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A Latent Dirichlet Allocation Systematic Literature Review on OSH Training and Education

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ABSTRACT IN ENGLISH

Occupational Safety and Health (OSH) in the industry is highly important to reduce diseases, injuries and fatalities among employees and its related company money lost. Training and education is an important step in OSH for controlling hazards that cannot be eliminated by previous OSH steps, nevertheless due to the vast amount of different industry activities, hazards are also very different from one industry field to another one. This among other reasons like technology availability and employees' cultural background have made of OSH a focus of interest for investigators. This literature review is aimed to identify the subjects of interest, investigation trends, lags and needs of investigation on OSH training and education.

The selection of journals and articles has followed a detailed search protocol. A total of 54 articles matched the selection criteria, corpus formed by the articles was first submitted to a descriptive analysis of the whole text and then Text Mining (TM) technique and Latent Dirichlet Allocation (LDA) topic model were used to cluster articles in different topics.

From topics obtained by LDA and the descriptive analysis performed, some observations can be made, authors have focused more commonly their work on: Training methods for reducing musculoskeletal disorders and on fall prevention programs for construction workers; Technology and 3D simulation software as tools for developing training programs; Training methods implemented on educational and vocational institutions; Techniques to increase the long-term efficacy of OSH training and on the effect of management commitment to safety on OSH outcomes.

The needs of further investigation required on OSH training and education have been identified on: techniques to assess long-term efficacy of OSH training; the correlation between training programs and performance; the correlation between OSH training and OSH direct outcomes.

KEYWORDS: Occupational Safety and Health; Training; Education; Literature review; Text mining; Latent dirichlet allocation.

ABSTRACT IN ITALIAN

La sicurezza e la salute sul luogo di lavoro (SSL) nel settore industriale é estremamente importante per ridurre malattie, incidenti e decessi tra i lavoratori e puó comportare perdite di denaro per la stessa azienda. La formazione e l'istruzione sono elementi del medesimo step di SSL per controllare i pericoli che non potrebbero essere eliminati dai precedenti stadi di quest'ultima, tuttavia in conseguenza alla grande quantità di diverse attività industriali, i pericoli cambiano molto anche in relazione ai diversi rami delle diverse attività. Tra le altre cose la disponibilità tecnologica e il background culturale dei lavoratori hanno permesso che la SSL diventasse un polo d'interesse per gli studiosi. Questa Revisione letteraria é volta a identificare le materie d'interesse, le tendenze degli studiosi, le mancanze e i bisogni di questo stadio di SSL di formazione e istruzione.

La selezione di giornali e articoli ha seguito una dettagliata selezione di criteri. Un totale di 54 articoli sono stati incrociati con criteri selezionati. Al corpo formato dagli articoli e' stata per prima effettuata un'analisi descrittiva dell'intero testo e successivamente e' stata utilizzata la tecnica del text mining (TM) e il modello del Latent Dirichlet Allocation (LDA) sono stati usati per raggruppare gli articoli nei differenti argomenti.

Dagli argomenti ottenuti dal LDA e dall'analisi descrittiva effettuata si possono individuare alcune osservazioni, gli studiosi hanno focalizzato per di piu' il loro lavoro su: i metodi di formazione per ridurre le patologie muscoscheletriche e i programmi di prevenzione della cadute degli operai edili; la tecnologia e il software di simulazione 3D come modi per sviluppare i programmi di formazione, i metodi formativi adottati negli istituti educativi e professionali; le tecniche per aumentare l'efficacia a lungo termine dello stadio di formazione di SSL e gli effetti dell'impegno alla gestione della sicurezza che la SSL ottiene.

I bisogni delle ulteriori ricerche richiesti per lo stadio di SSL di formazione e istruzione sono stati identificati in: tecniche per assestare l'efficacia a lungo termine della formazione di SSL, la correlazione tra i programmi di formazione e le prestazioni, la correlazione tra la formazione SSL e i risultati immediati di SSL

PAROLE CHIAVE: Sicurezza e Salute sul luogo di Lavoro, Formazione, Istruzione, Revisione Letteraria, Text Mining, Latent Dirichlet Allocation

EXECUTIVE SUMMARY

ABSTRACT

Occupational Safety and Health (OSH) in the industry is highly important to reduce diseases, injuries and fatalities among employees and its related company money lost. Training and education is an important step in OSH for controlling hazards that cannot be eliminated by previous OSH steps, nevertheless due to the vast amount of different industry activities, hazards are also very different from one industry field to another one. This, among other reasons like technology availability and employees' cultural background have made of OSH a focus of interest for investigators. This literature review is aimed to identify the subjects of interest, investigation trends, lags and needs of investigation on OSH training and education.

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The needs of further investigation required on OSH training and education have been identified on: techniques to assess long-term efficacy of OSH training; the correlation between training programs and performance; the correlation between OSH training and OSH direct outcomes.

KEYWORDS: Occupational Safety and Health; Training; Education; Literature review; Text mining; Latent dirichlet allocation.

INTRODUCTION

Safety towards work-related diseases and injuries were not always subjects to be concerned from owners, managers and company leaders. The science of Occupational Safety and Health (OSH) appeared and evolved as a consequence of several and tragically work-related accidents. Organizations related with OSH achieved to: reduce the workday to 8 hours; implement factory inspection laws; provide worker compensations and child labor protection by the end of 19th century (Abrams, 2001). Continuously OSH scope has improved and adapted the methods

to provide security and safety in the workplace in response to social, political, technological and economic changes (Jhonson, 2011). Today OSH is considered as science of anticipation, recognition, evaluation and control of hazards in the workplace that could affect health and wellbeing of workers (Alli, 2008).

Even with all the techniques, knowledge, tools and systems to prevent accidents and fatalities, the International Labour Organization (ILO) estimates that 2 million deaths are work-related across the globe every year and 160 million have work-related diseases (Alli, 2008). All these fatalities and diseases carry not only human and social pain but also an immense economical cost, all the accidents are caused by actions that could be prevented by implementing a correct measure and technique.

Education and training provides theoretical and practical knowledge required to carry out a task or occupation successfully; as it is difficult to change the behavior, habits and reflexes of people gain through time, it is important to introduce safe working methods and school the personal. It has to be provided taking into account the education level of the worker, technical level of their activity and nature of their responsibilities. (Alli, 2008)

Education and training is a key activity in which authority, employer and workers must be involved and it is the most important responsibility of employers and it shouldn't be treated as a separate activity but as an integral part of job activity training. All the workers must know how to protect their lives and of their colleagues in the workplace, for this reason the employer has to establish training and information programs on: 1) Safety and health aspects of the work and 2) Ways to prevent and minimize exposure to hazards.

For this work Knowledge Discovery in Data bases process KDD is used as is a nontrivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data. (Fayyad et al, 1996). However, this regular process is designed for structured databases where the information is presented in categorical, ordinal and continuous variables. For unstructured databases a different data mining technique has been developed called Text Mining (TM).

Text mining has been defined as the discovery by computer of new, previously unknown information by automatically extracting information from different written resources. (Fan et al, 2006). Figure 1 describes the basic TM process for a literature review.

Different techniques to face the problem of dimensionality of the final matrix obtained by TM have been developed, for this work, the Latent Dirichlet Allocation process (LDA) is used. LDA is a topic modelling technique that essentially integrates clustering with dimension reduction. According to Crain S.P. (2012) in LDA documents are associated with a number of latent topics, which correspond to both

documents clusters and compact representations identified from a corpus. Each document is assigned to the topic with different weights.

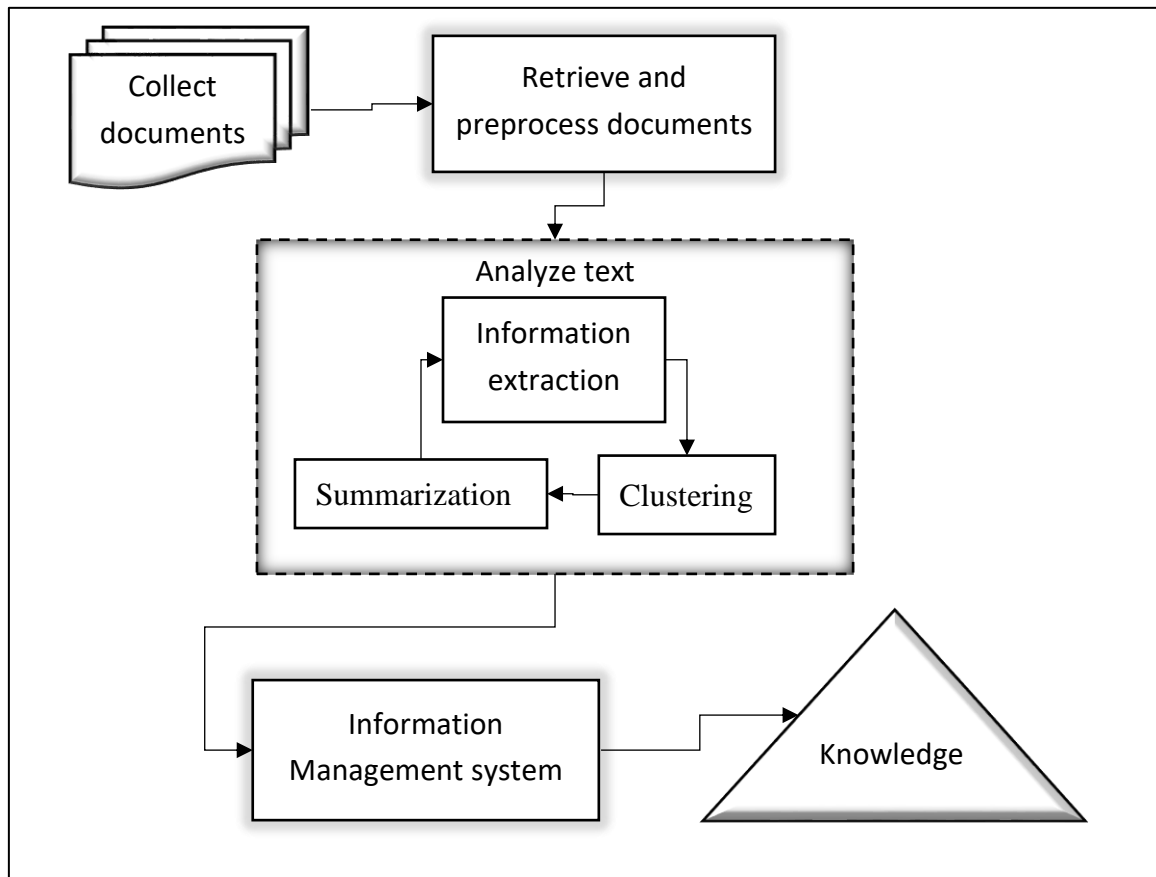


Figure 1. Basic Text Mining Process (Fan et al, 2006)

The result is an understandable representation of documents that is useful for analyzing the themes in documents. Moreover, LDA provides a generative probabilistic approach for different topics in arbitrary documents.

PROBLEM DESCRIPTION

OHS has a great significance for companies and for workers due to economic and social impacts that injuries, fatalities and illness in the workplace can carry. Thus, several researches, methodologies and other scientific literature regarding occupational safety and health have been published during last decades. The focus of this thesis is too perform a review of the existing literature regarding OHS training/education.

The context for Occupational Safety and Health education and training has been adapting to the globally changing nature of work. For example as the world has become better connected and the number of immigrants has increased in developed countries during the last decades, the effects of having personnel with different languages, education and cultural background has carried more difficulties to OSH training and educational programs and the way the methods are conceived.

Therefore, OSH training programs need to adapt to the very different work contexts of group of workers, based also in the level of organization of the worker community. (O'Connor et al, 2014)

Following the work conditions, the field of OSH has developed a wide range of creative, engaging training methods. Therefore one of the purposes of this thesis is to identify the training and education methods that have been object of interest to authors of the publications in the corpus of the literature review. As a precedence for this work, the study performed by Burke et al. (2006) shows that the types of methods regarding safety and health training are relevant for safety performance and reduction of accidents and injuries. Moreover, they conclude that going from traditional theoretical learning processes (education based on lecture) to experimentally-based methods (training) increase the knowledge acquisition.

The main objectives of this thesis is to perform a Latent Dirichlet Literature Review of OHS education and training and to extract conclusions on:

- Topics of interest to authors; what are the industry sectors where they focus their work? What are the types of workers authors take into account in their publications?
- Training methods applied by authors. What are the approaches authors used to develop their investigations?
- Trends of investigation. Where is the investigation heading on OSH training and education?
- Assess the need of further investigation on the field. What are the subtopics on the OSH training and education field that need more investigation based on actual findings and investigation tendencies?

METHODOLOGY

The process to perform the literature review is completely described to provide a clear guide to understand this work and two replicate this results for comparisons or further works in the topics related with education and training on OSH.

Search Protocol

A literature review depends on the articles selected for analysis, the articles are selected following a systematic process called search protocol, the description in detail of this process is explained where search protocol is split in Journal selection criteria and article selection criteria.

Journals selection

The databases from publications have been in constant growth in all the scientific fields, reason why indicators that assign weights to bibliographic citations

have been implemented. In this thesis or initial database is Scopus, the world's largest database (González-Pereira et al, 2010). The selection criteria is detailed:

Three search are performed for the words "safety", "ergonomics" and "accident" on the title of the sources. The resulting list is sorted according to the SJR¹ indicator and a review of all the possible sources is done in the following order.

- Coverage: must be at least 5 years old and ongoing (2012-ongoing).
- Source type: Journal.
- Subject area must be related with OSH field. Journals with subject area related exclusively to Engineering won't be selected as the main objective of this thesis is to perform a literature review in areas more related with Social science than Physical science.
- At this point Journals with a SJR score equal or higher than 1 are selected.
- For journals with a SJR score less than 1 and higher than 0.2, a review of their scope and publications is performed. Those with publications highly related with the interested area are selected.
- Journals with a SJR score less than 0.2 are not selected.

The entire process of the journals selection protocol described above is shown in figure 2 and according with the selection criteria established, the resulting Journals from which the search for articles will take place are indicated in table 1.

Source Title	Source Type	Publisher's Name	Publisher's Country
Accident Analysis and Prevention	Journal	Elsevier Ltd.	United Kingdom
Ergonomics	Journal	Taylor & Francis	United Kingdom
Applied Ergonomics	Journal	Elsevier Ltd.	United Kingdom
Safety Science	Journal	Elsevier BV	Netherlands
Journal of Safety Research	Journal	Elsevier Ltd.	United Kingdom
International Journal of Industrial Ergonomics	Journal	Elsevier BV	Netherlands
Safety and Health at Work	Journal	Occupational Safety and Health Research Institute.(OSHRI)	South Korea
International Journal of Occupational Safety and Ergonomics	Journal	Taylor & Francis	United Kingdom

Table 1. Journals selected

¹ SCImago Journal Rank is an indicator that ranks scholarly journals based on citation weighting schemes and eigenvector centrality **Invalid source specified.**

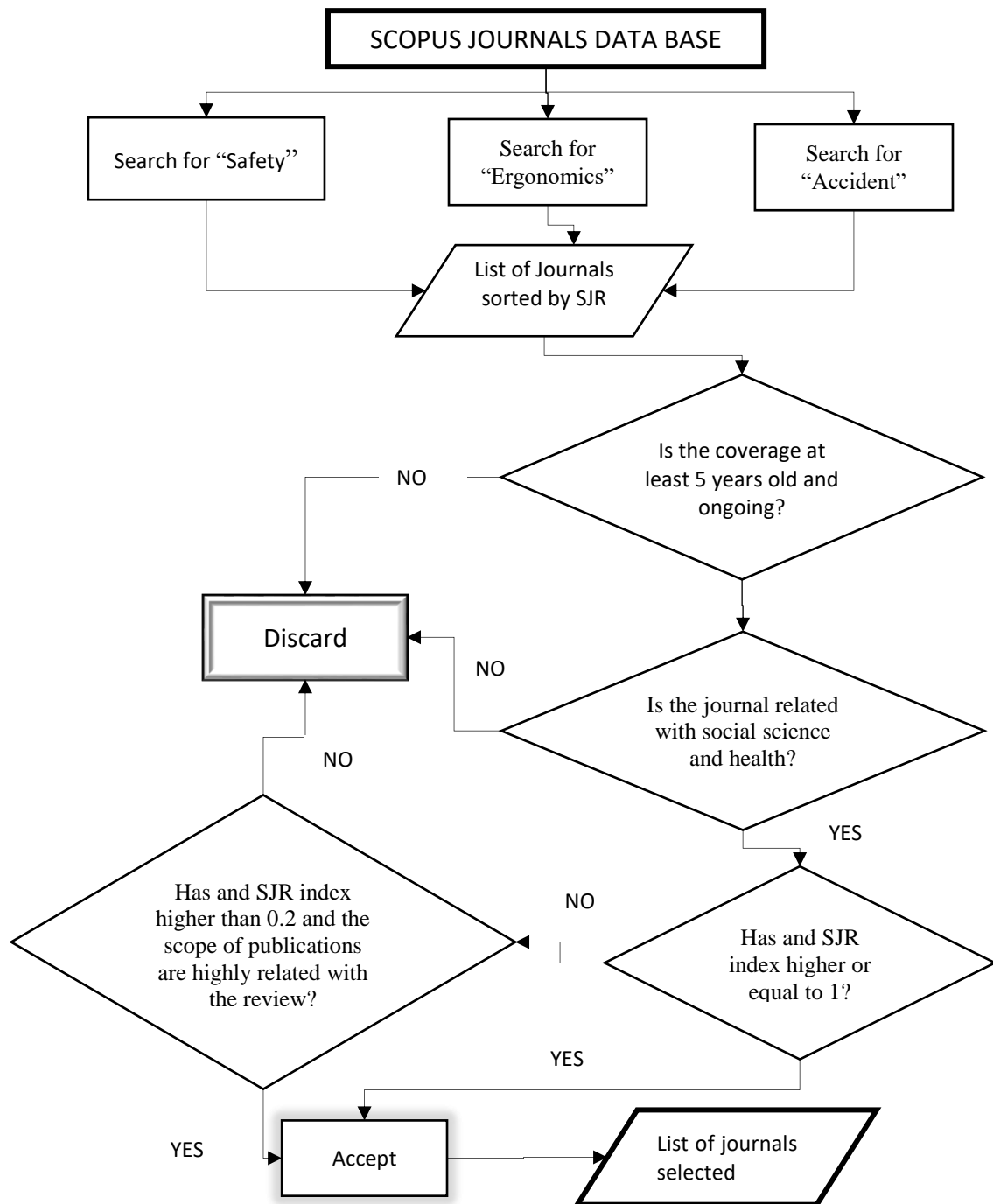


Figure 2. Journals search protocol

Articles selection

The search for the articles is performed in the search engine of SCOPUS using a specified query string that contains all the possible fields related with this literature review and connected through Boolean operators. First variables must be defined, to perform the search is necessary to specify what, where and in what time period.

