión ha obtenido una puntuación menor en la percepción que el trabajador tiene frente a la inmediatez de los efectos. Una regresión lineal muestra que el atributo global del riesgo puede ser explicado por la demora de las consecuencias ( $R^2=0.29$ ). Finalmente, mediante un análisis de la varianza (ANOVA) y varios análisis T se exploró la relación entre esta dimensión y las variables sociodemográficas de la muestra.

En conclusión, la demora de las consecuencias es la dimensión del riesgo que los trabajadores perciben más crítica en sus tareas diarias. Además, esta dimensión del riesgo es determinante en la creación de una alta percepción del riesgo global. La paternidad, una categoría laboral superior y la formación son las únicas variables sociodemográficas que tienen impacto en esta dimensión de la percepción del riesgo. Por consiguiente, hay una relación directa entre estas dos variables.

-----*Palabras clave:* riesgo percibido, higiene ocupacional, ergonomía, prevención

## Introduction

European Directive 89/391/EEC was enacted as a local law in Spain through Law 31/1995, or Spain's Labor Risk Prevention Act. This law was enacted for the construction industry through Royal Decree 1627/1997, dated October 24, that established the minimum safety and health standards for construction jobs. The law requires companies to be actively involved in its enforcement, although under article 19.2 it also determines workers are obliged to follow safety and hygiene regulations. The law's basic underlying principle is that all workers must receive appropriate training for the specific job they perform.

In Spain, as in other countries, a risk assessment is required before starting a project. Traditionally, project risk assessments were based on expert [1, 2]. In Spain, these assessments typically follow the methodology outlined by the National Labor Occupational Safety and Hygiene Institute (Instituto Nacional de Seguridad e Higiene en el Trabajo, INSHT), the highest authority in this field. However, [3] hold experts' risk evaluations are typically biased because of their own perception of risk and past experience. Nor are these assessments performed following

a systematic process. Moreover, the experts' experiences are actually distorted memories, and thus the objectivity of such risk assessments may be questioned [3].

Additionally, non-expert risk assessments have been typically rejected by both experts and governments because of their presumed partial nature [4, 5]. These approaches, in fact, exclude the workers from the process, even though they are directly affected by these evaluations. In other way, [6] created a method to carry out risk evaluations based on the seriousness and likelihood of accident occurrence. It claims to be an objective method, but forgets that risk evaluations are subjective [7]. Along this line of thinking, [8] cite a publication from The Royal Society defining risk in terms of the likelihood and consequences of occurrences. However, that definition omits a major factor, i.e. the basically human and social nature of risk. This paper examines risk in the construction industry from the construction worker's perspective.

## ***Risk and the perception of risk***

The International Organization for Standardization (ISO) defines risk as "the combination of events' likelihood and consequences" [9]. Other authors,

including [10], define it as “something negative that may happen in the future”. Risk analysis has been carried out from as far as engineering disciplines and philosophy [11]. Among others, [12] has provided up many formal definitions of risk.

Risks exist in any activity. So, [13] claims that it is impossible to completely cancel risk. Along the same line, almost 30 years earlier, [14] devised a theoretical mathematical formula defining risk as hazard divided by adopted safety measures. In this line of thinking, risk could be reduced by increasing safety measures, but could never be totally canceled.

First, [15] defines the perception of risk as the subjective likelihood of occurrence of a negative event. Second, [16] explains it as a personal assessment of the likelihood of occurrence of a non-desired consequence. The perception of risk is intimately related to the concept of risk itself. Therefore, explaining perceived risk has been the most important component of risk research itself [17].

According to [18] hold workers’ behavior before various risks depends, partly, on their perception of risk. They add the level of perceived risk is connected to a self-protective behavior [19-21]. In turn, [22] hold the workers’ experience has an influence on their perception of risk. The relationship between perceived risk and safe behavior has been studied in depth, e.g., [23-29].

The perception of risk can vary from one individual to another and even change over time for the same person [30]. In other words, people’s perception of risk may change [31]. Many authors have shown previous accidents suffered by workers positively change their perception of risk at work [32-35]. Other authors have [36, 37] reached similar conclusions from the ergonomic standpoint.

