

**IMPACT OF SAFETY WORKERS TRAINING IN ACCIDENT RESULTS**

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**PALABRAS CLAVE:** Training, Accident, Construction

**RESUMEN**

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Accidents in construction sector have become a serious problem that is continuously growing and whose analysis is hampered by the characteristics of the sector, which limits access to the necessary data to allow to study the phenomenon, draw conclusions and make targeted proposals to reduce work accidents.

The aim of this article is to analyse the preventive workers's training and some different organizational and economic characteristics of the companies in the sector to see their effect on accident rates as well as on labour efficiency.

At a European level statistics on accidents in the sector indicate that the incidence rate of accidents is progressively decreasing but continues at very high levels. At national level, incidence rates have risen after the economic crisis and the Balearic Islands is the region with the highest incidence rate in Spain, with an increase of 24.61% in three years (2013-2016).

To this end, 570 companies from the construction sector in the Balearic Islands has been selected. Building a panel data of 11 years (2007-2017) with all these companies data, with training, economic and accidents data, we aim to find empirical evidence in the relationship among safety training policy of a company, its accident rate and its economic performance. Using Poisson linear and quadratic regression methods, we test whether or not there exist a relationship between training in firms and their accident rate. The variables that are included in this study are, on the one hand, the training on safety received by the workers, considering the different levels of training established by the applicable regulations and some economic characteristics of the companies, on the other, the accidents occurred in these companies during the time of this study.

The results show evidence of a relationship between the level of training of the companies and their accident rates.

This study also aims to provide new empirical evidence on the relationship between safety training and level of safety at work and the subsequent accidents.



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## INTRODUCTION

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Accidents at work are one of the most important problems in the construction sector anywhere. Because of the incidence rate and the severity of the accidents. According to the data of Eurostat, "there were 3876 fatal accidents at work in the EU-28 during 2015, an increase of 102 deaths compared with the year before. And more than one fifth of all fatal accidents at work in the EU-28 took place within construction sector". Source: Eurostat

Looking at the Eurostat data it is easy to see that the rates of all countries in the EU-28 reflect a high number of accidents, fatal and non-fatal ones, in all the EU, and Spain is the 11th country in fatal accidents and the 3th one in non-fatal accidents, where the importance of the construction sector is remarkable due to accidents registered.

Looking at the data in the table 1 which reflects the incidence rates by autonomous communities within the Spanish state, we can assure that the trend has been similar in the last ten years in all of them, reflecting a decrease in the incidence rate of accidents in the construction sector during the years of economic crisis but since 2013 it is appreciated how the upward trend of accidents has returned. And within all the regions, the data reflects that the Balearic Islands is the region with the highest incidence rate.

Table 1. Índices de incidencia de accidentes de trabajo con baja en construcción por comunidades autónomas