Time period: articles published from 2008 to 2017 (last 10 years) will be considered. What: In order to avoid reduced or too extended results, the domain of the fields need to be correctly specified. The literature review is going to be done on articles related with education/training in Occupational Safety and Health (OSH) field, thus, three different blocks are identified. One for education/training, the second one for domain related to Occupational and a third one for accident domain.

Block / Domain	Terms
Education and training	Education
	Training
Occupational	Occupational
	Industrial
	Work-related
	Job-related
Accident	Accident
	Risk
	Safety
	Health
	Hazard

Table 2. Terms associated with domains. Articles selection

The query string is:

(Education OR training) AND (occupational OR industrial OR “work-related” OR “job-related”) AND (accident OR risk OR safety OR health OR hazard)

Where: In order to avoid the possibility of miss publications that are related with this review but could present different terms considering title, abstract or keywords by separate, the search will consider terms appearing in any of the three fields (title. Abstract and keywords) but all the terms must be contained.

A total of 487 publications match the query string in the journals selected for this review. The number is quite large due to the fact that both terms, training and education can be common and appear in publications that are not necessarily relevant for this review. At this point a manual analysis is performed that consists in reading titles, keywords and abstracts in order to identify articles that are close related to training and education on OSH.

To identify what publications should be discarded, an exclusion criteria is generated where those articles where the search terms appear but are mentioned in a different context, have a different meaning or mentioned as a brief description or conclusion are discarded. Figure 3 describes the articles’ search protocol.

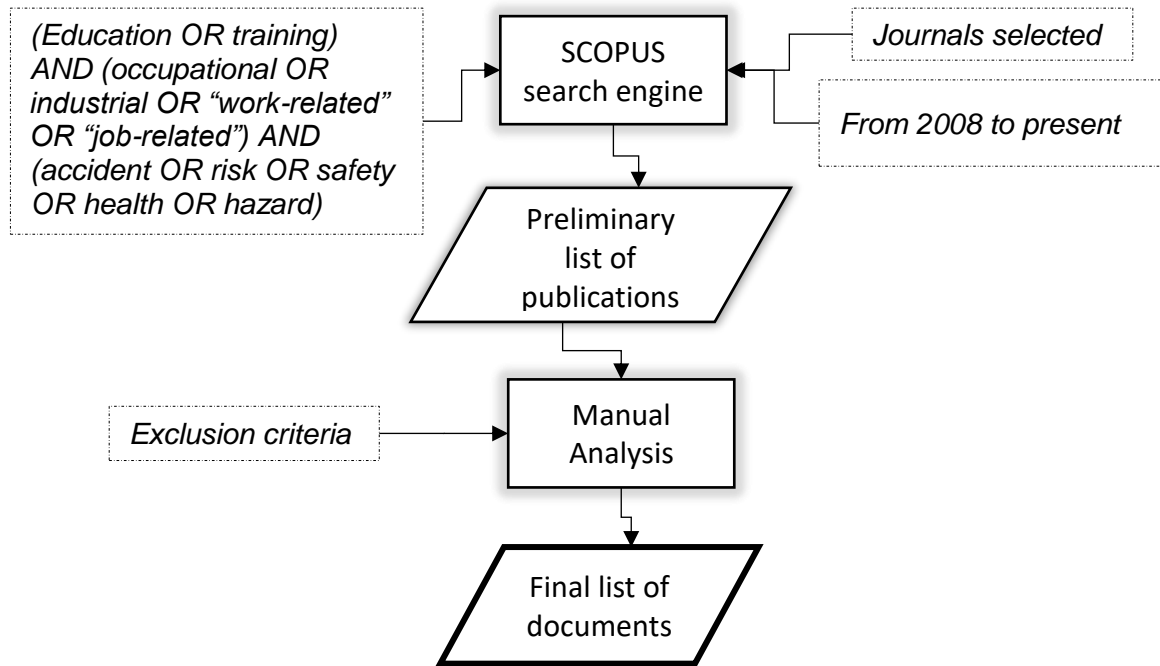


Figure 3. Articles' search protocol.

Documents that have cleared and passed the exclusion criteria will form the corpus of this literature review. Publications detailed in Table 3 will be read, studied and analysed using Data Mining and LDA topic model in further sections.

	Author(s)	Title
1	Lesch, 2008	Warning symbols as reminders of hazards: Impact of training
2	Molesworth et al., 2011	Rehearsal and verbal reminders in facilitating compliance with safety rules
3	Huang et al., 2012	Management commitment to safety vs. employee perceived safety training and association with future injury
4	Guo et al., 2012	Using game technologies to improve the safety of construction plant operations
5	Horswill et al., 2013	Even highly experienced drivers benefit from a brief hazard perception training intervention
6	van Eerd et al., 2010	Process and implementation of participatory ergonomic interventions: A systematic review

	Author(s)	Title
7	Levanon et al., 2012	Reducing musculoskeletal disorders among computer operators: comparison between ergonomics interventions at the workplace
8	Meinert et al., 2013	Web-based office ergonomics intervention on work-related complaints: a field study
9	Hogan et al., 2014	The effect of manual handling training on achieving training transfer, employee's behaviour change and subsequent reduction of work-related musculoskeletal disorders: A systematic review
10	Robertson et al., 2009	The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk
11	Kim et al., 2010	Development of an intervention to prevent work-related musculoskeletal disorders among hospital nurses based on the participatory approach
12	Taireb-Maimon et al., 2012	The effectiveness of a training method using self-modeling webcam photos for reducing musculoskeletal risk among office workers using computers
13	Hung et al., 2013	Identifying fall-protection training needs for residential roofing subcontractors
14	Szeto et al., 2013	The impact of a multifaceted ergonomic intervention program on promoting occupational health in community nurses
15	Robertson et al., 2017	Improvements in musculoskeletal health and computing behaviors: Effects of a macro ergonomics office workplace and training intervention
16	Jeschke et al., 2017	Process evaluation of a Toolbox-training program for construction foremen in Denmark
17	Vidal-Gomel, 2017	Training to safety rules use. Some reflections on a case study
18	Misiurek et al., 2017	Methodology of improving occupational safety in the construction industry on the basis of the TWI program

	Author(s)	Title
19	Freitas et al., 2017	Exploring OHS trainers' role in the transfer of training
20	Evanoff et al., 2017	Results of a fall prevention educational intervention for residential construction
21	Gummesson, 2016	Effective measures to decrease air contaminants through risk and control visualization - A study of the effective use of QR codes to facilitate safety
22	von Thiele Schwarz et al., 2016	Leadership training as an occupational health intervention: Improved safety and sustained productivity
23	Taylor , 2015	safety benefits of mandatory OSHA 10 h training
24	Olivieri et al., 2015	Empowering employers in work-related injuries prevention: A pragmatic trial
25	Nazir et al., 2015	Impact of training methods on distributed situation awareness of industrial operators
26	Grabowski et al., 2015	Virtual Reality-based pilot training for underground coal miners
27	Farina et al., 2015	Impact on safety of a preventive intervention in metalworking micro-enterprises
28	Stuart, 2014	A blended learning approach to safety training: Student experiences of safe work practices and safety culture
29	Laberge et al., 2014	Why are occupational health and safety training approaches not effective? Understanding young worker learning processes using an ergonomic lens
30	Pisaniello et al., 2013	The role of high schools in introductory occupational safety education - Teacher perspectives on effectiveness
31	Chin et al., 2010	Enabling youth to advocate for workplace safety
32	Crichton, 2009	Improving team effectiveness using tactical decision games

	Author(s)	Title
33	Tharmin et al., 2010	Time trends and predictive factors for safety perceptions among incoming South Australian university students
34	Kaskutas et al., 2010	Changes in fall prevention training for apprentice carpenters based on a comprehensive needs assessment
35	Williams Jr. et al., 2010	The impact of a peer-led participatory health and safety training program for Latino day laborers in construction
36	Kaskutas et al., 2013	Fall prevention and safety communication training for foremen: Report of a pilot project designed to improve residential construction safety
37	Brahm et al., 2013	Is more engaging safety training always better in reducing accidents? Evidence of self-selection from Chilean panel data
38	Wu et al., 2009	Effects of ergonomics-based wafer-handling training on reduction in musculoskeletal disorders among wafer handlers
39	McDermott et al., 2012	Investigation of manual handling training practices in organizations and beliefs regarding effectiveness
40	Langer et al., 2012	Reducing whole-body vibration exposure in backhoe loaders by education of operators
41	Ouellet et al., 2014	Work training and MSDs prevention: Contribution of ergonomics
42	Elfering et al., 2013	Stochastic resonance whole-body vibration, musculoskeletal symptoms, and body balance: A worksite training study
43	Andersson et al., 2014	Knowledge and experiences of risks among pupils in vocational education
44	Haas et al., 2014	An analysis of trainers' perspectives within an ecological framework: Factors that influence mine safety training processes

	Author(s)	Title
45	Lee et al., 2015	Factors influencing learning satisfaction of migrant workers in Korea with e-learning-based occupational safety and health education
46	Suleiman et al., 2015	Effectuality of cleaning workers' training and cleaning enterprises' chemical health hazard risk profiling
47	Terwoert et al., 2016	An Intervention Study on the Implementation of Control Banding in Controlling Exposure to Hazardous Chemicals in Small and Medium-sized Enterprises
48	Cecchini et al., 2017	Safety Knowledge and Changing Behavior in Agricultural Workers: An Assessment Model Applied in Central Italy
49	Pecitto, 2012	Results of implementing programmes for modifying unsafe behaviour in polish companies
50	Sigurdsson et al., 2012	Motivating ergonomic computer workstation setup: Sometimes training is not enough
51	Kintu et al., 2015	Occupational safety training and practices in selected vocational training institutions and workplaces in Kampala, Uganda
52	Abareshi et al., 2015	Educational intervention for reducing work-related musculoskeletal disorders and promoting productivity
53	Nie et al., 2017	A comparative study of vocational education and occupational safety and health training in China and the UK
54	Bulduk et al., 2017	Reduction of work-related musculoskeletal risk factors following ergonomics education of sewing machine operators

Table 3. Selected Publications for review

DESCRIPTIVE ANALYSIS

The results of analysing and summarizing the publications found according with search protocol are detailed in this section. Final corpus is composed by articles published between 2008 and 2017.

Classification of publications

Publications found can be classified according to the type of publication or study made. The corpus of this literature review can be classified in the following categories:

- Benefits of Experimental Methods.

Publications that describe methodologies or procedures developed by the authors in order to satisfy a necessity of Occupational Safety and Health education/training improvement in a specific industry section. Methods are tested and statistical results are reported.

- Evaluation of OSH Education.

Publications that explain and evaluate the outcomes of OSH education or training procedures already implemented in organizations, industry fields, education systems or methods detailed in legislations and agencies like Occupational Safety and Health Administration (OSHA).

- Theory Research.

Publications that describe a problem or hypothesis on a specific industry or region regarding Occupational Safety and Health, design an experiment or perform a literature research to evaluate and conclude about the proposed topic.

- Literature Review.

Publications that review and synthesize Occupational Safety and Health literature regarding education and training.

- Method Development.

Publications that described Occupational Safety and Health training/education procedures and how they have been achieved. Methods are not experimentally tested.

The quantity of publications belonging to each category and their percentage is shown in table 4 and figure 4 respectively.

Classification	Publications
Benefits of experimental methods	26
Evaluation of OSH education	13
Theory research	7
Literature review	2
Method development	6
Total	54

Table 4. Quantity of publications in each category

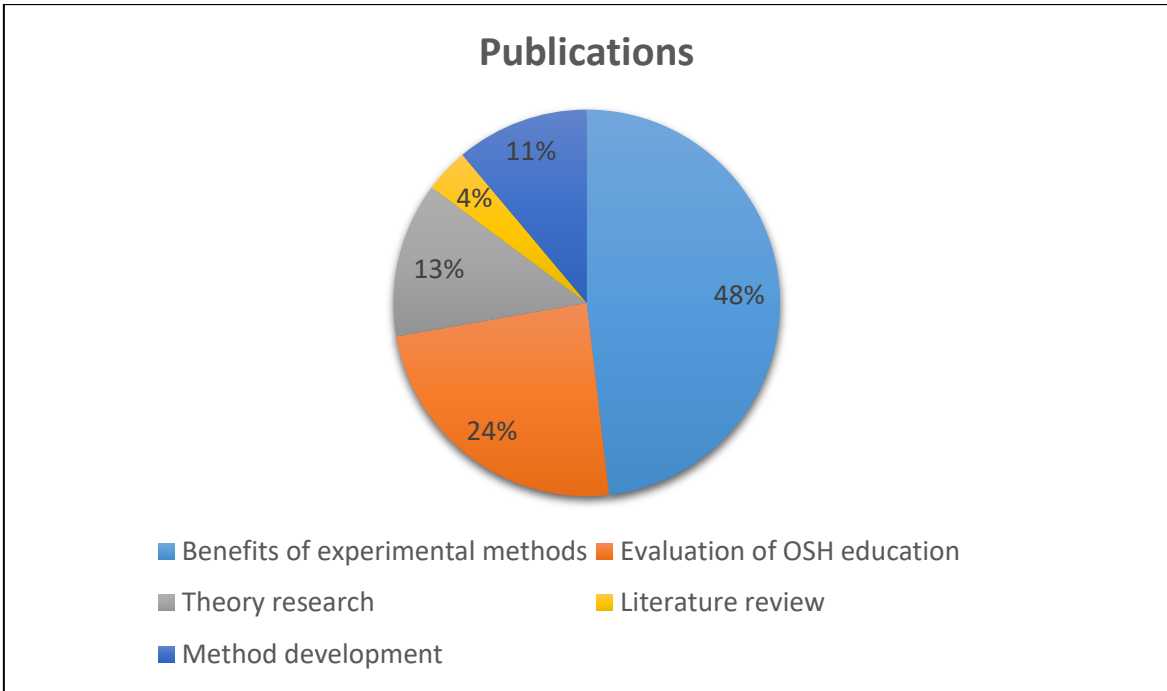


Figure 4. Classification of publications - Percentage

- **Benefits of experimental methods.**

This category reveals a trend in the last decade to study new techniques and approaches to face the training and education on safety in the work-place. However, it is worth to be mentioned that the differences on work-force requirements, responsibilities, duties, risks and hazards depending on the industry fields are very important. Each publication in this category is focused on one particular industry field. For this reason a sub classification is performed according to the type of worker the intervention or training is aimed to, the sub classification is shown in table 5. It is observed that most part of studies are focused on office workers, construction workers and manufacturing workers. Moreover these fields are very different regarding to type of hazards they face.

Method aimed to:	Quantity
Aviation pilots	1
Indifferent	2
Construction workers	5
Office workers	6
Nurses	1
Woodworkers	2
Leaders/managers	1
Manufacturing operators	4
Miners	1

Method aimed to:	Quantity
Metal workers	1
Paint industry workers	1
Textile industry workers	1
Total	26

Table 5. Object of the Benefits method studies

Office workers are under high risk of been affected by Musculoskeletal Disorders (MSD). Authors focused on study different methods, tools, techniques and approaches to prevent the injuries that cause almost 30% of the world's compensation cost. Construction and manufacturing workers on the other hand, are exposed to different type and severity level of hazards due to machinery operation or falling from altitudes like roofs on constructions. Moreover, Occupational Safety and Health education in this field is particularly more challenging because it has to deal with different level of worker's background education (Williams Jr. et al., 2010) and with small size enterprises. Authors are also principally concern with evaluating methods that can increase the workers change of behavior and knowledge acquisition, the most frequent worker target studied are young and new workers.

Analysing the methods used for knowledge transfer in the studies belonging to this category is observed that they can be clustered in groups. Groups are identified in table 6 and figure 5, and are defined according to the approach of the training or educational method used by the authors on their publications

Training method	Quantity	Software and technology	Training technique	Conventional method
Warnings and consequences	1		X	
3D simulation	3	X		
Rehearsal and reminders	5		X	
Biofeedback (MSD)	1	X		
Web based	2	X		
Conventional method	7			X
Qr codes	1	X		
Trainers education	1			X
Personalized training (cultural background)	1		X	
Tool box meetings	2			X
Vibration exposure	1		X	

Table 6. Training methods for benefits studies

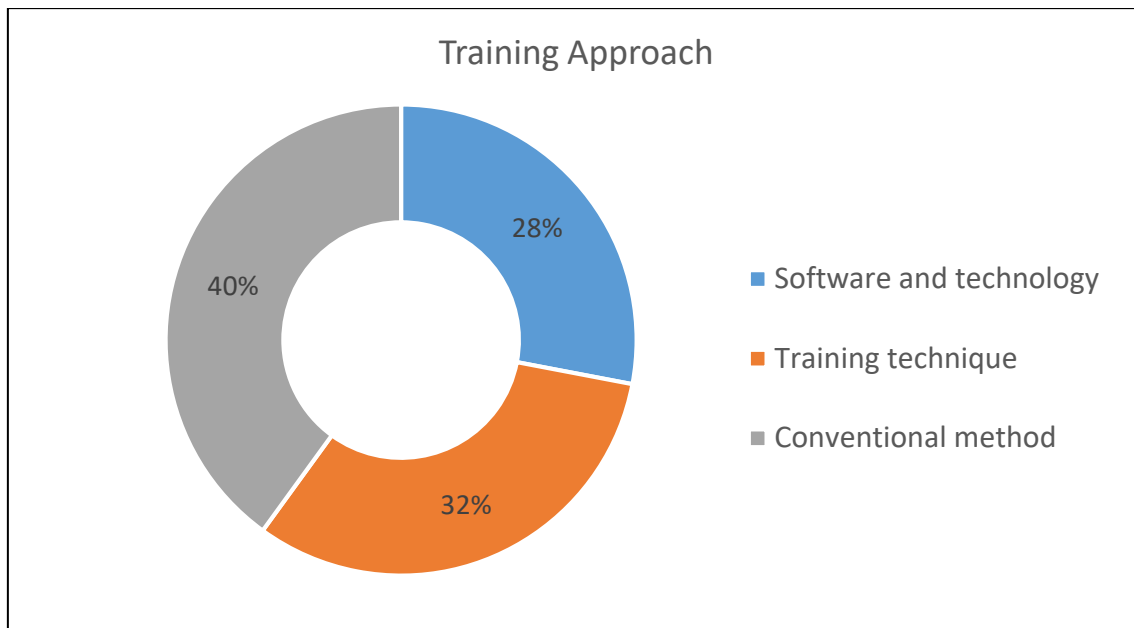


Figure 5. Training Approaches for benefits studies

Software and technology: Training methods that use tools developed to simulate work conditions and improve worker's recognition of warnings, hazards and the quality of response. Also web based training is used to continuously educate workers.