The relationship of socio-demographic factors to risk perceptions has been studied from different standpoints. These factors include: age [38], schooling [15], income [39], training [40, 41],

gender, ethnicity and socio-economic status [42-45]. However, despite abundant studies that examine perceived risk, not many studies have focused on the construction industry, and even less from the standpoint of disciplines such as ergonomics and hygiene.

### ***Psychometric paradigm***

In the mid 60s and early 70s initial research was done into what is known now as *perceived risk* [46-49].

This article applies the psychometric paradigm. This model proposes addressing risk as a multi-dimensional social construct [49]. Risk is not regarded as an objective fact that can be easily defined as in some of the definitions summarized in the previous section. On the contrary, it is founded on the opposite premise, i.e. that risk is subjective [7].

In this way, [47] frame their studies in the wider social context where risks would have a greater impact, such risks associated with nuclear energy, but also other less pervasive risks, including the use of pesticides, vaccines and food coloring, among others. The initial list used in risk evaluation covered thirty risks with nine dimensions each. The selection was based on the intuitive perception of the method’s creators about individuals’ willingness to take risk, the immediacy of the consequences, and the knowledge of risk or its human origin. The objective of this model [47] was to explain why different risks are perceived in different ways [50].

Our review of the literature revealed that not enough research had been done to analyze the perception of risk in the construction industry from the standpoint of the involved agents. The study presented herein addresses this problem by applying the Fischhoff’s proposal with certain required relevant modifications.

It proposes as its main objective to measure risk as it is perceived by construction workers and as specific objectives: (i) identify a risk profile

based on the responses for each risk dimension; (ii) search into the relationship among these dimensions and the global risk perception and (iii) determine what social-demographic variables can help in understanding the perception of risk.

After defining the objectives of this work and since this paper has adopted an exploratory approach, the following research questions are advanced: (i) What is the perception of risk of construction workers? (ii) What aspects of risk significantly influence the formation of the overall perception of risk? and (iii) Are there sociodemographic variables that help to understand the perception of risk of construction workers? And if this were the case, then what are these variables and how do they influence them?

## Experimentation

### Research design

The introduction mentioned INSHT, Spain's highest occupational security and hygiene regulator. The questionnaire is based on the modified Fischhoff questionnaire prepared for INSHT by [51] (See Table 1). Table 1 shows each risk dimension and the abbreviated nomenclature (A1, A2,...A9) that is used to designate those dimensions. We adapted this tool to the type of worker included in our research, i.e., construction workers. Moreover, the questionnaire's language was simplified and redrafted to make it easier to understand.

**Table 1** Risk dimensions in this study (prepared by the author based on [48, 51])

<i>Dimension</i>	<i>Question</i>	<i>Explored factor</i>
<i>Dimension or Qualitative Dimension</i>		
<b>A1</b>	Do you think you have enough knowledge about safety issues?	Worker's knowledge
<b>A2</b>	Do you think safety officials at you company are aware of the risk of your daily work?	Knowledge of safety and health officials
<b>A3</b>	How concerned are you about being hurt at work?	Fear
<b>A4</b>	What's the likelihood you might get hurt at work?	Personal vulnerability
<b>A5</b>	If a risk situation occurs at work, how could you be hurt?	Seriousness of consequences
<b>A6</b>	What can you do to prevent a problem that could create a risk situation?	Preventive action (fatality control)
<b>A7</b>	In an eventual risk situation, how likely is it you might intervene to control it?	Protective action (damage control)
<b>A8</b>	Are risk situations possible that could involve a large number of individuals?	Potential catastrophe
<b>A9</b>	Do you think your work can impair your health in the long run?	Delayed consequences

### Final questionnaire and data gathering

Based on the above, we prepared a structured questionnaire with two sections. First, we included the nine items relating to the various qualitative dimensions of risk perception and a single item (called G) to provide a quantitative risk assessment of global risk as perceived by workers in their daily work: "How do you evaluate the risk of having an accident or becoming seriously ill at work?". Answers to this section of the questionnaire were

rated on a Likert-type scale. Individuals valued their perception of each dimension on a score from 1 to 7 for the 9 qualitative dimensions (A1, A2,..., A9), and between 0 and 100 for the global risk quantitative measure (G).

The second section covered several socio-demographic characteristics of individuals. The socio-demographic data included age, marital status, number of children, nationality, gender, type

of work contract, specialization, present worker category, number of years in that category, number of years at work, number of company workers, and number of safety training hours received.