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>TOTAL</b>	12393,1	106684,0	8980,4	8546,1	7735,3	6296,9	6024,1	6314,7	6794,5	7217,2	7645,6
Andalucía	14707,1	12535,3	9974,4	9108,0	8677,0	6836,3	7039,8	7152,9	7682,6	8380,7	8722,4
Aragón	11207,1	9867,0	7019,6	7104,6	6832,2	5713,3	5502,9	5345,2	5971,1	6219,9	6693,6
Asturias	12740,2	11084,7	9761,3	8977,8	7951,7	6580,7	5781,2	5937,1	6416,8	6432,1	6023,7
Baleares	15917,4	13574,1	10634,2	9426,5	8881,5	7722,3	8028,5	8860,9	9764,1	10199,5	10882,9
Canarias	13748,1	11707,1	9416,5	9048,2	7996,4	6589,2	5984,3	6933,5	7118,0	7851,3	7880,9
Cantabria	10840,1	9609,8	7396,8	6841,1	6241,3	5386,3	4979,3	5875,2	6004,8	6126,2	6359,0
Castilla-La Mancha	13855,8	12126,2	10122,8	9658,3	9064,5	7166,3	6847,0	7048,6	7877,2	7996,9	8553,8
Castilla y León	11709,9	10404,0	8562,9	8485,0	7664,1	6447,4	5876,6	6144,5	6635,9	7169,2	7303,1
Cataluña	12157,8	10402,4	9167,2	8736,7	7797,1	6331,2	6047,3	6506,3	6839,7	7243,0	7432,4
C. Valenciana	11193,6	9495,2	7634,9	7149,0	6355,3	5353,0	5108,1	5175,2	5633,4	5911,4	6684,9
Extremadura	12634,1	11239,5	8913,3	8352,7	7272,0	6540,9	6021,3	6064,2	6620,0	6821,9	7199,4
Galicia	11490,4	10537,5	9520,7	9019,2	7780,5	6223,1	5586,6	6167,7	6220,0	6166,4	7274,7
Madrid	11640,8	9824,6	8135,4	8006,5	7126,1	5724,8	5346,3	5343,9	6023,3	6579,7	7007,3
Murcia	10711,3	9048,8	7744,1	7386,6	6745,6	5541,6	4987,1	5324,1	6098,4	6439,3	6912,3
Navarra	11245,2	96449,4	8318,8	8310,2	8016,5	5726,9	5782,8	6207,1	6396,4	7479,7	7003,7
País Vasco	125529,5	11900,1	10005,9	9827,7	8302,5	7123,9	6709,4	7195,2	7267,8	7532,8	7966,0
La Rioja	12357,5	10232,3	8740,6	8238,5	8203,3	5876,7	6415,4	6384,8	7293,6	7391,8	8648,7
Ceuta	11490,6	12205,1	8957,7	9526,9	7757,7	6131,7	6070,6	7592,5	6098,1	6385,2	74446,9
Melilla	11555,6	10413,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Source: Instituto Nacional de Seguridad y Salud en el Trabajo. Observatorio Estatal de Condiciones de Trabajo.

## LITERATURE REVIEW AND HYPOTHESES STATEMENT

There is a lot of literature that focuses interest on accidents at work in construction sector and other industries considering among other factors, some such accidents [1], management, performance and safety climate [2];[3], costs [4].



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But there is also a great research line emphasizing the importance of training and especially preventive training, in order to improve accident rate results as well as maximize workforce performance [5], [6].

Following this line, this study aims to provide new empirical evidence on the relationship between safety training and level of safety at work and the subsequent accidents. To this end, a literature review is carried on to highlight the predominant researching lines in construction safety training field. Then we work with the data we collected from 2016 to 2017, delivered by the responsible entity to do the training in Spain by Construction Agreement, that is the Fundación Laboral de la Construcción (FLC) and data of all accidents occurred in these years, both in the Balearic Islands, region from Spain that has the highest accident rate. With all these data we make a regression analysis to determine the relationship between training ratio and accident rate of a company.

On the one hand, to start this study, a literature research from the last twenty years, 1999-2019, was performed in different databases. In this quest were include all the studies that have investigated total or partially the safety training process, especially in construction sector but also in different industries. Where we want to focus is in workers training but, in the literature, we found also some data for training programs delivered also to stakeholders, contractors and technician [7].

To analyse all the training program is necessary consider all the details of training process including the training contents that workers received before starting work and also the continuous training that they received during working life, the methods that the training is given to the workers and if it is possible the assessment that should be made of this training.

To check the education program there are different aspects of training highlighted in the literature like individual characteristics, training effects on workers' competences, method of deliver the training, etc.

Regarding individual characteristics, [8] Chen & Jin in their study of 2015 determine that the training could be more specific and effective if characteristics of the workers such as seniority, experience, gender, working sector, age, origin, etc are considered in the training process. And this importance is greater if they are new employees, because they need safety orientation to inform them about safety goals [9], [10].

Whether the workers are self-employed or they belong to the staff of a company is another of the pointed characteristics, as well as if it is the firm that has to provide the training to the workers or if they have to do it at all. And in this point is relevant to differentiate the size and type of the firm because they regarding of these issues do not have the same resources to be able to provide the training to their workers. For example, if the firms or workers are integrated in a labor union. in some countries like EEUU the nature and quality of the training provided is very different when union or non-union construction workers are compared. [11] Goldenhar et al, 2001 have confirm that there is more offer and better structured training for union workers in EEUU. Consequently they have found evidence that the union workers take better advantage of this education, they verify that the behaviour improves on reduction in hazards exposures, which leads to a greater job satisfaction and productivity.