Training technique: Training programs that are modifications of conventional methods to increase the level of knowledge acquired, worker's change of behaviour and most import to maintain the effectiveness of training through time. Reminders are provided through tool-box meetings, e-mail or as a feedback provided by an automatized system.

Conventional method: Training methods that use theoretical presentations and classrooms training.

Authors conclude that their methods had increased worker's knowledge level, crew safety behaviour, safety climate, and risk perceptions. But as mentioned by Taylor E.L. (2015) there is weak evidence for improved safety outcomes due to training programs. From the methods used, some interesting results were obtained principally with simulation tools (Guo et al, 2012), (Nazir et al, 2015) and (Grabowski et al, 2015), where a desirable situation awareness was achieved and comparatively faster than using a conventional methods, also they show an efficient method to involve workers on non-routine tasks and abnormal situations. Moreover, these methods seem to be advantageous when training under real situations is not possible due to hazards or threats to human health and life. To increase the effectiveness of training through time, authors evaluated methods that use notifications, tool-box meetings, reminders and rehearsals after the formal training session. Robertson et al. (2009) reached an important conclusion that reminders

provided periodically to workers affect positively on patterns associated with behavioural changes.

▪ **Evaluation of OSH Education**

Publications belonging to this group describe and perform methods to evaluate a least one of the following safety outcomes related to safety efficacy: safety perception, training level received, learning satisfaction, injury experiences and their causes. The evaluation is done on organizations where training/education procedure had been implemented in the past. Types of locations where authors evaluated training and education efficacy are: 1) University, high school or vocational institution and 2) Workplace industry.

Authors collected data (i.e. interviews or surveys) to analyse and understand what are the principal problems that OSH training face under regular conditions.

- There is a student response positively associated with years of teaching and industry experience of the trainer, while a younger teacher (<46 years) was negatively associated (Pisaniello et al, 2013).
- Workplace training programs may not support young worker's self-advocacy on knowledge, communication and leadership (Chin et al, 2010).
- Training may be more effective if it is tailored to specific industry and task demands. (McDermott et al, 2012).
- Lack of systematic approach to pupil's training in work environment. Moreover, pupil's training don't reach required levels established by laws and the state-of-art of OSH. (Andersson et al, 2014).
- Immigrant worker's background education and culture impact in the perceived level of learning satisfaction. (Lee et al, 2015)
- Improving worker knowledge does not necessarily lead to correct behaviors, and motivational interventions may be needed to achieve lasting behavior change. (Sigurdsson et al, 2012)
- Inappropriate teaching methods in the workplaces, lack of adequate literature on safety and inadequate time to conduct safety training at the workplaces. (Kintu et al, 2015)

▪ **Theory research**

Authors of the articles focus their work on evaluating procedures, methods and laws to detect weakness or to accept hypothesis regarding Occupational Safety and Health. From articles of this group some interesting results and conclusions are indicated:

- Safety training is commonly aimed to new and young workers. However, experienced workers have lower levels of hazard perception than workers properly and regular trained. Expertise doesn't mean optimal level of hazard perception. (Horswill et al, 2013)

- Vidal-Gomel (2017) proposes to “consider training in occupational risk prevention as situated at the crossroads between regulated safety (based on prescribed safety rules and procedures) and managed safety (based on operators’ knowledge and experience)”. Moreover, the study reveals conflicts between respecting safety regulation and performing a task required by the company (fail to deliver or complete a task could put the operator under labour pressure).
- Factors that positively affect the transfer of training are good trainers’ capability, short training sessions, sessions focus on irregular safety behaviours and refresh knowledge. Moreover, OSH trainers revealed that often companies provide safety training because the company is under certification process. (Freitas et al, 2017)
- Training sessions have impact in workers’ “risk perception” and “change in behavior” but these improvements are not correlated with the reduction of accidents. (Brahm et al, 2013)
- Workers attitude towards Occupational Safety and Health learning is negatively impacted by the amount of years worked or experience. Highest percentage of strong negative attitude is among the people who have worked for more years, while employees who have worked for fewer years have a marked positive attitude. (Cecchini et al, 2017)

▪ **Literature Review**

Two articles perform systematic reviews of training or education in Occupational Safety and Health field. Some important results from these articles are described:

- Ergonomic training was described in 73% of the documents reviewed. The training was most often received in decreasing order by workers, supervisors, team members and senior managers. The time devoted to training varied from 2 hours to 100 hours. Principally, training covered general ergonomic information (including mechanisms of injury, risk factors, identification of hazards and strategies for reducing hazards). (Van Eerd et al, 2010)
- Key facilitators/ barriers for an effective training are identified to be related with: support of intervention; resources; ergonomic training/knowledge; creation of appropriate team; communication and organizational training/knowledge. (Van Eerd et al, 2010).
- Results obtained by Hogan et al. (2014) indicate a need for further research in the area of training transfer during training and subsequent behavioral change of employees following training, findings suggest that transfer of knowledge to employees occurs, however, not to the level expected and there was no evidence of employees behavioral change.

▪ Method development

Articles under this category are those that propose a training or education methodology based on their analysis and for a given industry sector. These methods are proposed, detailed and suggestions for improvement are described. However, an experimental evaluation of the method is not performed. From the studies performed some suggestions are found to be common in different industry sectors to increase training sessions' efficacy (Hung, et al., 2013) and (Jeschke, et al., 2017):

- Give importance to feedback and planning systems.
- Increase safety learning motivation among employees.
- Increases focus on the topics by switching from occupational accidents to occupational diseases.
- Increase Trainers' and program credibility.
- Provide physical demonstrations of tasks and procedures.
- Provide equipment demonstrations.
- Provide backup information depending on the background education level of the worker (media files, eLearning tools, hardcopy prints, etc.)

TEXT MINING AND LDA

For this literature review, a text mining technique is applied in the 54 articles that are part of the corpus. There are several options of TM software available in the market. For this review the software "*R statistical tool*" (The R Project for Statistical Computing) ² has been chosen as it is a free software available to download and install by any institution, it is an open source code that allows creation and instalment of software packages for specific statistical analysis. R statistical tool was used in previous reviews and studies using TM technique (Moro et al, 2015). The package selected is called *TM* and it's also available on the official R statistical tool platform. It has been chosen as it provides variety of functions for manipulating text documents. For performing the topic generation and classification, the Latent Dirichlet Allocation model proposed by Blei et al. (2003) Is used in this review and the package selected is *Topic Models*.

Text mining process

TM techniques provided as result a matrix of terms and their frequencies, the full-text will be analysed to improve the probability that frequent terms are relevant. However, terms that appear on citations and titles of references shouldn't be considered, for this reason reference sections will be removed from the text before proceeding with TM technique. This way, terms frequently mentioned are related with the main text of the articles only. The process followed is shown in figure 7.

² <https://www.r-project.org/>

In the process, words that don't provide any important information for the topic model process are removed. These words called stop-words are defined according two conditions:

- a. Words that are used frequently and their function is related to the language's structure, like articles (a, an, the, etc.), conjunctions (and, or, etc.), prepositions, etc.
- b. Words that are expected to be mentioned frequently in the articles because of their relation with the main topic of this literature review but don't provide relevant information for generating topics and classifying the articles (i.e. occupational, training, education, safety, osh, etc.).

Latent Dirichlet Allocation model uses as input the Document-Term matrix and the number of desired topics to generate topics represented by terms associated and provide the likelihood the articles belong to each topic. The process is written as code and it is detailed in figure 6.

```
## LOADING ARTICLES
path <- system.file("PDF", package="tm")
articles <- Corpus(DirSource(path, encoding="UTF-8"), readerControl = list(language="en"))

## REMOVING SPACES, PUNCTUATION, STOPWORDS AND CONVERTING TO LOWERCASE
articles <- tm_map(articles, removeNumbers)
articles <- tm_map(articles, removePunctuation)
articles <- tm_map(articles, tolower)
articles <- tm_map(articles, stripWhitespace)
articles <- tm_map(articles, removeWords, stopwords("english"))

## DOCUMENT-TERM MATRIX CREATION
dtm <- DocumentTermMatrix(articles)

## REMOVING SPARSE TERMS FROM MATRIX
dtm <- removeSparseTerms(dtm, 0.95)

## LATENT DIRICHLET ALLOCATION MODEL
lda <- LDA(dtm, method= "Gibbs", control = list(alpha = 0.5), k = 10)
topics(lda, k=2, threshold=0.1)
terms(lda, k=5, threshold=0.01)
```

Figure 6. Code for TM and LDA

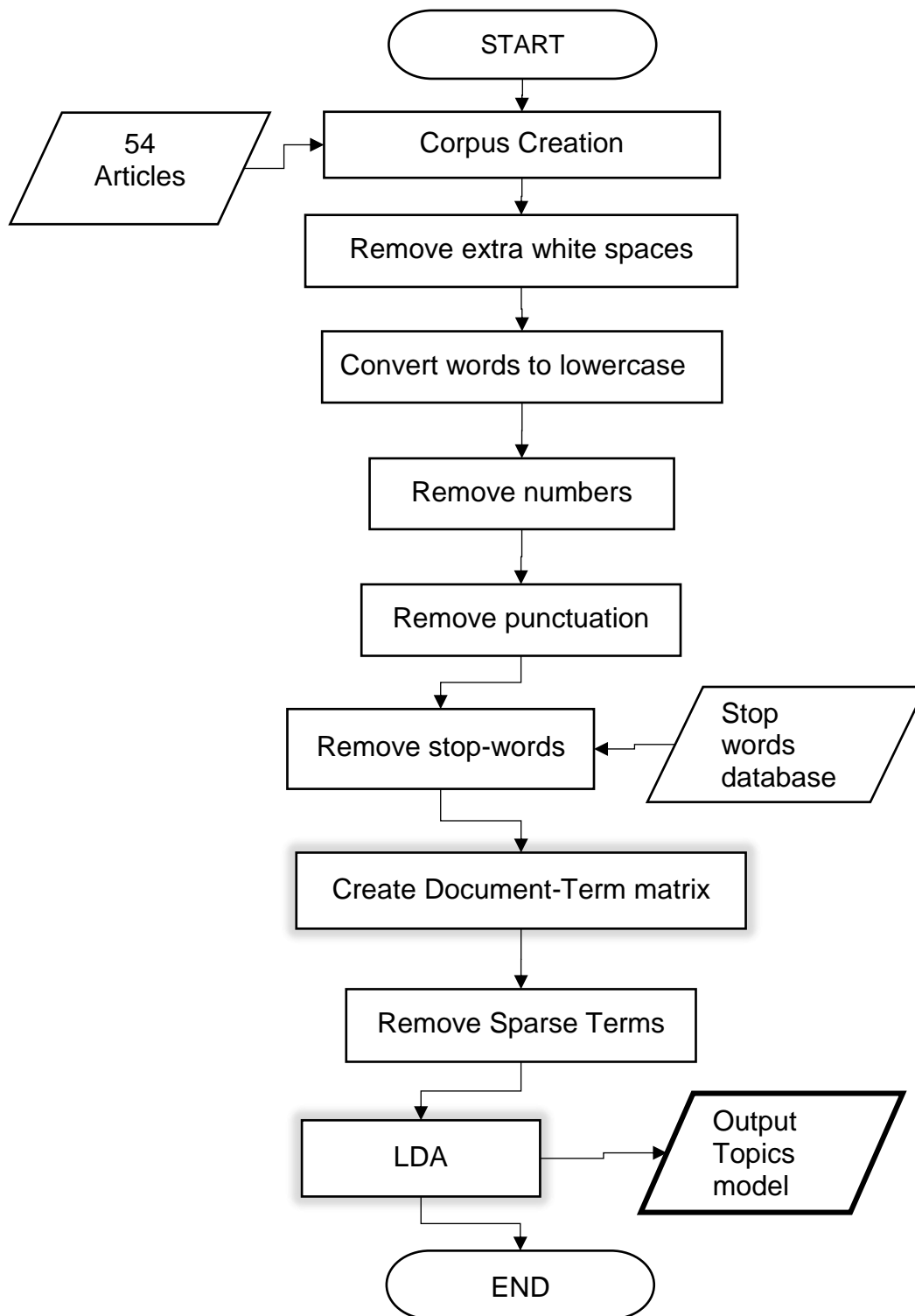


Figure 7. TM and LDA Topic modelling process

Setting the number of desired topics to eight, LDA model compute the probability of one term to belong to a particular topic. In table 7 the three terms more likely associated to each topic are listed.

Term	1	2	3
Topic 1	Participants	Test	Perception
Topic 2	Leadership	Injury	Climate
Topic 3	Risk	Operators	Level
Topic 4	Construction	Fall	Foremen
Topic 5	Workers	Program	Analysis
Topic 6	Intervention	Handling	Manual
Topic 7	Students	Skills	Knowledge
Topic 8	Ergonomics	Intervention	Musculoskeletal

Table 7. Terms for each topic LDA

The likelihood of one article belongs to one of the eight topics generated is computed and is reported by the software. The likelihood is reported by the software with values from 0 to 1.

Topics generated

This topic modelling process has an important limitation due to document clustering technique used. Document clustering is completely dependent on the technique used for creating the clusters, which is based on term identification. (Moro et al, 2015). To address the topics and accept or reject topics generated, the article with highest likelihood in each topic is selected to be analyzed and to understand the topics generated by LDA. Articles selected as the most relevant for each topic and their associated terms provide a better understanding of the topic.

Topic 1 is best represented by work of Lesch (2008) that describes the importance and effectiveness of training based on accident scenarios, provides a method based on warning symbols to increase hazard perception among the participants of the test. Considering the terms more relevant for the group and the analysis from the article more representative. It can be established that topic 1 clusters articles that describe an experiment to evaluate hazard and risk perception before and after interventions.

Topic 2 is best represented by Huang et al. (2012) that studies the factors that affect safety climate in the industry, the study is more focus on the correlation between employee's perceived management commitment to safety and employee's perceived safety training. The study proposes that management commitment to safety is a factor predictor for safety outcomes like injuries and accidents. Based on terms related with Topic 2 and the most relevant article for this group. Topic 2 can be described as the group that clusters articles that evaluate the theory that commitment to safety from managers, owners and leaders will impact safety climate and safety outcomes.

The most relevant article for Topic 3 is the one done by Misiurek et al. (2017), the article describes and proposes a method to improve occupational safety by selecting TWI programs that reduce the probability of occurrence of the three main causes of human errors: lack of or poorly led training, badly defined and developed work standards and lack of supervision of employees. From terms associated to the topic and the most relevant work, Topic 3 can be described as articles that perform studies on the effects of training and safety education provided to workers of indistinct fields on change of behavior, situation awareness and other measures for training efficacy.

Topic 4 is best represented by Kaskutas, et al. (2010) that developed a research on the specific field of construction and the risk related to fall from altitudes. The study performs a needs assessment to determine the gaps in the school programs about fall prevention education and actual needs in the industry, conclusions and suggestions are obtained from the research. From terms and the publication most relevant described above, topic 4 can be inferred as the group that clusters articles that study training methods, needs and provide results on the construction industry.

The research performed by Andersson, et al. (2014) has been selected as the most relevant for Topic 5. The article is the report of a study about the level of knowledge and risk awareness of young or unexperienced workers after they have finished their preparation on vocational institutions. Holes and gaps in educational programs are inferred. Based on terms related to the topic and the analysis performed on the most relevant article, Topic 5 can be described as articles that perform researches on educational programs about safety for young or unexperienced workers provided in educational institutions.

The most relevant work for the topic is a systematic literature review about handling manual training and its effects on improving employee's behaviour change. The study focus on MSDs as a consequence of work-related conditions and safety training methods or ergonomic interventions (Hogan et al, 2014). From terms associated and the analysis performed on the most relevant work for the topic, the topic 6 can be described as the group of articles that evaluate interventions programs and conditions to improve safety behaviour for avoiding manual handling related disorders (i.e. MSDs).

The article most relevant for the topic is a report about training method development after a one day workshop team-level decision making had been done. Tactical decision games were used in the workshop by multidisciplinary experts of oil and gas drilling industry and details the benefits on safety and team performance. (Crichton, 2009). From terms associated and the most relevant work to this topic, topic 7 can be described as articles that are aimed to propose methods to increase workers' knowledge level about occupational safety and industry performance.

Topic 8 is best represented by the work done by Robertson, et al. (2017). The article describes an ergonomic intervention for office or computer workers to improve their computing behaviors, postures, and musculoskeletal discomfort. Based on the most relevant article and terms associated to the topic, topic eight can be described as articles that study intervention methods to improve office workers' well-being and decrease musculoskeletal disorders.