Before collecting the data from construction workers, we reviewed the questionnaire for language, clarity, and time needed for answering. The questionnaire was first tested with 5 construction and engineers to obtain their opinions on various issues, including the appropriateness of the socio-demographic data required from workers. The required modifications were included. Secondly, the questionnaire was tested with 32 construction workers with the same socio-demographic and qualification profiles as those planned for the study sample. The outcome was satisfactory. Some minor errors were corrected and the final questionnaire was then drafted.

The questionnaires for data gathering were self-administered. To identify the number of individuals needed for the study, we visited several construction sites and established contacts with organizations providing construction workers training.

The questionnaire was filled in the presence of the survey-taker or interviewer to ensure all questionnaires would be completed between 12 and 17 minutes. Workers filled the questionnaire in groups between 15 and 25 individuals.

The data gathering took place in February and March 2013. The questionnaire was filled by 179 individuals. Two questionnaires which had not been fully completed were discarded. Consequently, the final sample comprised 177 individual questionnaires.

### ***Statistical analysis***

Data was processed using software IBM SPSS Statistics 21. To meet the first proposed specific objective (identifying the typical profile of risk as perceived by construction workers), the first analysis consisted in computing the descriptive statistics for each of the qualitative dimensions of risk perception. Specifically, the statistical average, standard deviation and variance were computed.

With the data, characteristic profile of perceived risk was created. Next, many key tests were performed for the related samples as paired combinations were possible among the various dimensions. The purpose of this paired comparison was to analyze the presence or absence of significant differences between the obtained scores and thus determine the relevance of our qualitative dimensions for the construction industry.

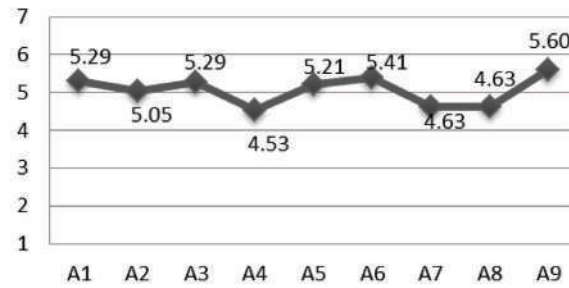
Next, to address the second identified objective, a linear simple regression was conducted with the objective of identifying the relevance of the dimensions with the highest values corresponding to the general perception of risk.

Thirdly, in view of the outcomes of the prior analysis, the socio-demographic variables were examined to determine which may relate to dimension A9 (delayed consequences) to understand which personal circumstances resulted in a stronger or weaker perception of the risk of suffering delayed consequences. These analyses required running several parametric statistics' tests. Parametric tests were chosen as they are more robust than non-parametric ones, and the study's sample size permitted using the Central Limit Theorem. Assuming a normal distribution for variable A9, Student t-tests for independent samples and variance analysis (ANOVA) were conducted, as appropriate, including the socio-demographic variables as independent ones. Finally, for variance analyses, wherever significant differences were reported, comparative paired tests using the Bonferroni Test were ran to further examine the results.

## **Results**

### ***Characteristic profile of the risk perceived by construction workers***

Figure 1 shows the perceived risk profile resulting on average for each dimension. Results fluctuate between A4 (media=4.53) and A9 (media=5.60). Table 2 reflects the variance and standard deviation for each dimension resulting from the performed analysis.



**Figure 1** Perceived risk profile

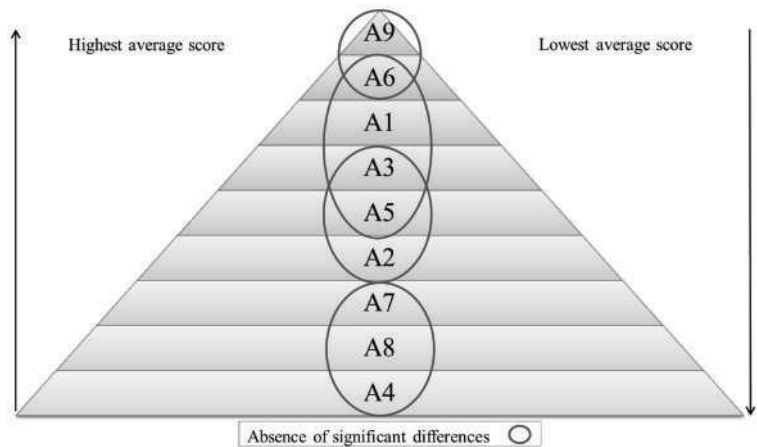
**Table 2** Number of individuals, average, standard deviation and variance for the analyzed sample