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Another issue that has been analysed in the literature is the effect of safety training on competences such as knowledge, skills, abilities and, also, attitudes. Unfortunately, mixed evidence and different results has been found what prevent forming general conclusions.

Based on the fact that there are many accidents due to lack of knowledge that result in greater exposure to risk, there are a lot of studies that affirm that safety training provided to workers increases their safety knowledge by showing the causes of the most common accidents and how to avoid them. What has a direct effect on the behaviour of the workers in the moment of the implementation of the necessary measures to avoid risks at site. So that set the training like an essential element of Occupational Safety and Health (OSH) management [6]. Furthermore, safety training is effective in improving OSH awareness and behavior. [12]; [13]; [14]. Some studies remark the importance of educating all employees to enhance their knowledge and skills about safety at work. The increase of knowledge improves the attitude of the workers facing the risk, and also the welfare of workers and peer co-worker relationships specially improving workers communication and consequently the safety climate [15]; [16] and some studies such [17] Dale et al, 2012 confirm these better results evaluating the training contents in ergonomic issue in construction sector to avoid musculoskeletal injuries and proposing new ergonomic solutions to include in the training.

For these reasons it is reasonable to say that there is a direct and positive relationship between delivering good training and get some benefits of a healthy organizational climate. Improving the attitude and behaviour of workers it is easier to improve also the safety implementation on site.

In order to be able to carry out a good safety implementation on site is necessary to reach a good safety climate including personal awareness and a good communication like a key factors [18]. Furthermore, is remarkable that the wellbeing improves the stability of the workforce of the companies, creating an environment of trust between colleagues, improving communication for daily works and resolution of labour conflicts, and improving productivity [19].

On the other hand, it is also important consider the method of delivering this training, because in recent years more and more training methods has been implemented that depart from traditional methods, based on transmitting just theory, adopting modern approaches with more practices, inclusive e-learning or virtual reality simulation.

Methods that generate more workers' engagement seems to have better results in general [20] and increasing the sophistication of delivery methods according to previous levels of OSH commitment of the companies [21]. In this sense, there are some case studies that prove that changing the training delivering method is possible to get better results in transference of learning. To confirm this idea there are a few empirical studies like [15] Jeschke et al, 2017, they prove and analyse in a case study that changing the workers' training program in contents and method improves workers' knowledge and behaviour that together with an improvement in communication reduces the accident rate.

Unfortunately, there is not sound empirical evidence of the estimated effect that training may have on objective outcomes such as, for example, accidents on site. The majority of these studies are theoretical and the few empirical ones are mostly case studies that describe direct connections between safety training and accident results.



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There is a lack of empirical studies using representative samples trying to connect training to objective OSH outcomes, also longitudinal studies are needed [12]; [20], and there is a very few number studies with a high quality randomized samples in the area of OHS training effectiveness [13] [14].

This kind of analysis is hampered by the characteristics of the construction sector, which limits access to the proper data for studying the phenomenon, drawing conclusions and making appropriate proposals to reduce occupational accidents.

This research is aimed to better understand the relationship between safety training and accidents. In doing so, we have built a panel of relevant data (accidents, level of training, firm performance and other control variables) from a representative sample of firms.

## **METHODOLOGY**

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### **HYPOTHESIS STATEMENT**

To answer our main question we propose the next hypothesis for the development of our study:

#### **H1. HIGHER LEVEL OF WORKER'S SAFETY TRAINING REDUCES ACCIDENT RATE.**

We intend to verify if there is a direct relationship between the previous and currently mandatory training in Spain that workers of a contractor must have in order to work in the construction sector and the positive accident levels of these companies.

Studying the economic effects of accidents in companies there is a lot of literature. In this study and taking advantage of the economic data that we have of the companies, we intend to investigate if as we have established in the previous hypothesis if the companies invest in a greater training in safety and health of their workers, they have fewer accidents, and if it were the case if the cost of these has a greater or lesser effect on the economic results of these companies.

### **STUDY AND CLASSIFICATION OF COMPULSORY TRAINING**

The training established by the collective agreement for the construction sector is divided into several levels. On the one hand, the current minimum level is the first cycle of eight hours, with basic concepts plus training equivalent to the "Second cycle of training in occupational risk prevention in the construction sector: training by job or by trades" that will have a minimum duration of 20 hours and whose content is fixed by the agreement itself. This training can be of 6 hours when there are circumstances such as that a module of 20 hours has already been carried out or that the worker has previously completed the basic level training mentioned for the construction sector.