Article's allocation acceptance criteria

Topics are sorted in descending order for each article, where the first ranked topic is the one with highest likelihood for the particular article, for this criteria is consider the first and second ranked topic for each article, the allocation acceptance criteria process is shown in figure 8. Articles with likelihood higher than 0.5 to belong to a particular topic are accepted in the cluster assigned by LDA model. Articles with likelihood lower or equal to 0.5 to belong to a particular model are submitted to a process to evaluate the topic allocation according to an acceptance criteria: articles with low likelihood to belong to a particular topic or articles where the likelihood for the two first topic allocated according LDA model are similar, are analysed to confirm them in the first topic option or assign them to the second topic according to the description of each topic detailed before.

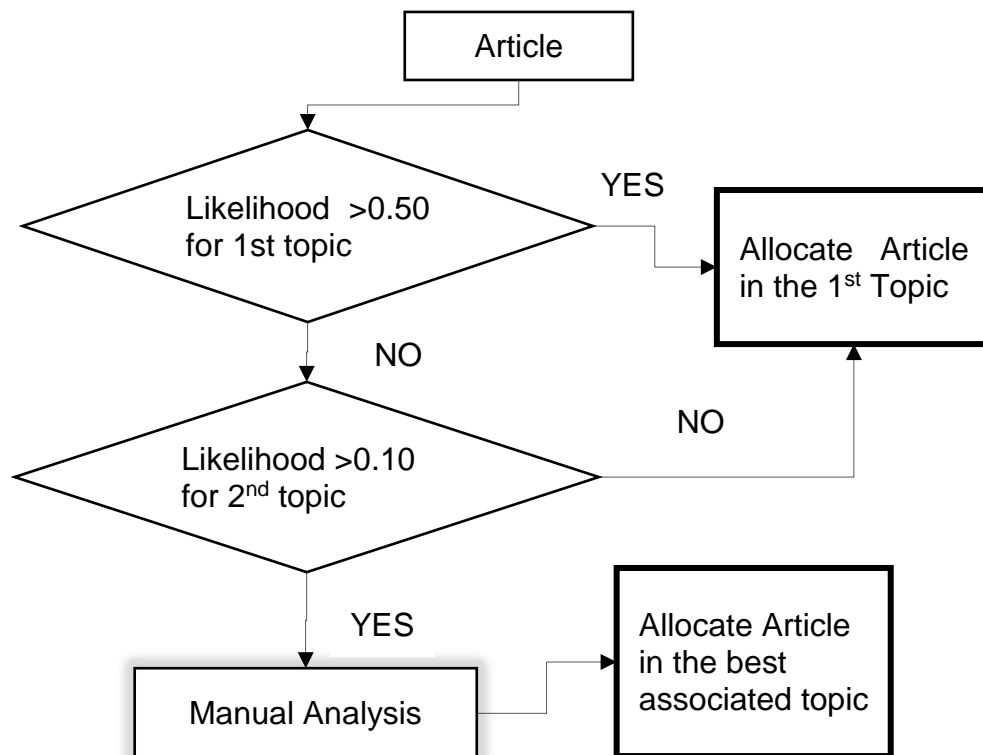


Figure 8. Allocation acceptance process. LDA results

The manual analysis is done by reading and understanding the publication in order to accept or reject the first topic, in case the first topic is rejected, the analysis

is done for the second topic. Taking as example the work done by Hung, et al. (2013), the article has a likelihood of 0.31 and 0.31 to belong to Topic 4 and Topic 5 respectively. A manual analysis is done in the article and it is understood that the research is aimed to identify needs and provide recommendations for fall-protection training to construction workers. Therefore, the article is better associated to Topic 4 than to Topic 5. The article is confirmed in the cluster of Topic 4. The final allocation resulting from LDA topic modelling technique is shown in table 8.

Articles			
Topic 1 Programs efficacy factors	Lesch, 2008	Molesworth et al., 2011	Horswill et al., 2013
Topic 2 Management commitment to safety	Huang et al., 2012	von Thiele Schwarz et al., 2016	Taylor , 2015
	Olivieri et al., 2015	Farina et al., 2015	Brahm et al., 2013
Topic 3 Methods to improve safety training outcomes	Guo et al., 2012	Vidal-Gomel, 2017	Misiurek et al., 2017
	Nazir et al., 2015	Grabowski et al., 2015	Langer et al., 2012
	Suleiman et al., 2015	Nie et al., 2017	Cecchini et al., 2017
Topic 4 Methods for the construction industry	Hung et al., 2013	Jeschke et al., 2017	Evanoff et al., 2017
	Kaskutas et al., 2010	Williams Jr. et al., 2010	Kaskutas et al., 2013
Topic 5 Programs in vocational institutions	Laberge et al., 2014	Chin et al., 2010	Ouellet et al., 2014
	Andersson et al., 2014	Kintu et al., 2015	
Topic 6 Programs for MSDs industry workers	van Eerd et al., 2010	Hogan et al., 2014	Kim et al., 2010
	Szeto et al., 2013	McDermott et al., 2012	Pecitto, 2012
Topic7 Programs to improve safety knowledge and performance	Freitas et al., 2017	Gummesson, 2016	Stuart, 2014
	Pisaniello et al., 2013	Crichton, 2009	Tharmin et al., 2010
	Haas et al., 2014	Lee et al., 2015	Terwoert et al., 2016
Topic 8 Programs for MSDs among office workers	Levanon et al., 2012	Meinert et al., 2013	Robertson et al., 2009
	Taireb-Maimon et al., 2012	Robertson et al., 2017	Wu et al., 2009
	Elfering et al., 2013	Sigurdsson et al., 2012	Abareshi et al., 2015
	Bulduk et al., 2017		

Table 8. Articles allocation

RESULTS AND DISCUSSION

OSH Training and educational methods have particularly high importance in industries where hazards cannot be completely removed, thus different programs and measures to reduce injuries, diseases and fatalities in the workplace are implemented. Legislations and organization establish mandatory training programs for workers; nevertheless programs and methods should adapt to industry hazards, worker's background education and culture, technology available, workers motivation to learning, management commitment to safety among other particular factors of each industry. Thus, the main purpose of this literature review is to identified topics of interest, training methods applied, trends of investigation, gaps in the literature and finally to assess the need for further research on education and training in occupational safety and health.

From TM and LDA results, a list of eight topics have been identified in the corpus: 1) Identification and description of factors that influence training programs efficacy; 2) Impact of leaders and management commitment to safety on OSH training and safety climate; 3) Safety training methods to improve training efficacy outcomes on workers of different fields; 4) Occupational Safety and Health training methods for construction industry; 5) Occupational Safety and Health educational programs in vocational institutions; 6) Intervention and training programs to reduce musculoskeletal disorders among industry workers; 7) Training methods to improve safety workers' knowledge and performance and 8) Intervention and training methods to reduce musculoskeletal disorders among office workers. Figure 9 shows the composition of the corpus with the eight topics generated.

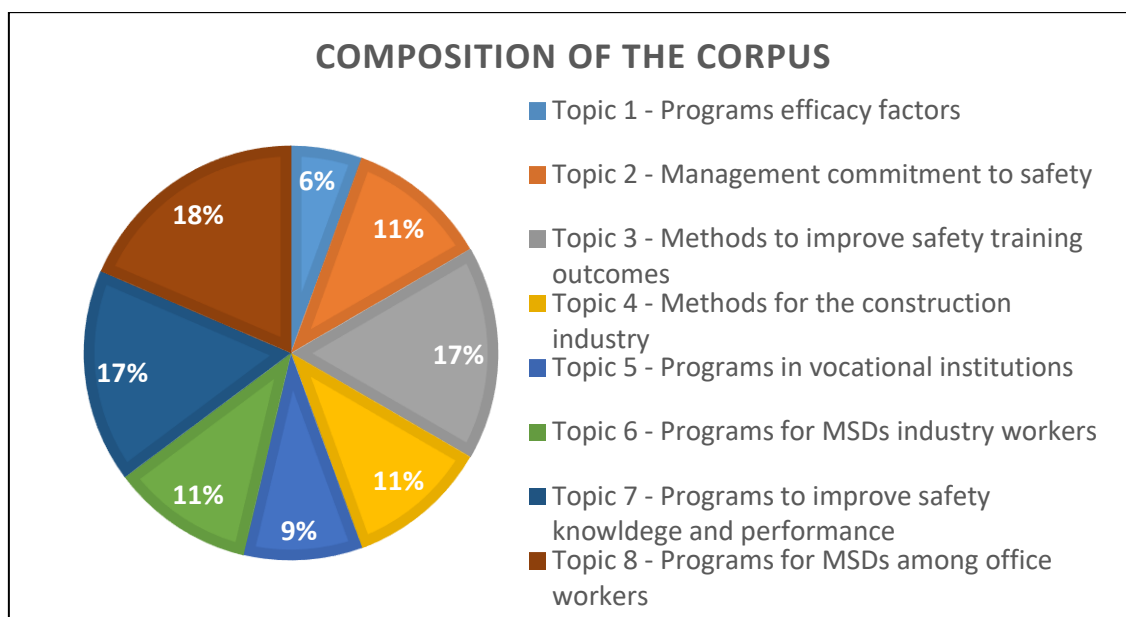


Figure 9. Composition of the corpus

Figure 10 shows the timeline of the publications inside the cluster of topic 1 and topic 4, trend lines show had have an equally importance for researches over the

last ten years, nevertheless the quantity shows a tendency for more researches on topic 4 that is related to OSH training methods for the construction industry.

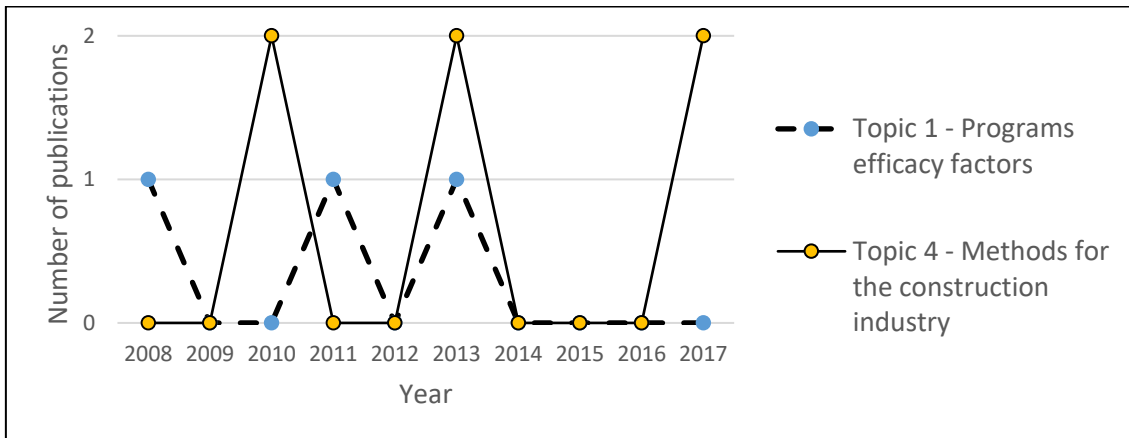


Figure 10. Topic 1 and Topic 4 Publication's timeline

Figure 11 shows the number of articles published that belong to topics 2 and topic 5. Trend lines shown that both topics have increased the attention for authors over the last period. Management commitment to safety and the importance of studies on OSH vocational educational institutions seem to have importance in further researches.

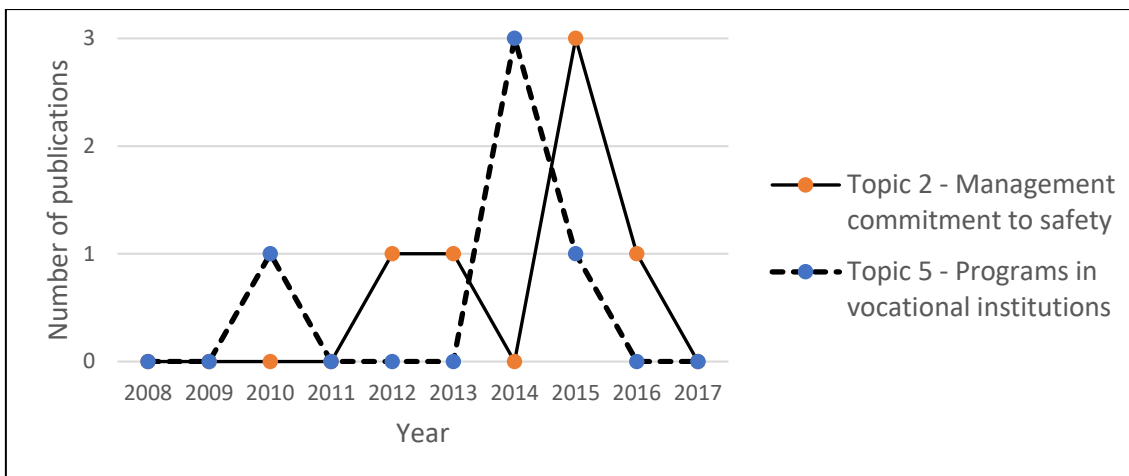


Figure 11. Topic 2 and Topic 5 Publication's timeline

Numbers of publications of Topic 3 and Topic 7 according to year of publication is shown in Figure 5.6. Topic 3 and Topic 7 Publication's timeline Trend lines show and increment of authors' interest on study methods that improve safety training outcomes while number of studies on programs to improve safety knowledge are relative constant over the time period studied.

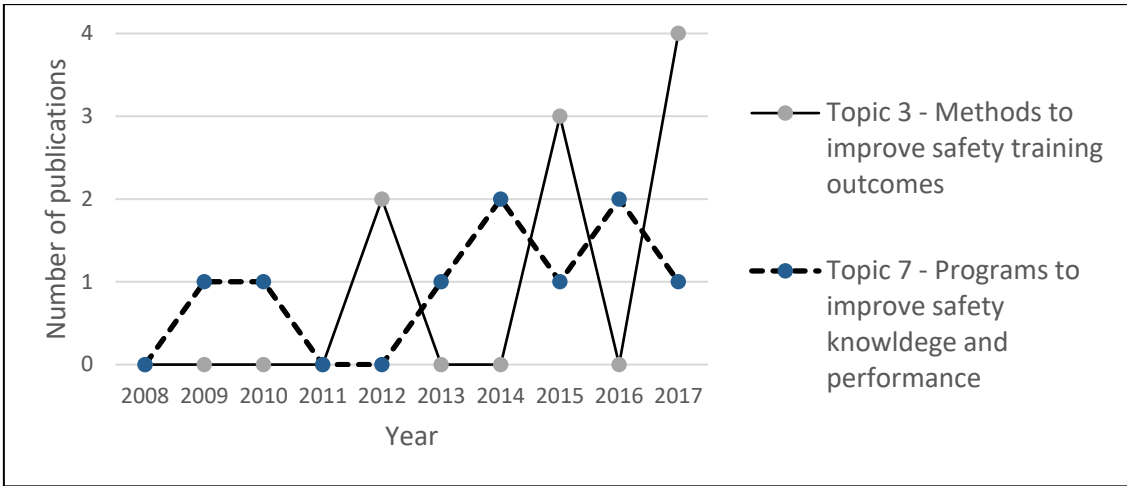


Figure 12. Topic 3 and Topic 7 Publication's timeline

Figure 5.7. Topic 6 and Topic 8 Publication's timeline Shows the number of publications belonging to Topic 6 and Topic 8 during the last decade. Topics are focused on targets with an important percentage of accidents or fatalities and MSDs respectively. The trend lines show a relative constant number of publications over the period studied for these topics.

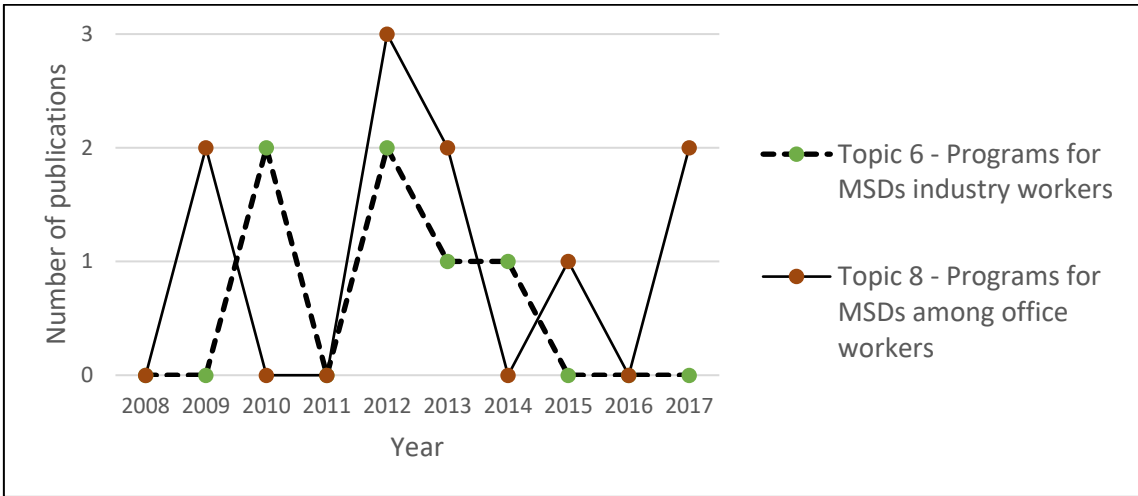


Figure 13. Topic 6 and Topic 8 Publication's timeline

Number of publications of OSH training and educational methods to improve safety outcomes have increased during the last ten years; number of publications about evaluation of vocational programs, educational programs and the importance of managers, leaders and owners commitment to safety have also increased in this ten years period reviewed.

Topic 1 generated by LDA refers to publications that are aimed to identify, describe and propose recommendations to control factors that influence the training program efficacy. Authors performed experiments to evaluate factors and knowledge before and after interventions. Publications belonging to Topic 1 evaluate the effects of verbal warnings, rehearsals and experience as factors that

could influence safety training outcomes, finding that last minute rehearsals and the experience of workers don't influence positively on safety knowledge outcomes.

Topic 2 study the importance, correlation and effectiveness of leaders, company owners and managers commitment to safety by evaluating OSH outcomes and safety climate improvement in the industry. Authors propose that higher management commitment to safety affects positively on safety climate in the industry and later on OSH outcomes. Authors have found that focusing training on leaders and managers produce transformational leadership, contingent rewards and safety self-efficacy as proxies for positive control behaviours increased and safety climate improved. Suggesting that leader training is a promising OSH intervention

Topic 3 refers to publications that implement a particular safety training method to improve training efficacy outcomes among industry workers of indistinct fields. Methods are described and experimentally tested by authors.