	A1	A2	A3	A4	A5	A6	A7	A8	A9
<b>N</b>	177	177	173	177	174	177	177	176	177
<b>Average</b>	5,29	5.05	5.29	4.53	5.21	5.41	4.63	4.63	5.6
<b>Standard deviation (σ)</b>	1.217	1.661	1.642	1.709	1.643	1.535	1.347	1.887	1.531
<b>Variance (σ<sup>2</sup>)</b>	1.481	2.759	2.695	2.921	2.7	2.356	1.813	3.56	2.344

Variables A1 and A7 show the lowest data fluctuations. Dimension A8 yielded the largest standard deviation and variance. A paired comparison using the t-test yielded the following outcomes. First, no significant differences exist between all pairs of A1, A3, A5 and A6, and secondly, no statistically significant differences existed between all pair combinations of A4, A7 and A8.

In addition, significant differences were identified between A9 and the other dimensions, excepting A6, where the existence of significant differences was not confirmed ( $t=1.242, p>0.05$ ).

Figure 2 shows graphically the results in an ordered pyramid from lower to higher statistically different averages. Dimension A9 ranks at the top as it show the largest average, although related to A6, because no significant differences were identified among them.



**Figure 2** Distribution of averages for qualitative dimensions of the risk perception as a function of results of pair comparisons

**Relationship between the dimension relating to the delayed consequence (A9) and the perceived global risk (G)**

To identify the relevance of the dimensions contributing the largest values to determine the dimension of general risk (A9 and A6), we ran a Multiple Linear Regression with A9 and A6 as independent variables and G as dependent variable. The backward method was used to identify whether the two variables explained the reported G value. The model cancelled A6 because the identified beta was not significant ( $\beta_{A6}=0.003$ ;  $t=0.041$ ;  $p=0.967$ ). On the other hand, the A9 value was found to be significant. In view of the above outcomes, we decided to run a Simple Linear Regression, including A9 as the only independent variable.

Firstly, homoscedasticity was analyzed for disturbance behavior. The disturbance method was based on the examination of residues on a graph representing residues against forecasted values. The graph showed a staggered dispersion characteristic when the only explanatory variable in a model is a variable measured on a Likert-type scale.

Secondly, the absence of self-correlation was confirmed in disturbances. To detect self-correlation a Durbin-Watson test was conducted. The value of the Durbin-Watson  $d$  was 1.92 for dimension 1, included in the [1.63-2.37] interval, thus revealing the lack of self-correlation, based on the test for  $K'=1$  variable,  $n$  = more than 100 cases and 95% confidence level.

Then, we proceeded to estimate the model. To do so, the data coefficient ( $\beta$ ) was first analyzed. Results showed a strong significance (at 1%) for the A9 coefficient ( $t=8.417$ ;  $p=0.000$ ), and for the constant term ( $t=2.977$ ;  $p=0.003$ ).

To determine whether the regression model was well adjusted, we used the adjusted determination coefficient ( $R^2=0,29$ ) which showed that A9 explained 29% of G variability. In addition, the model was significant as a whole, as confirmed

by the ANOVA test for the final model ( $F=70.85$ ;  $p=0,000$ ).

**Influence of socio-demographic characteristics on determining A9**

Finally, given the importance of the A9 variable, we ran several parametric analyses (t-test or ANOVA, as appropriate) to identify which socio-demographic variable could affect or influence the variable's determination.

The analysis showed significant differences in A9 as a function of the following socio-demographic variables *number of children*, *professional category* and *training*. No significant results were computed for the other socio-demographic characteristics in the tests ( $p>0.05$ ). It was concluded that those variables do not influence the determination of A9.

Firstly, variance analysis (ANOVA) showed significant differences in the socio-demographic variable *number of children* ( $F=3.890$ ;  $p=0.022$ ) as regards the A9 dimension, which explored the delayed consequences. The universe of that variable included individuals without children (media=5.22), individuals with one child (media=5.56), and individuals with two or more children (media=5.92).