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The training database is currently the most limited, since it only gives the information of 2016 and 2017. We expect in the future to widen the data until minimum ten years to be able to increase our knowledge of the real situation.

## SAMPLE

There are 5.609 construction companies registered in Balearic Islands according to the data received from IBESTATI. We start the study with the database of all the companies that figures at SABIi, in order to have the economic information to use it at our study. In SABI database were 3.549 companies of the total mentioned, it represents the 63,27%.

We crossed the result of companies of Sabi with the training of 2017 and the accidents databases. Of the total of the companies in the construction sector in the region, some worker of 1656 companies suffered some type of accident with loss. And of these, 728 companies are in Sabi's first database. Thus, the final sample is of 728 companies of the construction sector in the Balearic Islands.

## DEVELOPMENT PROCESS

Once the databases were crossed, and proceeded to create the aforementioned variables in order to make a matrix with companies, training, accidents data.

Thus the process of analysis of each variable was started by using the STATA program.

Then the correlation matrix was created to see the dependence between our variables in order not to distort the results of the study. After the analysis, as appreciate in table 3, where the correlation matrix is shown, the labour cost variable (ulcr) and the solvency ratio variable (solvencyratio) were eliminated due to their correlation with the others variables. Labor cost is correlated with form\_rate and solvencyrate with ownresources\_emp.

Table 3. Correlation matrix

	acc_rate	form_rate	roa	roa_lag	asseturn	asseturn_lag
acc_rate	1.0000					
form_rate		1.0000				
roa			1.0000			
roa_lag				1.0000		
asseturn			0.1598		1.0000	
asseturn_lag			-0.5195*		0.2693*	1.0000
solvencyratio	0.1441			0.1420		
solvencyratio_lag						
ownresources per employee					-0.1382	
ownresources per employee_lag						
ulcr		-0.1647*	-0.3094*			
ulcr_lag		-0.1681*		-0.2289*		
	solvencyratio	solvencyratio_lag	ownresources_employee	ownresources_employee_lag	ulcr	ulcr_lag
acc_rate						
form_rate						
roa						
roa_lag						
asseturn						
asseturn_lag						
solvencyratio	1.0000					
solvencyratio_lag	0.8596*	1.0000				
ownresources per employee	0.4947*	0.3993*	1.0000			
ownresources per employee_lag	0.4790*	0.3921*	0.9796*	1.0000		
ulcr			-0.2875*	-0.2416*	1.0000	
ulcr_lag			-0.3105*	-0.2935*	0.8345*	1.0000



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When analysing the data it was verified that the most of the observations of accident rate was concentrated between 0 and 0.9, as reflected in the figure nº1, thus being able to focus the study in such cases. In order to carry out the study of companies in which at least one of their employees had an accident with sick leave, the data of the companies that had not suffered an accident was removed, that is, the observation in the variable num\_acc was 0.

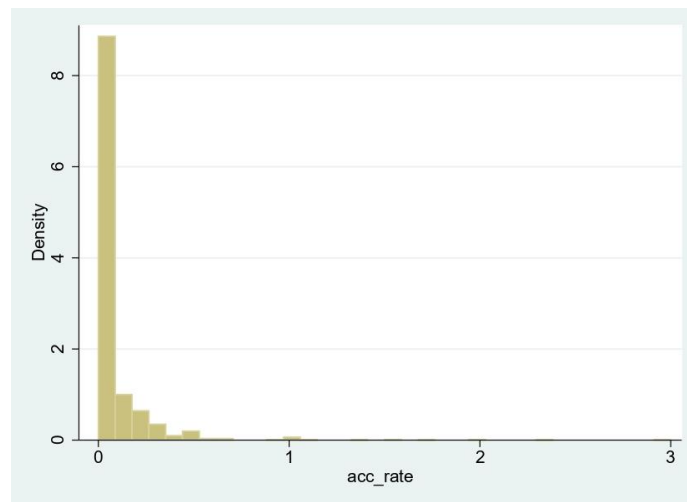


Figure 1. observations of accident rate

Once the variables created were validated and the data analysed with STATA, a regression of the observations that complied with the given requirements was carried out, and after having eliminated the companies in which no worker had suffered any accident, 670 observations remained.