Topic 4 refers to articles that propose OSH training methods for construction workers, where the hazard with higher severity is to fall from altitudes. Authors use different training and educational methods to improve workers safety commitment, safety knowledge, change behaviour and hazard or risk perception among other factors, most of the programs use tool-box training techniques or conventional training techniques to perform the study. Authors' works principally are aimed to establish factors that influence construction workers to acquire knowledge and safety behaviours from training, considering this work field has commonly a wider diversity of employees' educational and cultural background.

Topic 5 clusters publications that study strengthens, weakness and needs of improvement on OSH educational programs already implemented on a particular educational or vocational institution. Authors focus their work on identify factors that influence transfer of knowledge to young and unexperienced workers. Authors use different techniques to conduct and evaluate their studies, focusing principally on methods and factors that increase safety knowledge acquisition like software and e-learning tools.

Topic 6 is related with articles that focus the work on intervention and training methods to reduce musculoskeletal disorders among industry workers. Principally author focus on work activities that require manual handling and as a consequence employees are under risk of suffering of MDS symptoms. Training methods are proposed and described by authors.

Topic 7 refers to publications that are aimed to propose training methods to improve safety workers' knowledge and their performance. Authors use different training and educational techniques to increase safety knowledge while also providing information for improving performance. As a result authors haven't found

results that significantly have shown positively link between OSH training programs implemented and performance improvement.

Topic 8 clusters articles that are focused on reducing the effects of musculoskeletal disorders among office workers. Publications are aimed to face MDS symptoms for office employees, due to the quantity of office workers this work-related disease is one of the most frequent. Different techniques for reducing this disease are proposed by authors, described and experimentally tested.

Authors have developed interest on covering and proposing training methods to reduce musculoskeletal disorders among office workers and to reduce injuries and fatalities among construction workers, this is consistent with the fact office workers are most likely to suffer MSDs and construction workers are under hazards of higher severity among employees. Authors have taken three approaches to develop training programs that are: use of software and technology, conventional training methods and modifications on conventional training methods. Training methods that are different than conventional classroom training sessions have been tested by authors, where methods that involve e-learning techniques and 3D simulation software have been used specially during last years and they show some promising results on transferring knowledge, improving hazard and risk perception and situation awareness. Nevertheless, further investigation is required following technology improvement to increase the range of industry fields where these techniques could be applied.

Topic 1 shows interaction with the other topics as a better understanding of factors that influence training programs efficacy will impact on safety knowledge outcomes, safety outcomes, behaviour change, situation awareness, risk perception, performance, etc. in the industry. In a similar way Topic 5 can interact with the other topics as it focus on identifying factors that influence training efficacy and outcomes on young or unexperienced worker. This type of workers are particularly under higher risk that other workers with preparation and experience in the same industry field.

Authors have used reminders techniques provided in periodical toolbox meetings, emails, automated feedback to refresh employees' knowledge, situation awareness and improving employee's behaviour change but still further investigation is required on techniques to assess long-term efficacy of OSH training.

Articles that evaluate training programs efficacy have used risk perception, situation awareness, behaviour change, knowledge transferred among others as outcome indicators directly related to the training session, but authors have failed or haven't tried to link the training program to a reduction of direct occupational safety and health indicators like number of fatalities, injury frequency rate or severity rate. Further investigation could be required on the correlation between OSH training and OSH outcomes.

At last, an important subject of investigation that has shown a positive tendency during last years and it is related with the impact of management commitment to safety and training programs provided to leaders, managers and industry owners in training efficacy and safety outcomes.

Limitations of this work

Articles selected for the review were published between 2008 and 2017. Thus, articles based their studies and training methods proposed on theory and publications made out of this review's scope. As a consequence of the time period selected for this review, important information and articles may be missed. Some OSH training programs that use software and technology tools could be published on journals related to education and for this reason, they are not consider in this review. LDA topic modelling is completely dependent on number of desired topics, how the terms were identified and what terms where set as stop-words and then removed. Setting a base dictionary could improve LDA results but is required to know what you are looking for.

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TABLE OF CONTENTS

AKNOWLEDGMENTS	iii
ABSTRACT IN ENGLISH.....	iv
ABSTRACT IN ITALIAN	v
EXECUTIVE SUMMARY.....	vi
TABLE OF CONTENTS	1
LIST OF FIGURES.....	3
LIST OF TABLES	4
LIST OF ABBREVIATIONS	5
1 INTRODUCTION	6
1.1 A brief review on Occupational Safety and Health.....	6
1.2 Education and training	9
1.3 Literature Review.....	10
1.4 Knowledge discovery in data bases and text mining	13
1.5 Problem description.....	16
2 METHODOLOGY.....	19
2.1 Search Protocol.....	19
2.1.1 Journals selection.....	19
2.1.2 Articles selection.....	25
3 DESCRIPTIVE ANALYSIS.....	32
3.1 Classification of publications.....	32
3.1.1 Benefits of experimental methods.....	34
3.1.2 Evaluation of OSH Education	37
3.1.3 Theory research	38
3.1.4 Literature Review.....	39
3.1.5 Method development	40
4 TEXT MINING AND LDA	42
4.1 Software selection	42
4.2 Text mining process.....	43
4.3 Latent Dirichlet Allocation output analysis	46
4.3.1 Topics generated.....	48

4.3.2	Article's allocation acceptance criteria.....	52
5	RESULTS AND DISCUSSION.....	56
6	LIMITATIONS OF THE LITERATURE REVIEW	65
7	BIBLIOGRAPHY	66

LIST OF FIGURES

Figure 1.1 OSH System (ILO, 2001)	8
Figure 1.2 Education/Training Spectra Source: (Tight, 2002)	9
Figure 1.3 Literature review main steps	11
Figure 1.4 Types of information sources	12
Figure 1.5 Steps of the KDD process	14
Figure 1.6 Basic Text Mining Process (Fan et al, 2006)	15
Figure 2.1 Journals search protocol	24
Figure 2.2 Articles search and selection protocol	28
Figure 3.1 Corpus' Articles Timeline	32
Figure 3.2 Publications classification	33
Figure 3.3. Classification of publications - Percentage	34
Figure 3.4 Training Approaches for benefits studies	36
Figure 4.1 TM and LDA Topic modelling process	44
Figure 4.2 Code for TM and LDA	45
Figure 4.3. Document-Term matrix generated. TM	45
Figure 4.4. Results display from R-console. Likelihood values	46
Figure 4.5 Allocation acceptance process. LDA results	52
Figure 5.1 Composition of the corpus	57
Figure 5.2 Topics publication timeline	58
Figure 5.3. Topic 1 Publication's timeline	59
Figure 5.4. Topic 4 Publication's timeline	59
Figure 5.5. Topic 2 and Topic 5 Publication's timeline	60
Figure 5.6. Topic 3 and Topic 7 Publication's timeline	60
Figure 5.7. Topic 6 and Topic 8 Publication's timeline	61

LIST OF TABLES

Table 2-1 Journals related with SAFETY. Source SCOPUS	22
Table 2-2. Journals related with ERGONOMICS. Source SCOPUS	23
Table 2-3. Journals related with ACCIDENT. Source: SCOPUS.....	23
Table 2-4. Journals selected	25
Table 2-5. Preliminary number of articles	27
Table 2-6. Selected Publications for review.....	31
Table 3-1. Quantity of publications in each category.....	33
Table 3-2. Object of the Benefits method studies.....	35
Table 3-3. Training methods for benefits studies.....	36
Table 3-4. Type of Organization evaluated	38
Table 3-5. Articles and methods (Method development category)	41
Table 4-1. Terms for each topic LDA.....	46
Table 4-2 Likelihood for each article. Results LDA.....	48
Table 4-3. Article selected in each topic. LDA results	49
Table 4-4. Articles with low likelihood. LDA.....	53
Table 4-5. Topic Acceptation criteria results. LDA.....	54
Table 4-6. Articles allocation	55
Table 5-1. Articles topic vs year	58

LIST OF ABBREVIATIONS

OSH: Occupational Safety and Health

MSD: Musculoskeletal Disorders

KDD: Knowledge Discovery in Database

TM: Text Mining

LDA: Latent Dirichlet Allocation

1 INTRODUCTION

This initial chapter is aimed to describe the background field and to explain the purpose objectives of the thesis. The chapter provides brief explanations on occupational safety and health (OSH), literature review, text mining. Then the problem in which this thesis is focused is detailed.

It starts with some basic explanations on importance, principles and policies of OSH are described. Then, the Literature review and Text Mining (TM) techniques are explained; the problem in which this thesis is focused is detailed. Finally the objectives to the thesis: A Latent Dirichlet Allocation Systematic Literature Review on OSH training/Education.

1.1 A brief review on Occupational Safety and Health

With the industrial revolution on the late 18th century, the born and growth of manufacturing companies have increased in a very significant rate, starting with textile mills, mining, coal and metallurgy industries to the large amount of companies and their almost endless variety of products and production capacity. The concerned of safety towards the employee has not been treated as an important factor inside the industrial field, at least in the first years.

In the United States of America for example inside the textile mills, their first large industry, the conditions, hours of work, wages, child labor and housing of the workers were issues no one gave importance. Childs reached to work 14 hours per day, 6 days per week. Tragically this industrial behavior continued the whole 19th century where accidents and fatalities in the industry was considered normal and cheap to cover. It was not until 1911 when the U.S. Public Health Service recognized the importance of occupational health and created the Office of Industrial and Hygiene Sanitation, the first attempt to improve the safety in the industry. Basically the period from 1890 to 1920 was a remarkable period in the history of health and welfare, were the workday was reduced to 8 hours, and were implemented factory inspection laws, worker compensations and child labor protection. (Abrams, 2001)

In 1931 Heinrich published the book "Industrial Accident Prevention: A Scientific Approach" where he described that 88 percent of the accidents are caused by unsafe acts of persons, approaching the problem by putting emphasis on the worker behaviour. (Jhonson, 2011)

After a huge disaster occurred in 1930 where 2000 workers developed diseases and finally 700 died few years later due to acute silicosis while were working in the excavation of a tunnel for a hydro-electrical plant in West Virginia. Then, the struggle was to achieve recognition for prevention and compensation of occupational diseases. Through all these accidents the investigation and legislation

of laws to protect the worker were increasing until the creation of the actual Occupational Safety and Health Act (OSHA) in 1970.

The scope of OSH has evolved gradually and continuously in response to social, political, technological and economic changes. Today OSH is considered as science of anticipation, recognition, evaluation and control of hazards in the workplace that could affect health and wellbeing of workers. (Alli, 2008)

Even with all the techniques, knowledge, tools and systems to prevent accidents and fatalities, the International Labour Organization (ILO) estimates that 2 million deaths are work-related across the globe every year and 160 million have work-related diseases (Alli, 2008). All these fatalities and diseases carry not only human and social pain but also an immense economical cost, all the accidents are caused by actions that could be prevented by implementing a correct measure and technique. Nowadays, Occupational Safety and Health principles are identified as the means used to promote safety in the workplace are international standards, codes of practicing, technical advices. Standards created by organizations like ILO or OSHA can be ratified by a State, causing specific binding obligations.

Despite the vast amount of different activities, specific fields and hazards. All the standards share some common principles, detailed below (Alli, 2008):

- All workers have rights.
- Occupational safety and health policies must be established.
- A national system for occupational safety and health must be established.
- Employers and workers must be consulted.
- OSH programs must be aimed both to prevention and protection.
- Continuous improvement of the program.
- Adequate feedback information about hazards, workplaces and good practices.
- Occupational health services covering all the workers must be established.
- Compensation, rehabilitation, curative services for the workers who have suffered accidents and work-related diseases.
- Education and training are vital components of safe, health work environments.
- Workers, employers and authorities have responsibilities, duties and obligations.
- Enforce the policies.

Inside the scope of OSH and as one the key means are education and training, these provide theoretical and practical knowledge required to carry out a task or occupation successfully; as it is difficult to change the behavior, habits and reflexes of people gain through time, it is important to introduce safe working methods and school the personal. It has to been provided taking into account the education level of the worker, technical level of their activity and nature of their responsibilities. (Alli, 2008)

Education and training is a key activity in which authority, employer and workers must be involved as is shown on figure 1.1.

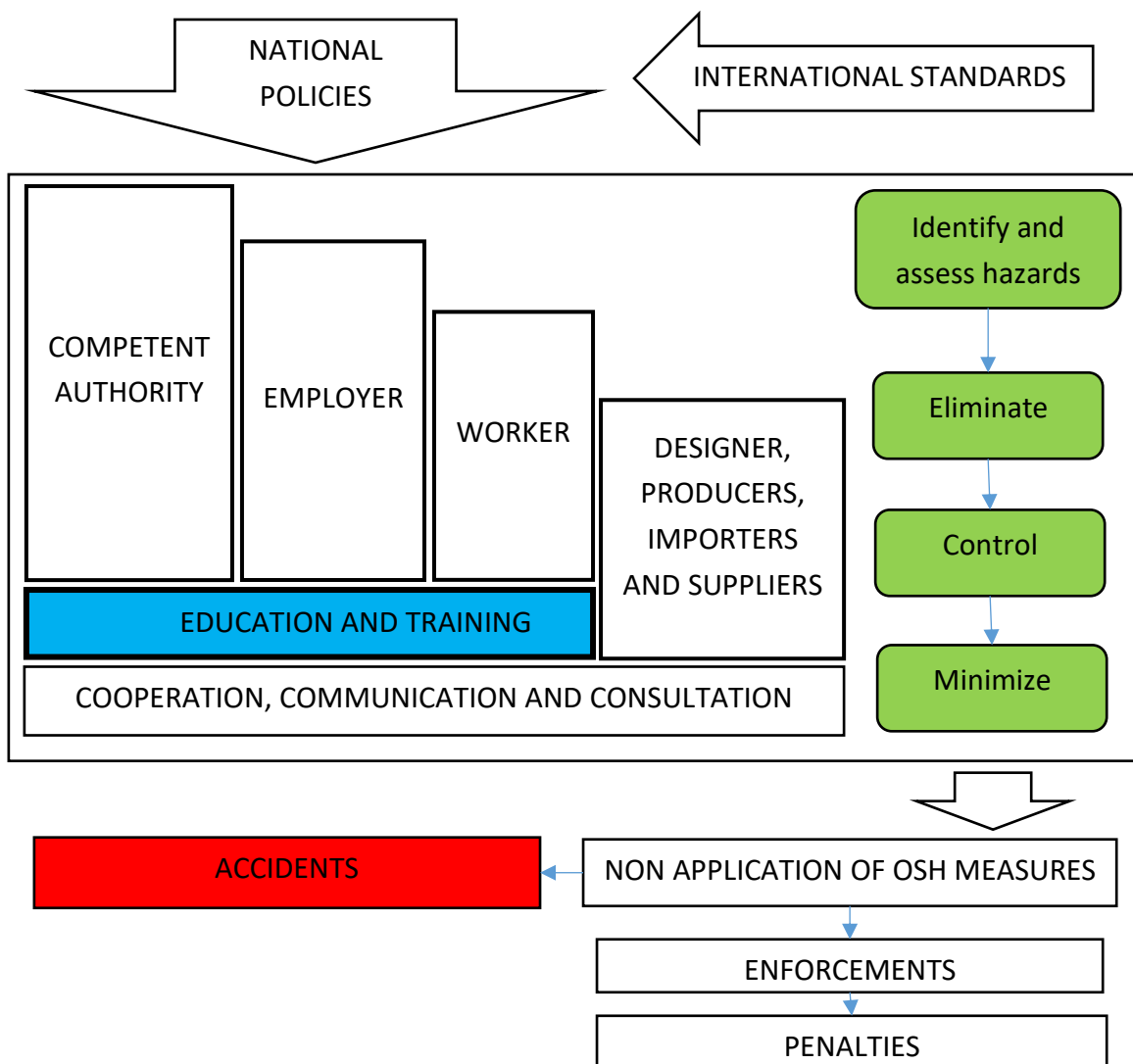


Figure 1.1 OSH System (ILO, 2001)

Training is the most important responsibility of the employers and it shouldn't be treated as a separate activity but as an integral part of job activity training. All the workers must know how to protect their lives and of their colleagues in the workplace, for this reason the employer has to establish training and information programs on:

- Safety and health aspects of the work.
- Ways to prevent and minimize exposure to hazards.

1.2 Education and training

Even if education and training in this review are related only to Occupational Safety and Health, they can have different meanings or perceptions that are important to highlight.

Education can be seen as process of conceptualization, this means an organized and sustained instruction designed to communicate a combination of knowledge, skills and understanding valuable for all activities of life. (Tight, 2002)

Training on the other hand has entered the field of educational quite late and as an inferior form of education. Its definition stresses the idea of mastering a specific task or role, and the need for repetitive practice to enable the individual to do so, while underlining that the task could be performed mechanically and with lack of knowledge and understanding. (Tight, 2002)

Focusing directly on OSH training, it can be defined as a range of efforts designed to engage trainees with the goal of affecting motivation, attitudes, and behavior for the purpose of improving workers' safety and health in the job. (O'Connor et al., 2014)

Figure 1.2 shows the commonest approach to make the distinction between education and training, where is shown the higher breadth and/or depth required in education and the improvement for immediate application and critically obtained by training.

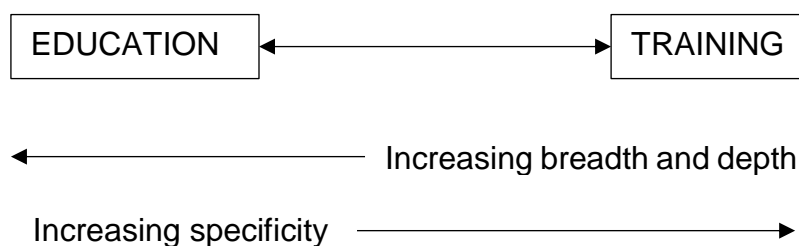


Figure 1.2 Education/Training Spectra Source: (Tight, 2002)

Based on human capital theory, education and training in an institution can provide pecuniary and non-pecuniary returns, therefore skills and knowledge inherent in individuals is measurable and can be used as an indicator of rational calculation of individuals' rate of return.