Secondly, the Student t-test for independent variables in the *professional category* variable and dimension A9 revealed statistically significant differences ( $t_{g.l.=153}=-3.578$ ;  $p<0.05$ , assuming equal variances) with regard to the population of hand laborers (media=4.82) and officials' group (media=5.84).

Thirdly, the Student t-test revealed the relationship between the training variable and dimension A9 showed statistically significant differences ( $t_{g.l.=129,42}=-2.029$ ;  $p=0.045$ ; assuming equal variances with respect to the population with training in safety and hygiene under 20 hours (media=5,46) and the population in the group exhibiting safety and hygiene training over 20 hours (media=5,93).



## Discussion

Findings provide an interesting view of the perceived risk of construction workers. The average scores are above the central or neutral line (See Figure 1). As a consequence, the value of each dimension is a positive manifestation of the perceived risk. This correlates with findings from previous studies as for instance, [23], showing groups belonging to professions that work in potential risk environments or using heavy equipment have a higher risk perception than other workers. Along the same line, [52] showed construction workers can identify and evaluate labor security and health risks to a reasonable degree of accuracy. Consequently, findings from this study combined with previous findings and contradict others such as [53] or [54].

The same graphic shows that the dimension with the highest score is A9 which, as mentioned, relates to the delayed consequences. It showed significant differences with all other dimensions excepting A6. This dimension (A6) explores the workers perception of his/her own ability to prevent a potentially harmful risk. This, in turn, suggests workers are persuaded that controlling the consequence of a risk depends on his or her awareness that work can be the root of danger if no appropriate protection is available. This suggestion deserves a specific study, proposed as a potential future research area.

Dimension A9 deals with occupational hygiene and ergonomics [55]. Both are characterized by their potential repercussions on the workers' future health. Inhaling or swallowing a toxic product can have an obvious negative effect, but, generally, their impact on health is long term. The importance of this is that traditionally, the literature has attributed workers from various industries a relaxed perception of this concern [23, 27, 56, 57]. Specifically, in the construction industry, this finding does not reproduce such conclusion but rather shows construction workers are aware that their daily work can, for instance, result in back injuries, including lumbalgia or hernia; inhaling toxic particles can result in a lung

disease, managing certain products including epoxy resins, can trigger allergic reactions; inhaling some paint vapors can change mood and damage their liver or kidneys; exposure to sunlight can result in skin cancer, and repetitive exercise without resting like brick laying, can trigger chronic tendinitis. In sum, that their daily shores can damage their health.

The linear regression showed that A9 (the dimension relating to the delayed consequences) accounts for 29% of G's variability (a quantitative global dimension related to perceived risk). In other words, A9 value predicts 29% of the risk perceived, generally, by construction workers.

In addition, our analysis of significant differences between dimension A9 and various social-demographic variables, including a variance analysis (ANOVA) and Student t-tests identified significant differences between such dimension and the following social-demographic variables *number of children, professional category and training*. The only one among these variables that may impact occupational safety and hygiene officials is training. Clearly, training has an influence on the perception of delayed consequences among workers and in turn, on the global risk perception: more workers training will result in a higher risk perception. This has significant implications because risk perception is related to self-protection behaviors [19-21] and safe behavior [28, 29]. Therefore, as a function of findings in this study, we suggest to strengthen training among groups where a lower risk perception is identified (for instance, among lower professional category workers).

## Conclusions

This study suggests the construction workers' labor risk perception is high. In other words, they regard their work as risky. The dimension referring to delayed consequences received the highest score in the workers' responses to the questionnaire. In addition, this dimension generally emerges as a significant predictor for perceived risk. This condition is attributed, to a

large extent, to training activity, as workers with a stronger perception of this dimension are also those showing more training. Other influencing factors include the individuals' condition as parents and their labor category.

Construction workers attaching a higher value to the delayed consequences dimension than to other risk dimensions is an important finding contradicting previous research outcomes. However, those studies were not specific to the construction industry. Consequently, our study more clearly reveals specific conditions in this industry.

To conclude, it must be recalled that this study was carried out in Spain where the occupational safety legal framework was put in place in 1995. As a consequence, practically all workers are well trained to a larger or lesser degree. As a result of the above, the sample was segregated among workers with under 20 hours' training (almost all with at least 8-hours' training) and workers with over 20 hours' training (with almost all workers having received between 40 and 60 hours of training). This should be regarded as a limitation to our study.

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