## RESULTS

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The result of the regression of the data performed as can be seen in table 4, shows that there is a negative and significant relationship between training ratio and accident rate of a company. That is to say, the greater the training of workers by a company, the lower its accident rate.

The negative ratio of accident ratio and own resources per employee is also significant. That is to say, the greater the investment of the company in own resources per employee, the accident rate is reduced.





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Table 4. Regression analysis

Source	SS	df	MS		Number of obs	=	670
Model	.291164599	4	.07279115		F(4, 665)	=	3.99
Residual	121.361.252	665	.018249812		Prob > F	=	0.0033
Total	124.272.898	669	.018575919		R-squared	=	0.0234
					Adj R-squared	=	0.0176
					Root MSE	=	.13509
acc_rate	Coef.	Std. Err.	t	P>[t]	[95% Conf. Interval]		
form_rate	-.008948	.0037135	-2.41	0.016	-.0162396		-.0016564
roa_lag	-.000113	.0001084	-1.04	0.298	-.0003259		.0000998
asseturn_lag	.0001641	.0001343	1.22	0.222	-.0000996		.0004278
aownresource_emp_lag	-.0001885	.0000736	-2.56	0.011	-.000333		-.0000441
_cons	.2070907	.0060543	34.21	0.000	.195203		.2189785

Making a regression analysis of the data performed in the previous table, shows that there is a negative and significant relationship between training ratio and accident rate of a company. That answered to our Hypothesis 1. Therefore, the hypothesis is not null.

## H1. HIGHER LEVEL OF WORKER'S SAFETY TRAINING REDUCES ACCIDENT RATE.

The greater the training of workers by a company, the lower its accident rate.

We found a negative and significant effect of own resources per employee over the accident rate.

The greater the investment of the company in own resources per employee, the lower accident rate.

## CONCLUSIONS

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The main objective of this paper is to analyse the relationship between training and accidents in a representative sample of companies in the construction sector, where we know that is a very important problem.

After analysing all the training, accident and economic data of the companies in the study, the importance is highlighted not only of the necessary training and obligation that every company must provide its employees, but also continuous training. As well as highlighting that the investment a company makes for each of its employees, both in training and in necessary means in safety and health revert positively in the company with better results lowering the accident rate and consequently the cost thereof.

## LIMITATIONS AND FUTURE CHALLENGES

There are some limitations to considering and the principal one is the complication to have real and sufficient data of workers, accidents and companies. The construction sector is very closed when it comes to analyse the necessary data. But it opens a future challenge, is important not to leave this



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way and be able to complete this study with a panel data of a minimum of ten years. (2007-2017). In that way we will be able to make a better study and extract more and better conclusions of the relationship between safety training and accidents.

## REFERENCES

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i IBESTAT: Institut d'Estadística

de les Illes Balears

ii SABI: Iberian Balance Sheet Analysis System. Database that contains financial information of Spanish companies.

[1] Marhavillas, P.K., & Vrontas, P.T. (2018). Risk Assessment in the Constructions Sector of EU Countries: Application of a Methodological Framework using Quantitative Techniques and Occupational Accidents' Data throughout the period 1996-2011

[2] Fernández-Muñiz, B., Montes-Peón, J. M., & Vázquez-Ordás, C. J. (2007). Safety management system: Development and validation of a multidimensional scale. *Journal of Loss Prevention in the Process Industries*, 20(1), 52–68. <https://doi.org/10.1016/j.jlp.2006.10.002>

[3] Forteza, F. J., Carretero-Gómez, J. M., and Sese, A. (2017). Occupational risks, accidents on sites and economic performance of construction firms. *Safety Science*, 94, 61-76.

[4] Gurcanli, G.E., Bilir, S., and Sevim, M. (2015). Activity based risk assessment and safety cost estimation for residential building construction projects. *Saf. Sci.* 80, 1–12.