1.3 Literature Review

Literature review can be seen as “the selection of available documents (both published and unpublished) on a specific topic which contains information, data and evidence written from a particular standpoint to fulfil certain aims or to express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed” (Hart, 1998).

The main reasons to perform a literature review are several and include:

- To develop policies.
- To evaluate current practices.
- A step in research process.
- For academic assessments.

A well done literature review has to be not just limited to list all the information sources but it has to identify the correct sources related to a given subject, analyze the info and identify trends of research and possible gaps to be fulfilled with future works. The overall purpose of a literature review is to critically appraise and synthesize the current state of knowledge related to the topic under investigation. (Carnwell et al., 2001)

Literature review is an important tool that helps the researcher to:

- Helping to understand the existing body of knowledge, including fields with excess and lack of research.
- Providing a solid theoretical foundation of the subject to be studied.
- Identifying a possible new research problem. (What is needed to be known)
- Framing the methodologies, techniques, approach and goals for the proposed study. (Levy et al., 2009)

As we need to well-define the approach to reviewing the literature in the specific topic under study, the selected type of literature review to be performed is a Systematic literature review. A systematic literature review details the time frame within the literature was selected and the methods used to evaluate and draw the findings of the study. (Cronin et al., 2008)

To prove the validity of the review, the precise criteria used must be presented:

- Formulate the research question.

- Set inclusion or inclusion criteria.
- Select and assess the literature.
- Assess the quality of the literature included.
- Analyze, synthesize and disseminate the findings.

The main purpose of this review is to provide as completed a list of all published and unpublished studies related with the topic in question. (Cronin et al, 2008).

Figure 1.3 shows the five main steps to carry out a traditional literature review (Jones et al, 2014).

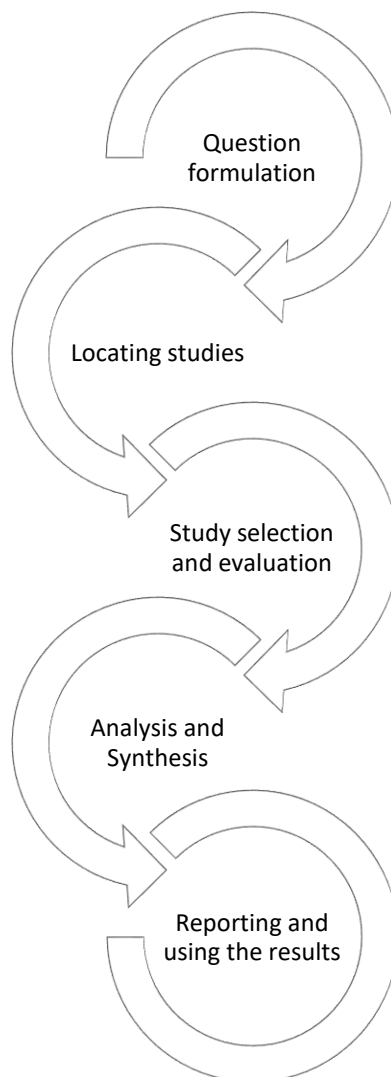


Figure 1.3 Literature review main steps

➤ **Step 1 - Question and formulation**

The initial step normally is one of the first issues that a researcher faces and something the student struggles with. It is necessary to determine the correct review

in topic in order to get a sufficient but manageable amount of information. Selection of a topic too broad will result in reviews too long or too superficial (Cronin et al, 2008)

➤ **Step 2 - Locating studies.**

Once selected the correct topic it is requested to identify in a structured way the appropriated and related information, this means searching the literature. Nowadays, internet gives a large amount of information on our disposal, therefore the quality of the databases must be considered. (Cronin et al, 2008)

➤ **Step 3 – Study selection and evaluation.**

What a reviewer most considerer as more important factors to decide if include or not an article in the review is comprehensiveness and relevance, but also the quality of the information source must be take it in consideration.

Type of source is a key factor and can be classified as is showed below. (Reed, 1998)

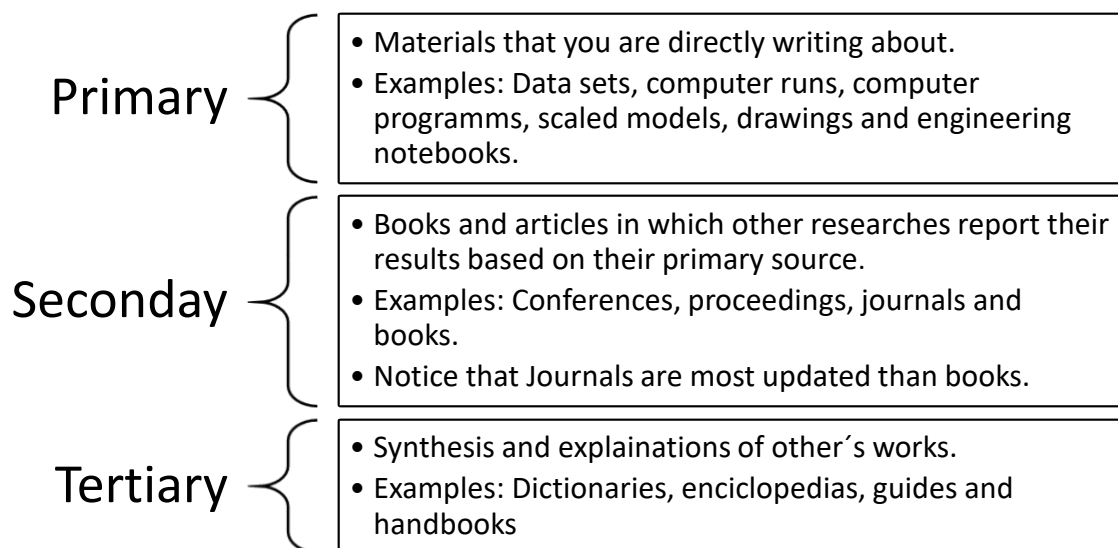


Figure 1.4 Types of information sources

The selection and evaluation of the literature is the main difference between traditional and systematic review. Where in systematic review the search strategy must be sufficiently detailed to allow the search to be replicated. (Tranfield et al., 2003)

➤ **Step 4 - Analysis and synthesis.**

In this steps the task can be approached using different techniques depending on the type of review is being performed and in the quantitative and qualitative level of the sources. In a traditional review the basic procedure consists in:

- Undertake a first read of the articles collected (summary or abstract) to get a sense of what they are about.
- Eliminate possible articles not suitable to our selection criteria.
- Perform an initial classification of the articles by the type of source.
- Undertake a more systematic and critical review of the content.
- Perform an indexing or summary system of the articles (Principally purpose, methodology and comments concerning strengths and weakness of the publication are important). (Cronin et al, 2008)

➤ **Step 5 – Reporting and using the results.**

Here is where the results of our review are written down and it has to be clear, easy to understand avoiding long and confusing words. Typically includes:

- Introduction: Purpose of the review and brief explanation of the problem, sources and key words are detailed as well as the criteria for inclusion or exclusion.
- Main body: Presents and discusses the findings from the literature according to the used approach (see Table 1), address contradictions, inconsistencies, weakness and strengths.
- Conclusions: Concise summary of the findings that describe current knowledge and ideas for future research, recommendations and implications.
- References: Full list of books, journal articles, reports and other media used in the work. (Cronin et al, 2008)

1.4 Knowledge discovery in data bases and text mining

Historically, the knowledge discovery in data bases (KDD) has been a work of analyzing and interpreting data manually. Literature review is a task that fits under this consideration.

As has been explained previously, the amount of information at disposal of the student or researcher developing a literature review could be large depending on the topic, sources and time period under consideration. In this case the student/researcher struggles with gathering, organizing, analyzing and assimilating the information; where performing a traditional literature review would be near impossible. The traditional literature review approach presents some few shortcomings (Delen et al, 2008):

- Key words the research chooses for the search may not be necessarily correlated with the words designed by the authors.
- Potentially missing of important works by optimizing and reducing the number of online libraries accessed.
- Due to vague or even fanciful titles of the publications, the researcher may neglect to even read the abstract.

KDD is the nontrivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data. (Fayyad et al, 1996). The main steps of KDD process can be seen on the figure 1.4.

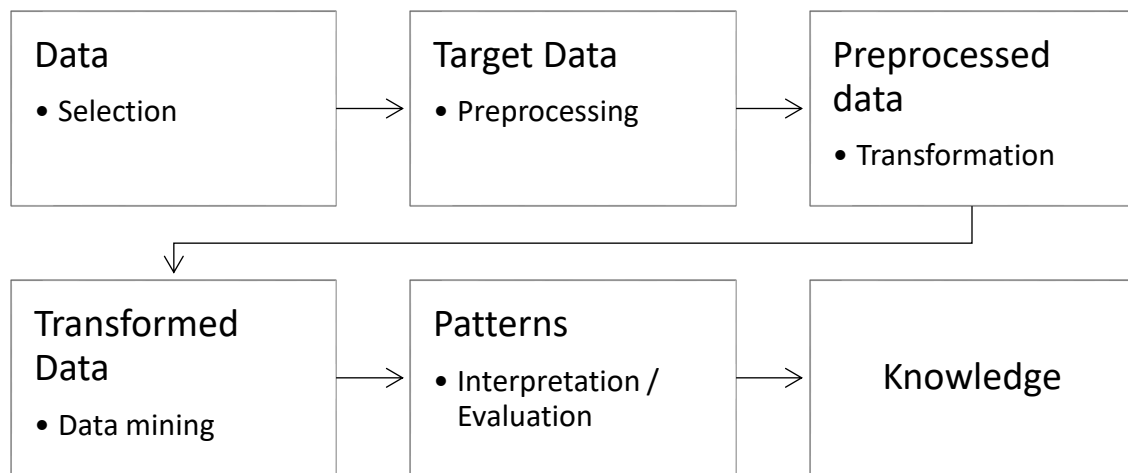


Figure 1.5 Steps of the KDD process

“The KDD process involves using the database along with any required selection, processing, subsampling and transformations of it; applying data-mining methods (algorithms) to enumerate patterns from it and evaluating the products from data-mining to identify if them deemed knowledge” (Fayyad et al, 1996)

However, this regular process is designed for structured databases where the information is presented in categorical, ordinal and continuous variables. For unstructured databases a different data mining technique has been developed called Text Mining (TM).

Text mining has been defined as the discovery by computer of new, previously unknown information by automatically extracting information from different written resources. (Fan et al, 2006).

Figure 1.5 describes the basic TM process for a literature review. The main difference with data mining is that text mining extracts information from natural

language text rather than from structured databases. Text mining first numericizes the unstructured text document and then through different techniques extracts patterns from them.

A more detailed description of text mining process is: data (text documents) is first collected then is transformed and organized in the same representation form (e.g. ASCII text files). The list of organized documents then is processed and converted in a term-by-document matrix. The matrix contents indices than relate the terms with the documents, from these indices is possible to extract patterns for managerial decision making. Thus, the main goal of TM is to convert the list of documents in a matrix with appropriate indices that will be used later on during the final steps for conclusions and decision making. (Delen et al, 2008)

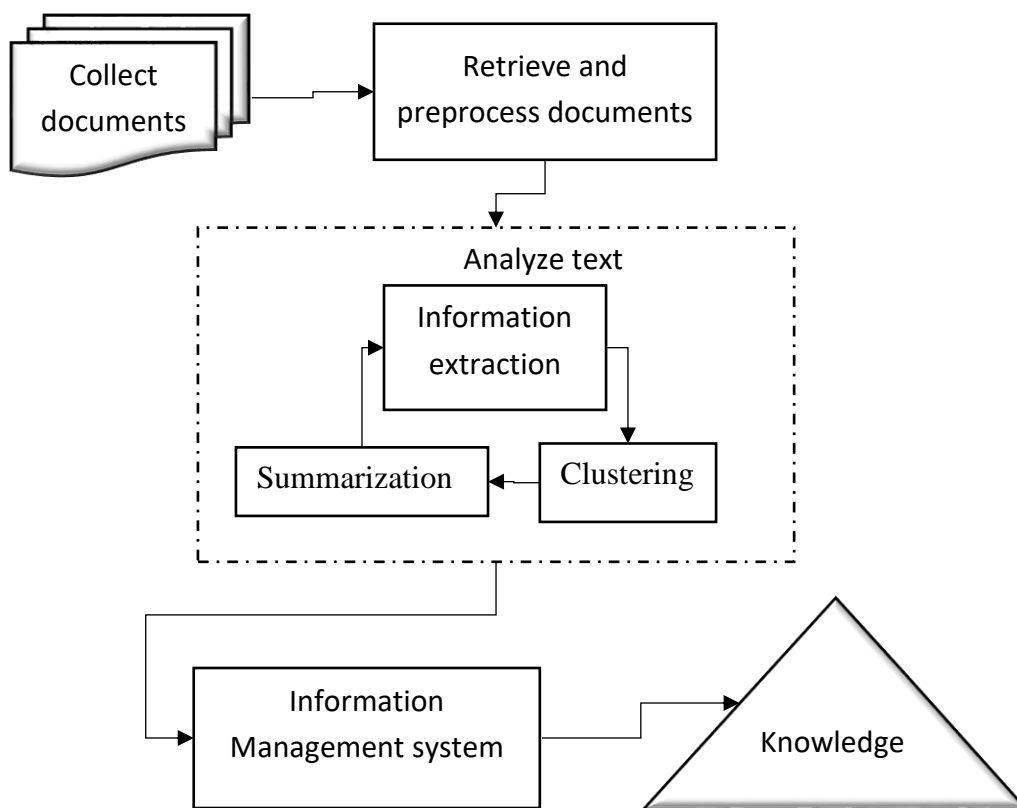


Figure 1.6 Basic Text Mining Process (Fan et al, 2006)

Applications of TM include (Delen et al, 2008):

- Information extraction: identifying key phrases and relation with the text by pattern matching.
- Topic Tracking: prediction of topics of interest based on a profile view history.
- Summarization.

- Categorization: Identifying themes of the document and placing them among the predefined topics.
- Clustering: grouping documents which are similar to each other without a pre-defined set of categories.
- Concept linking: Connect documents by their commonly shared concepts.
- Question answering: find the best answer to a given question by knowledge-driven pattern.

For literature review is possible to specify a list of terms to be excluded from the term matrix and called “stop terms” identified by domain experts. In the same way is possible to set a pre-determined terms under which the documents are going to be indexed called “include terms”. (Delen et al, 2008)

However, this term-by-document matrix can be dimensionally too big because same concepts in documents can be expressed using any number of different terms (synonymy) and by the contrary, apparently same terms can have very different meanings in different contexts (polysemy). Thus, a dimension reduction technique should be applied in order to collapse together terms that have the same semantics, identify and disambiguate terms with multiple meanings and provide low-dimensional that reflect concepts instead of raw views (Crain S.P., 2012)

Different techniques to face the problem of dimensionality of the final matrix obtained by TM have been developed, for this thesis work, the Latent Dirichlet Allocation system (LDA) is used. LDA is a topic modelling technique that essentially integrates clustering with dimension reduction. According to Crain S.P. (2012) in LDA documents are associated with a number of latent topics, which correspond to both documents clusters and compact representations identified from a corpus. Each document is assigned to the topic with different weights. The result is an understandable representation of documents that is useful for analyzing the themes in documents. Moreover, LDA provides a generative probabilistic approach for different topics in arbitrary documents. The LDA process and methodology is treated later in this thesis, under the methodology section.

1.5 Problem description.

OHS has a great significance to companies and to workers due to economic and social impacts that injuries, fatalities and illness in the workplace can carry. Thus, several researches, methodologies and other scientific literature regarding occupational safety and health have been published during last decades.

The context for Occupational Safety and Health education and training has been adapting to the globally changing nature of work. Until recently and commonly

OSH training fell into two categories: 1) training organized by employers and carried out in the workplace and 2) training organized and focused in specific unionized workers. As the world has become more connected and number of immigrants has increased in developed countries during the last decades, the effects of having personnel with different languages, education and cultural background has carried more difficult to OSH training and educational programs and the way the methods are conceived. Therefore, OSH training programs need to adapt to the very different work contexts of group of workers, based also in the level of organization of the worker community where they can be: 1) Unionized workers with stable employment; 2) Temporary and contractual workers with high levels of job insecurity and little influence on decision making on their working conditions; 3) Undocumented immigrant workers who are fearful that complaining about their working conditions could affect the relation with their employer or that could conduct to deportation. (O'Connor et al, 2014)

Following the work conditions, the field of OSH has developed a wide range of creative, engaging training methods. Therefore one of the purposes of this thesis is to identified the training and education methods that have been object of interest to authors of the publications in the corpus of the literature review.

The need to understand how to design, implement, manage and control OHS systems is important due to the great quantity of employees affected by work-related accidents or illness reported every year. The focus of this thesis is too perform a review of the existing literature regarding OSH training/education.

The study performed by Burke et al. (2006) shows that the types of methods regarding safety and health training are relevant for safety performance and reduction of accidents and injuries. Moreover, they conclude that going from traditional theoretical learning processes (education based on lecture) to experimentally-based methods (training) increase the knowledge acquisition.

In previous reviews different training and educational methods have been identified based principally on the primary purpose of the program. The principally primary focus of programs are on (O'Connor et al., 2014):

- Knowledge transfer/skills development (e.g., a program designed to teach workers about the chemical hazards present in their workplace and the warning signs and labels associated with each).
- Attitudinal change (e.g., a program geared towards increasing workers' degree of concern about safety and health hazards in the workplace or enhancing the extent to which they believe that it is possible to reduce their exposure to such hazards by taking certain actions); or

- Social action or “empowerment” (e.g., a program designed to encourage workers to talk with each other about job hazards and to take collective action to solve problems).

The main objectives of this thesis is to perform a Latent Dirichlet Literature Review of OHS education and training and to extract conclusions on:

- Topics of interest to authors; what are the industry sectors where they focus their work? What are the types of workers authors take into account in their publications?
- Training methods applied by authors. What are the approaches authors used to develop their investigations?
- Trends of investigation. Where is the investigation heading on OSH training and education?
- Assess the need of further investigation on the field. What are the subtopics on the OSH training and education field that need more investigation based on actual findings and investigation tendencies?

2 METHODOLOGY

In this chapter all the process to perform this literature review is completely described to provide a clear guide to understand this work and two replicate this results for comparisons or further works in the topics related with education and training on OSH.

This section includes the criteria and procedure for journals and articles selection.

2.1 Search Protocol

A literature review depends on the articles selected for analysis, the articles are selected following a systematic process called search protocol, the description in detail of this process is explained next where search protocol is split in Journal selection criteria and article selection criteria.

2.1.1 Journals selection

Taking in account that the objective of this work is to perform a literature review on training and education in the OHS field, journals with subjects areas more related with social science and health science will be preferred rather than physical science.

The databases from publications have been in constant growth in all the scientific fields, reason why indicators that assign weights to bibliographic citations have been used.

In this thesis or initial database is Scopus, the world's largest database (González-Pereira et al., 2010). Scopus covers 37448 sources from all subject areas.

The selection criteria is detailed:

- Three search are performed for the words “safety”, “ergonomics” and “accident” on the title of the sources.
- The resulting list is sorted according to the SJR³ indicator and a review of all the possible sources is done in the following order.
 - Coverage: must be at least 5 years old and ongoing (2012-ongoing).
 - Source type: Journal.
 - Subject area must be related with OSH field. Journals with subject area related exclusively to Engineering won't be selected as the main

³ SCImago Journal Rank is an indicator that ranks scholarly journals based on citation weighting schemes and eigenvector centrality (González-Pereira, Guerrero-Bote, & Moya-Anegón, 2010)

objective of this thesis is perform a literature review in areas more related with Social science than Physical science.

- At this point Journals with a SJR score equal or higher than 1 are selected.
- For journals with a SJR score less than 1 and higher than 0.2, a review of their scope and publications is performed. Those with publications highly related with the interested area are selected.
- Journals with a SJR score less than 0.2 are not selected.

Table 2-1, table 2-2 and table 2-3 show the list of journals resulting for “Safety”, “Ergonomics” and “Accident” respectively, using SCOPUS search engine, sorted by the SJR indicator and those that match all the selection criteria are indicated with a X.

SOURCES RESULT FOR: Safety				
Source Title	Coverage	2016 SJR	Source Type	Selected
BMJ Quality and Safety	2011-ongoing	2.540	Journal	
Comprehensive Reviews in Food Science and Food Safety	2005-ongoing, 2002-2003	2.386	Journal	
Therapeutic Advances in Drug Safety	2012-ongoing	1.670	Journal	
Structural Safety	1982-ongoing	1.615	Journal	
Pharmacoepidemiology and Drug Safety	1994-ongoing	1.479	Journal	
Drug Safety	1990-ongoing	1.445	Journal	
Reliability Engineering and System Safety	1988-ongoing	1.407	Journal	
Expert Opinion on Drug Safety	2002-ongoing	1.297	Journal	
Ecotoxicology and Environmental Safety	1977-ongoing	1.205	Journal	
Safety Science	1991-ongoing	1.054	Journal	X
Journal of Safety Research	1982-ongoing, 1969-1980	1.020	Journal	X
Fire Safety Journal	1977-ongoing	0.932	Journal	
Journal of Patient Safety	2006-ongoing	0.888	Journal	
Joint Commission Journal on Quality and Patient Safety	2005-ongoing	0.791	Journal	
Process Safety and Environmental Protection: Transactions of the Institution of Chemical Engineers, Part B	1990-ongoing	0.685	Journal	
Caikuang yu Anquan Gongcheng Xuebao/Journal of Mining and Safety Engineering	2009-ongoing	0.634	Journal	
Patient Safety in Surgery	2010-ongoing	0.561	Journal	
Safety and Health at Work	2010-ongoing	0.538	Journal	X

SOURCES RESULT FOR: Safety				
Source Title	Coverage	2016 SJR	Source Type	Selected
Drug, Healthcare and Patient Safety	2009-ongoing	0.522	Journal	
Journal of Transportation Safety and Security	2010-ongoing	0.476	Journal	
Process Safety Progress	1993-ongoing	0.476	Journal	
Current Drug Safety	2006-ongoing	0.454	Journal	
International Journal of Injury Control and Safety Promotion	2005-ongoing	0.410	Journal	
Journal of Food Safety	1993-ongoing	0.383	Journal	
Crime Prevention and Community Safety	1999-ongoing	0.342	Journal	
SAE International Journal of Transportation Safety	2013-ongoing	0.306	Journal	
Drug Safety - Case Reports	2015-ongoing	0.303	Journal	
Quality Assurance and Safety of Crops and Foods	2011-ongoing	0.297	Journal	
International Journal of Risk and Safety in Medicine	1991-ongoing	0.284	Journal	
Workplace health & safety	2012-ongoing	0.272	Journal	
International Journal of Reliability, Quality and Safety Engineering	1996-ongoing	0.267	Journal	
International Journal of Occupational Safety and Ergonomics	1999-ongoing, 1995-1996	0.259	Journal	X
Journal of Chemical Health and Safety	2006-ongoing	0.249	Journal	
Journal of Agricultural Safety and Health	1997-ongoing	0.236	Trade Journal	
Case Studies in Fire Safety	2014-ongoing	0.229	Journal	
International Journal of Reliability and Safety	2008-ongoing	0.219	Journal	
Italian Journal of Food Safety	2013-ongoing	0.216	Journal	
International Journal of Vehicle Safety	2007-ongoing	0.211	Journal	
Sensing and Instrumentation for Food Quality and Safety	2008-2013	0.172	Journal	
Policy and Practice in Health and Safety	2013-ongoing	0.124	Journal	
Topics in Safety, Risk, Reliability and Quality	2012-ongoing, 2010, 2006-2008	0.117	Book Series	
Open Drug Safety Journal	2010-2011	0.112	Journal	
Applied Biosafety	2015-ongoing, 2001	0.111	Journal	
Nuclear and Radiation Safety	2012-ongoing	0.106	Journal	
Journal of Occupational Health and Safety - Australia and New Zealand	1986-ongoing	0.101	Journal	
Occupational health & safety (Waco, Tex.)	1976-ongoing	0.101	Journal	
International Journal of Safety and Security Engineering	2011-ongoing	0.100	Journal	

SOURCES RESULT FOR: Safety				
Source Title	Coverage	2016 SJR	Source Type	Selected
AIHA journal : a journal for the science of occupational and environmental health and safety	2002-2003		Journal	
AIHAJ : a journal for the science of occupational and environmental health and safety	2000-2002		Journal	
Chemical Health and Safety	1999-2005, 1995		Journal	
Environmental Biosafety Research	2002-2011		Journal	
Health care security and safety management	1980-1982		Journal	
Hospital security and safety management	1982-2002		Journal	
Industrial Safety Series	2008, 2005, 1998, 1995		Book Series	
Injury control and safety promotion	2002-2004		Journal	
International Journal of Food Safety, Nutrition and Public Health	2008		Journal	
Joint Commission journal on quality and safety	2003-2004		Journal	
Joint Commission Perspectives on Patient Safety	2006-2011		Journal	
National Safety and Health News	1985-1986		Journal	
National safety news	1974-1985		Journal	
Nuclear Plant Safety	1985-1986		Journal	
Nuclear Safety	1969-1997		Journal	
Professional safety	1975-1989		Journal	
Quality and Safety in Health Care	1996-2010		Journal	
Safety and Health	2006-2012, 1987-1988, 1976-1978		Trade Journal	
SESHA Journal: Semiconductor Environmental Safety and Health Association	2004-2010		Journal	
SSA Journal: Journal of the Semiconductor Safety Association	1997-2002		Journal	
The International journal of occupational health & safety	1974-1976		Journal	
Workplace HR and Safety Magazine	2007-2008		Trade Journal	

Table 2-1 Journals related with SAFETY. Source SCOPUS

SOURCES RESULT FOR: Ergonomics				
Source Title	Coverage	2016 SJR	Source Type	Selected
Ergonomics	1965-ongoing, 1961	0.913	Journal	X
Applied Ergonomics	1969-ongoing	0.875	Journal	X
International Journal of Industrial Ergonomics	1986-ongoing	0.564	Journal	X
Reviews of Human Factors and Ergonomics	2011-ongoing	0.403	Book Series	
Theoretical Issues in Ergonomics Science	2010-ongoing	0.386	Journal	
Human Factors and Ergonomics In Manufacturing	1996-ongoing	0.344	Journal	
International Journal of Occupational Safety and Ergonomics	1999-ongoing, 1995-1996	0.259	Journal	X
Ergonomics in Design	1995-ongoing	0.252	Journal	
Occupational Ergonomics	2004-ongoing, 2000-2002, 1998	0.151	Journal	
Advances in Human Factors/Ergonomics	1997, 1995		Book Series	
Elsevier Ergonomics Book Series	2005, 2002, 2000		Book Series	
International Journal of Human Factors and Ergonomics	2016-ongoing		Journal	

Table 2-2. Journals related with ERGONOMICS. Source SCOPUS

SOURCES RESULT FOR: Accident				
Source Title	Coverage	2016 SJR	Source Type	Selected
Analytic Methods in Accident Research	2013-ongoing	5.092	Journal	
Accident Analysis and Prevention	1969-ongoing	1.490	Journal	X
Emergency nurse : the journal of the RCN Accident and Emergency Nursing Association	1998-ongoing, 1992	0.146	Journal	
Accident and Emergency Nursing	1993-2007		Journal	
Journal of Accident and Emergency Medicine	1994-2000		Journal	
Journal of Occupational Accidents	1976-1990		Journal	
Zeitschrift für Unfallmedizin und Berufskrankheiten. Revue de medecine des accidents et des maladies professionnelles	1953-1982, 1947-1948		Journal	

Table 2-3. Journals related with ACCIDENT. Source: SCOPUS

The entire process of the journals selection protocol described above is shown in figure 2.1

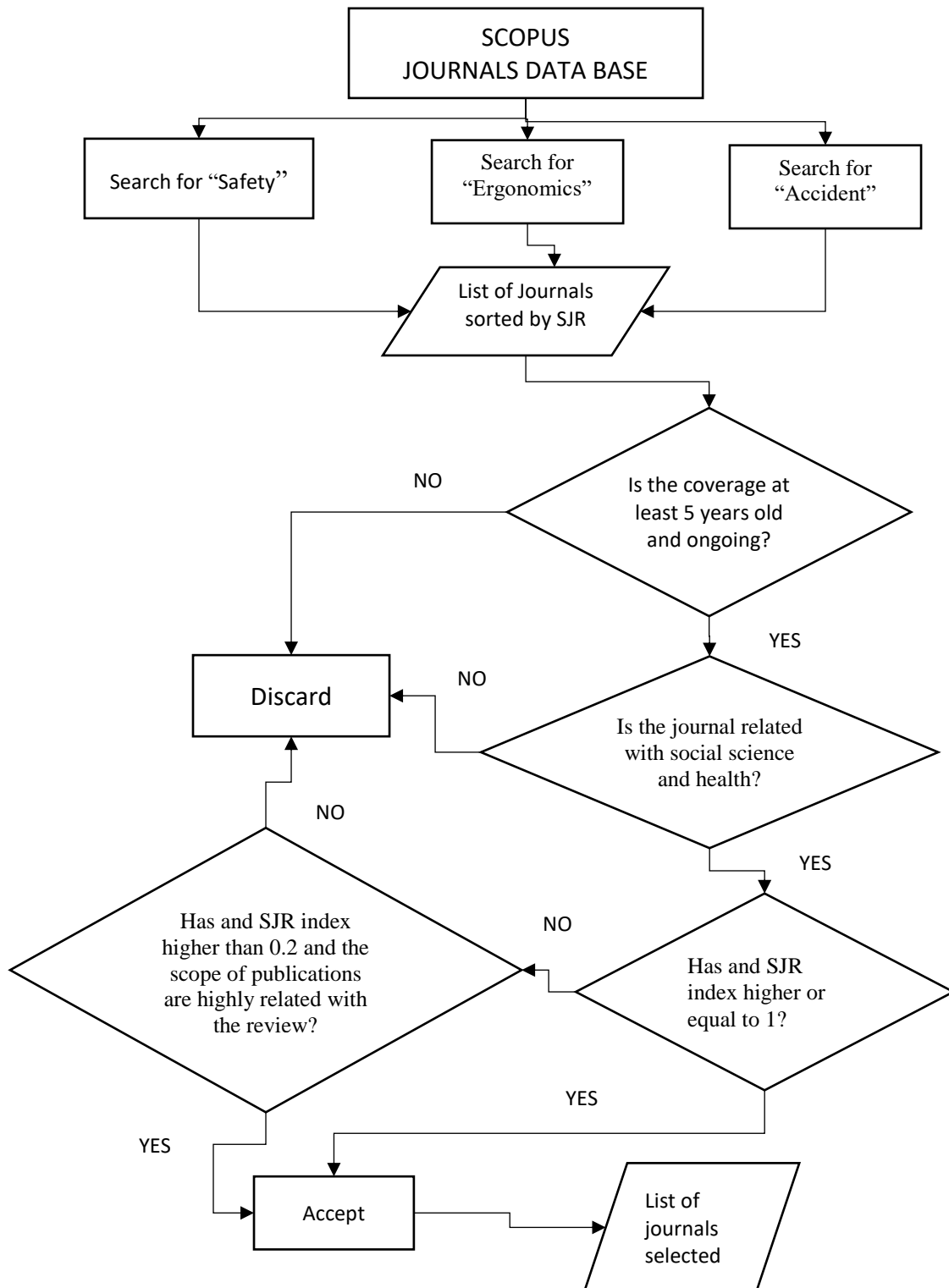


Figure 2.1 Journals search protocol

According with the selection criteria established, the resulting Journals from which the search for articles will take place are indicated in table 2-4.

Source Title	Source Type	Publisher's Name	Publisher's Country
Accident Analysis and Prevention	Journal	Elsevier Ltd.	United Kingdom
Ergonomics	Journal	Taylor & Francis	United Kingdom
Applied Ergonomics	Journal	Elsevier Ltd.	United Kingdom
Safety Science	Journal	Elsevier BV	Netherlands
Journal of Safety Research	Journal	Elsevier Ltd.	United Kingdom
International Journal of Industrial Ergonomics	Journal	Elsevier BV	Netherlands
Safety and Health at Work	Journal	Occupational Safety and Health Research Institute.(OSHRI)	South Korea
International Journal of Occupational Safety and Ergonomics	Journal	Taylor & Francis	United Kingdom

Table 2-4. Journals selected

2.1.2 Articles selection

The search for the articles is performed in the search engine of SCOPUS using a specified query string that contain all the possible fields related with this literature review and connected through Boolean⁴ operators. The array of the complex query string can be subjective and depends on how the variables are going to be defined.

First, variables must be defined, to perform the search is necessary to specify what, where and in what time period.

Time period: articles published from 2008 to present (last 10 years) will be considered.

What: In order to avoid reduced or too extended results, the domain of the fields need to be correctly specified. The literature review is going to be done on articles related with education/training in Occupational Safety and Health (OSH)

⁴ Connectors (AND, OR, NOT, etc) that indicate the relationship that two or more terms in the search expression must have in a document in order for the document to be included in your search results.

field, thus, three different blocks are identified. One for education/training, the second one for domain related to Occupational and a third one for accident domain.

- Education/training:
 - Education.
 - Training.
- Occupational:
 - Occupational.
 - Industrial.
 - Work-related.
 - Job-related.
- Accident:
 - Accident.
 - Risk.
 - Safety.
 - Health.
 - Hazard.

Where: Using advanced search engines normally available in journals is possible to specify where we want to look for the terms. In order to avoid the possibility of miss publications that are related with this review but present different terms considering title, abstract or keywords by separate, therefore, the search will consider terms appearing in any of the three fields (title. Abstract and keywords) but all the terms must be contained.

The searches are performed using the query string generated considering the aspects that have been already detailed. The query string is:

(Education OR training) AND (occupational OR industrial OR “work-related” OR “job-related”) AND (accident OR risk OR safety OR health OR hazard)

Table 2-5 shows the result of the searches that are represented by the number of matches in each journal according to the search criteria.

The number of publications found is quite large due to the fact that both terms, training and education can be common and appear in publications that are not necessarily important for this review. At this point a manual analysis is performed

on the 487 publications that matched the query string search. Analysis consists in reading titles, keywords and abstracts in order to identify articles that are close related to training and education on OSH.

To identify what publications should be discarded, an exclusion criteria is generated where is established those articles where the search terms appear but are mentioned in a different context, have a different meaning or mentioned as a brief description or conclusion.

Source Title	Number of Articles
Accident Analysis and Prevention	72
Ergonomics	26
Applied Ergonomics	50
Safety Science	160
Journal of Safety Research	49
International Journal of Industrial Ergonomics	28
Safety and Health at Work	53
International Journal of Occupational Safety and Ergonomics	49
TOTAL	487

Table 2-5. Preliminary number of articles

Publications where education and training are related to: prevention through design, education of engineers and university professors, teaching or education in institutions, violence, worker's education background, name of organizations referred (Example: Centre for Construction Research and Training) and physical training are discarded, also same publications in different journals and publications where terms education and training appear only on conclusions or recommendations are discarded. This is defined as the exclusion criteria.