[5] Tam, C. M., Zeng, S. X., & Deng, Z. M. (2004). Identifying elements of poor construction safety management in China. *Safety Science*, 42(7), 569–586. <https://doi.org/10.1016/j.ssci.2003.09.001>

[6] Taylor, E. L. (2015). Safety benefits of mandatory OSHA 10 h training. *Safety Science*, 77, 66–71. <https://doi.org/10.1016/j.ssci.2015.03.003>

[7] Hallowell, M. R., Hinze, J. W., Baud, K. C., & Wehle, A. (2013). Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators. *Journal of Construction Engineering and Management*, 139(10), 04013010. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000730](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000730)

[8] Q. Chen and R. Jin, "A comparison of subgroup construction workers' perceptions of a safety program - 1-s2.0-S0925753514003099-main.pdf," vol. 74, pp. 15–26, 2015.

[9] Cheng, C. W., Lin, C. C., & Leu, S. S. (2010). Use of association rules to explore cause-effect relationships in occupational accidents in the Taiwan construction industry. *Safety Science*, 48(4), 436–444. <https://doi.org/10.1016/j.ssci.2009.12.005>

[10] Bavafa, A., Mahdiyar, A., & Marsono, A. K. (2018). Identifying and assessing the critical factors



# CONTRACT

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for effective implementation of safety programs in construction projects. *Safety Science*, 106(June 2017), 47–56. <https://doi.org/10.1016/j.ssci.2018.02.025>

[11] Linda M Goldenhar, Stacey Kohler Moran, Michael Colligan, Health and safety training in a sample of open-shop construction companies, *Journal of Safety Research*, Volume 32, Issue 2, 2001, Pages 237-252, ISSN 0022-4375

[12] Cohen, A., Colligan, M., 1998, *Assessing Occupational Safety and Health Training*, DHHS (NIOSH) Publication No. 98-145, National Institute for Occupational Safety and Health, Cincinnati, OH.

[13] Robson, L., Stephenson, C., Schulte, P., Amick, B., Chan, S., Bielechy, A., et al. (2010). A systematic review of the effectiveness of training and education for the protection of workers. Report mandated by the Institute for Work & Health (IWH — Canadian Agency) and National Institute for Occupational Safety and Health (NIOSH — US Agency).

[14] Robson, L. S., Stephenson, C. M., Schulte, P. A., Amick, B. C., Irvin, E. L., Eggerth, D. E., ... Grubb, P. L. (2012). A systematic review of the effectiveness of occupational health and safety training. *Scandinavian Journal of Work, Environment and Health*, 38(3), 193–208. <https://doi.org/10.5271/sjweh.3259>

[15] M. R. Hallowell and J. A. Gambatese (2009). "Construction Safety Risk Mitigation," *J. Constr. Eng. Manag.*, vol. 135, no. 12, pp. 1316–1323

[16] Jeschke, K. C., Kines, P., Rasmussen, L., Andersen, L. P. S., Dyreborg, J., Ajslev, J., ... Andersen, L. L. (2017). Process evaluation of a Toolbox-training program for construction foremen in Denmark. *Safety Science*, 94, 152–160. <https://doi.org/10.1016/j.ssci.2017.01.010>

[17] A. Marie, L. Jaegers, B. Buchholz, L. Welch, and B. A. Evanoff, (2012). "Using process evaluation to determine effectiveness of participatory ergonomics training interventions in construction," vol. 41, pp. 3824–3826

[18] Z. Ismail, S. Doostdar, and Z. Harun, (2012). "Factors influencing the implementation of a safety management system for construction sites," *Saf. Sci.*, vol. 50, no. 3, pp. 418–423,

[19] Kines, P., Andersen, L. P. S., Spangenberg, S., Mikkelsen, K. L., Dyreborg, J., & Zohar, D. (2010). Improving construction site safety through leader-based verbal safety communication. *Journal of Safety Research*, 41(5), 399–406. <https://doi.org/10.1016/j.jsr.2010.06.005>

[20] M. J. Burke, S. A. Sarpy, K. Smith-Crowe, S. Chan-Serafin, R. O. Salvador, and G. Islam, (2006). "Relative effectiveness of worker safety and health training methods," *Am. J. Public Health*, vol. 96, no. 2, pp. 315–324.

[21] Brahm, F., & Singer, M. (2013). Is more engaging safety training always better in reducing accidents? Evidence of self-selection from Chilean panel data. *Journal of Safety Research*, 47, 85–92. <https://doi.org/10.1016/j.jsr.2013.09.003>