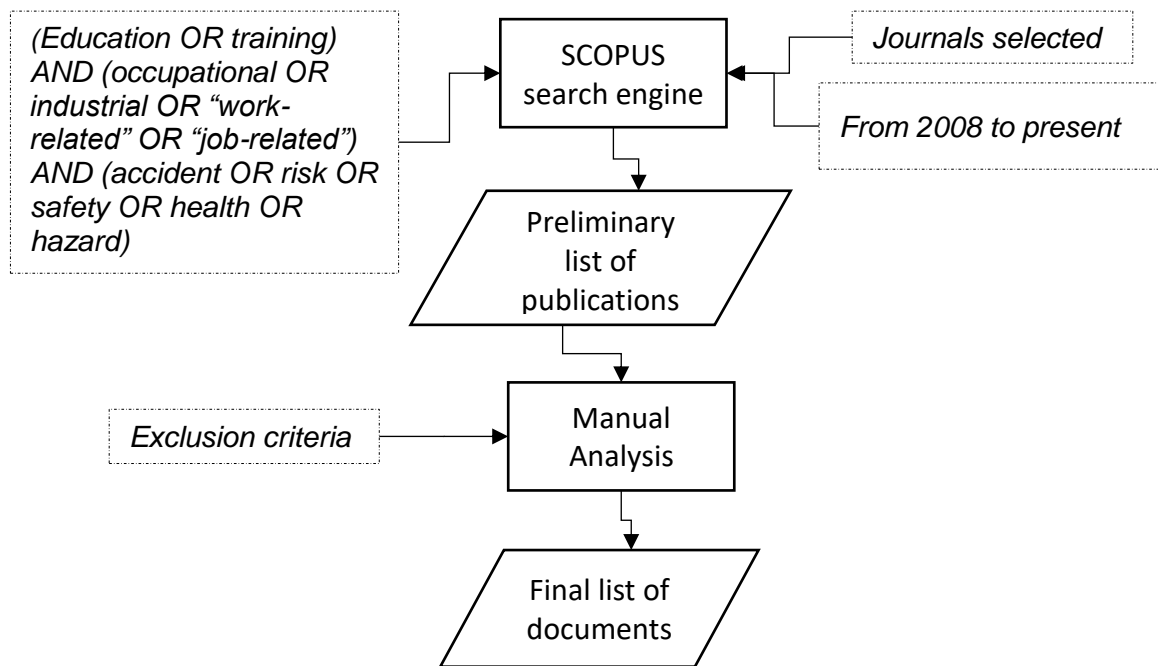


Figure 2.2 Articles search and selection protocol

Documents that have cleared and passed the exclusion criteria will form the corpus of this literature review. Publications detailed in Table 2-6 will be read, studied and analysed using Data Mining and LDA in further sections.

	Author(s)	Title
1	Lesch, 2008	Warning symbols as reminders of hazards: Impact of training
2	Molesworth et al., 2011	Rehearsal and verbal reminders in facilitating compliance with safety rules
3	Huang et al., 2012	Management commitment to safety vs. employee perceived safety training and association with future injury
4	Guo et al., 2012	Using game technologies to improve the safety of construction plant operations
5	Horswill et al., 2013	Even highly experienced drivers benefit from a brief hazard perception training intervention
6	van Eerd et al., 2010	Process and implementation of participatory ergonomic interventions: A systematic review
7	Levanon et al., 2012	Reducing musculoskeletal disorders among computer operators: comparison between ergonomics interventions at the workplace
8	Meinert et al., 2013	Web-based office ergonomics intervention on work-related complaints: a field study
9	Hogan et al., 2014	The effect of manual handling training on achieving training transfer, employee's behaviour change and subsequent reduction of work-related musculoskeletal disorders: A systematic review

	Author(s)	Title
10	Robertson et al., 2009	The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk
11	Kim et al., 2010	Development of an intervention to prevent work-related musculoskeletal disorders among hospital nurses based on the participatory approach
12	Taireb-Maimon et al., 2012	The effectiveness of a training method using self-modeling webcam photos for reducing musculoskeletal risk among office workers using computers
13	Hung et al., 2013	Identifying fall-protection training needs for residential roofing subcontractors
14	Szeto et al., 2013	The impact of a multifaceted ergonomic intervention program on promoting occupational health in community nurses
15	Robertson et al., 2017	Improvements in musculoskeletal health and computing behaviors: Effects of a macro ergonomics office workplace and training intervention
16	Jeschke et al., 2017	Process evaluation of a Toolbox-training program for construction foremen in Denmark
17	Vidal-Gomel, 2017	Training to safety rules use. Some reflections on a case study
18	Misiurek et al., 2017	Methodology of improving occupational safety in the construction industry on the basis of the TWI program
19	Freitas et al., 2017	Exploring OHS trainers' role in the transfer of training
20	Evanoff et al., 2017	Results of a fall prevention educational intervention for residential construction
21	Gummesson, 2016	Effective measures to decrease air contaminants through risk and control visualization - A study of the effective use of QR codes to facilitate safety
22	von Thiele Schwarz et al., 2016	Leadership training as an occupational health intervention: Improved safety and sustained productivity
23	Taylor , 2015	safety benefits of mandatory OSHA 10 h training
24	Olivieri et al., 2015	Empowering employers in work-related injuries prevention: A pragmatic trial
25	Nazir et al., 2015	Impact of training methods on distributed situation awareness of industrial operators
26	Grabowski et al., 2015	Virtual Reality-based pilot training for underground coal miners
27	Farina et al., 2015	Impact on safety of a preventive intervention in metalworking micro-enterprises
28	Stuart, 2014	A blended learning approach to safety training: Student experiences of safe work practices and safety culture
29	Laberge et al., 2014	Why are occupational health and safety training approaches not effective? Understanding young worker learning processes using an ergonomic lens

	Author(s)	Title
30	Pisaniello et al., 2013	The role of high schools in introductory occupational safety education - Teacher perspectives on effectiveness
31	Chin et al., 2010	Enabling youth to advocate for workplace safety
32	Crichton, 2009	Improving team effectiveness using tactical decision games
33	Tharmin et al., 2010	Time trends and predictive factors for safety perceptions among incoming South Australian university students
34	Kaskutas et al., 2010	Changes in fall prevention training for apprentice carpenters based on a comprehensive needs assessment
35	Williams Jr. et al., 2010	The impact of a peer-led participatory health and safety training program for Latino day laborers in construction
36	Kaskutas et al., 2013	Fall prevention and safety communication training for foremen: Report of a pilot project designed to improve residential construction safety
37	Brahm et al., 2013	Is more engaging safety training always better in reducing accidents? Evidence of self-selection from Chilean panel data
38	Wu et al., 2009	Effects of ergonomics-based wafer-handling training on reduction in musculoskeletal disorders among wafer handlers
39	McDermott et al., 2012	Investigation of manual handling training practices in organisations and beliefs regarding effectiveness
40	Langer et al., 2012	Reducing whole-body vibration exposure in backhoe loaders by education of operators
41	Ouellet et al., 2014	Work training and MSDs prevention: Contribution of ergonomics
42	Elfering et al., 2013	Stochastic resonance whole-body vibration, musculoskeletal symptoms, and body balance: A worksite training study
43	Andersson et al., 2014	Knowledge and experiences of risks among pupils in vocational education
44	Haas et al., 2014	An analysis of trainers' perspectives within an ecological framework: Factors that influence mine safety training processes
45	Lee et al., 2015	Factors influencing learning satisfaction of migrant workers in Korea with e-learning-based occupational safety and health education
46	Suleiman et al., 2015	Effectuality of cleaning workers' training and cleaning enterprises' chemical health hazard risk profiling
47	Terwoert et al., 2016	An Intervention Study on the Implementation of Control Banding in Controlling Exposure to Hazardous Chemicals in Small and Medium-sized Enterprises
48	Cecchini et al., 2017	Safety Knowledge and Changing Behavior in Agricultural Workers: An Assessment Model Applied in Central Italy
49	Pecitto, 2012	Results of implementing programmes for modifying unsafe behaviour in Polish companies
50	Sigurdsson et al., 2012	Motivating ergonomic computer workstation setup: Sometimes training is not enough

	Author(s)	Title
51	Kintu et al., 2015	Occupational safety training and practices in selected vocational training institutions and workplaces in Kampala, Uganda
52	Abareshi et al., 2015	Educational intervention for reducing work-related musculoskeletal disorders and promoting productivity
53	Nie et al., 2017	A comparative study of vocational education and occupational safety and health training in China and the UK
54	Bulduk et al., 2017	Reduction of work-related musculoskeletal risk factors following ergonomics education of sewing machine operators

Table 2-6. Selected Publications for review

3 DESCRIPTIVE ANALYSIS

In this section the results of summarizing and analysing the publications found according with the selection criteria described in the previous section are shown. Final corpus is composed by articles published between 2008 and 2017.

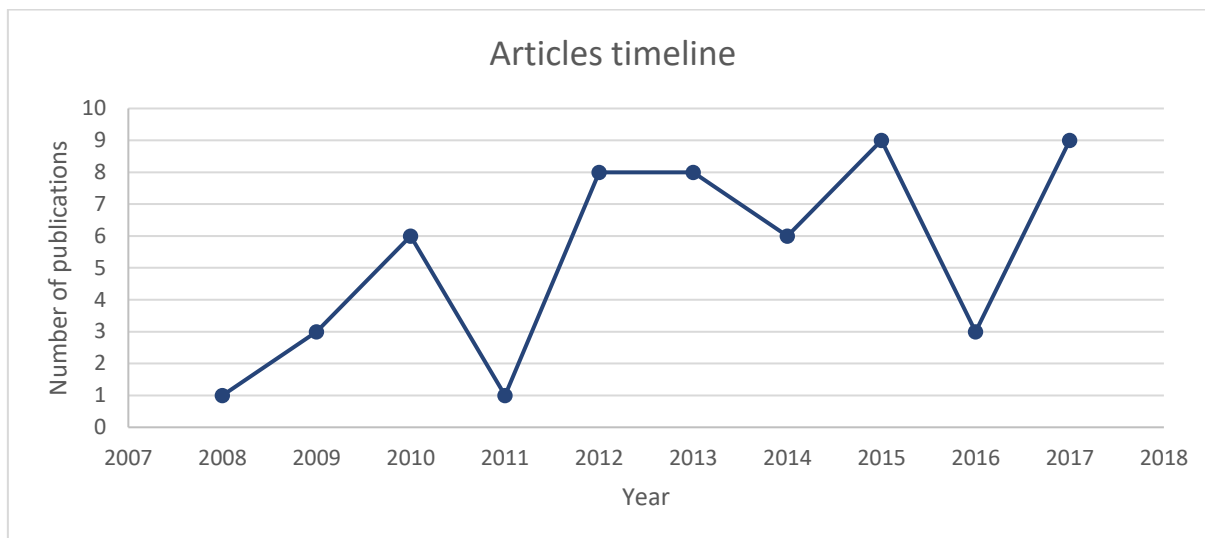


Figure 3.1 Corpus' Articles Timeline

All the publications have been read, classified and analysed according to the content, approach and type of study developed.

3.1 Classification of publications

Publications found can be classified according to the type of publication or study made, for this, all the publications found had been read, understood and analysed. The author found that the corpus of this literature review can be classified in the following categories:

- Benefits of Experimental Methods.

Publications that describe methodologies or procedures developed by the authors in order to satisfy a necessity of Occupational Safety and Health education/training improvement in a specific industry section. Methods are tested and statistical results are reported.

- Evaluation of OSH Education.

Publications that explain and evaluate the outcomes of OSH education or training procedures already implemented in organizations, industry fields, education systems or methods detailed in legislations and agencies like Occupational Safety and Health Administration (OSHA).

- Theory Research.
Publications that describe a problem or hypothesis on a specific industry or region regarding Occupational Safety and Health, design an experiment or perform a literature research to evaluate and conclude about the proposed topic.
- Literature Review.
Publications that review and synthesize Occupational Safety and Health literature regarding education and training.
- Method Development.
Publications that described Occupational Safety and Health training/education procedures and how they have been achieved. Methods are not experimentally tested.

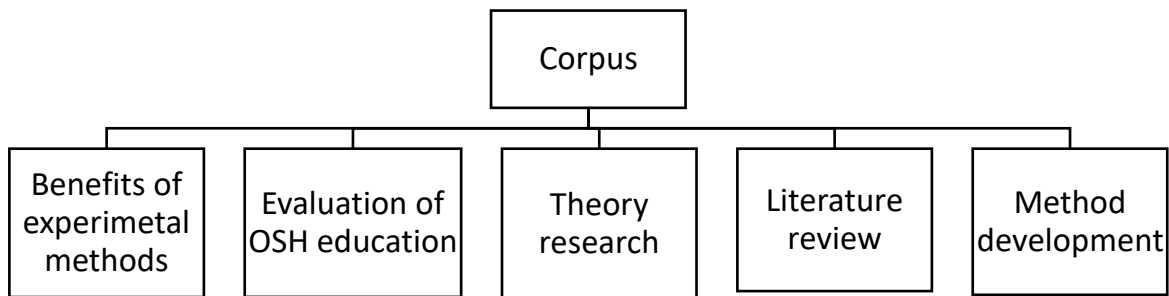


Figure 3.2 Publications classification

The quantity of publications belonging to each category and their percentage is shown in table 3-1 and figure 3.3 respectively.

Classification	Publications
Benefits of experimental methods	26
Evaluation of OSH education	13
Theory research	7
Literature review	2
Method development	6
Total	54

Table 3-1. Quantity of publications in each category

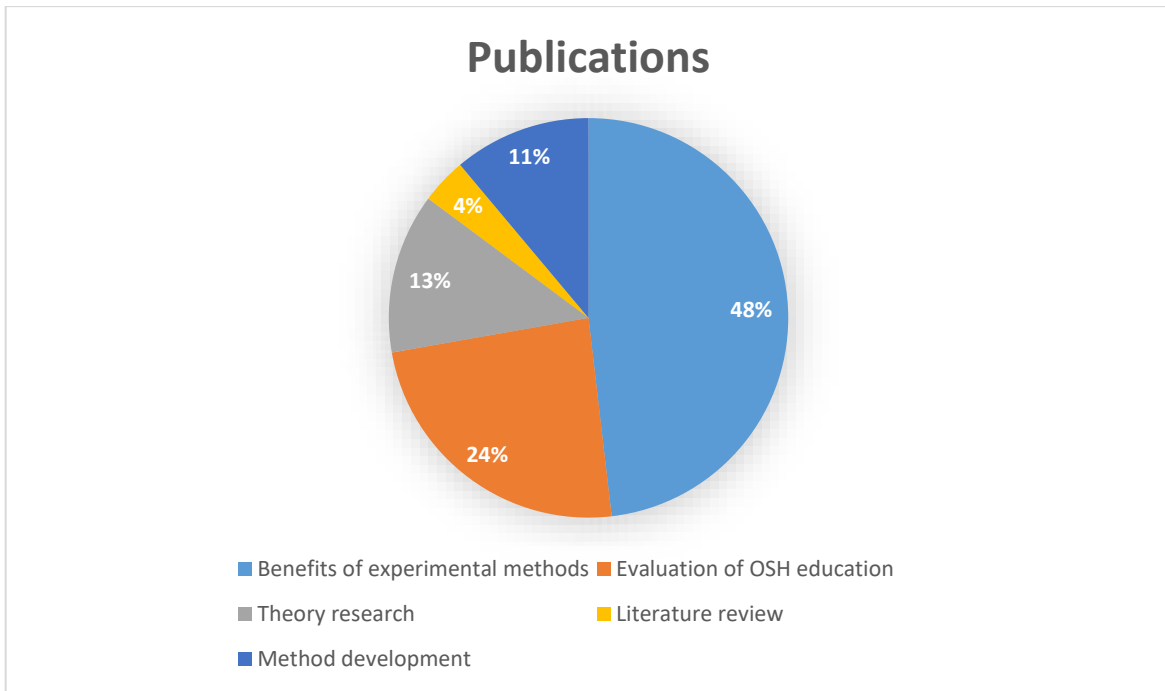


Figure 3.3. Classification of publications - Percentage

Each category is analysed in order to identify what are the main topics the publications are focused in and what are the research trends.

3.1.1 Benefits of experimental methods.

A total of 26 publications of 54 that compose this literature corpus are related to experimental methods to improve the efficacy of training and education on Occupational Safety and Health. Moreover this reveal a trend on the last decade to study new techniques and approaches to face the training and education on safety in the work-place.

However, it is worth to be mentioned that the differences on work-force requirements, responsibilities, duties, risks and hazards depending on the industry fields are very important. Each publication in this category is focused on one particular industry field. For this reason a sub classification is performed according to the type of worker the intervention or training is aimed to.

From table 3-2 is observed that most part of studies are focused on office workers, construction workers and manufacturing workers. Moreover this fields are very different regarding to type of hazards they face.

Method aimed to:	Quantity
Aviation pilots	1
Indifferent	2
Construction workers	5
Office workers	6
Nurses	1
Woodworkers	2
Leaders/managers	1
Manufacturing operators	4
Miners	1
Metal workers	1
Paint industry workers	1
Textile industry workers	1
Total	26

Table 3-2. Object of the Benefits method studies

Office workers are under high risk of been affected by Musculoskeletal Disorders (MSD) that are considered the largest work related injury category, characterized by discomfort and pain in joints, muscles and soft tissues (Levanon et al, 2012). Authors focused on study different methods, tools, techniques and approaches to prevent the injuries that cause almost 30% of the world's compensation cost.

Construction and manufacturing workers on the other hand, are exposed to different type and severity level of hazards due to machinery operations or falling from altitudes like roofs on constructions. Moreover, Occupational Safety and Health education in this field is particularly more challenging because it has to deal with different level of worker's background education (Williams Jr. et al., 2010) and with small size enterprises.

Authors are also principally concern with evaluating methods that can increase the workers change of behavior and knowledge acquisition, the most frequent worker target studied are young and new workers.

Young / New workers: Workers that are less than 24 years old or with less than 6 months of experience performing a specific task. These workers are most frequently the target of job-related hazards and they are in risk because of

- Lack of experience and training to avoid and recognize hazards in the industry.
- They ignore their rights.

- They haven't received properly orientation.

Analysing the methods used for knowledge transfer in the studies belonging to this category is observed that they can be clustered in groups.

Training method	Quantity	Software and technology	Training technique	Conventional method
Warnings and consequences	1		X	
3D simulation	3	X		
Rehearsal and reminders	5		X	
Biofeedback (MSD)	1	X		
Web based	2	X		
Conventional method	7			X
Qr codes	1	X		
Trainers education	1			X
Personalized training (cultural background)	1		X	
Tool box meetings	2			X
Vibration exposure	1		X	

Table 3-3. Training methods for benefits studies

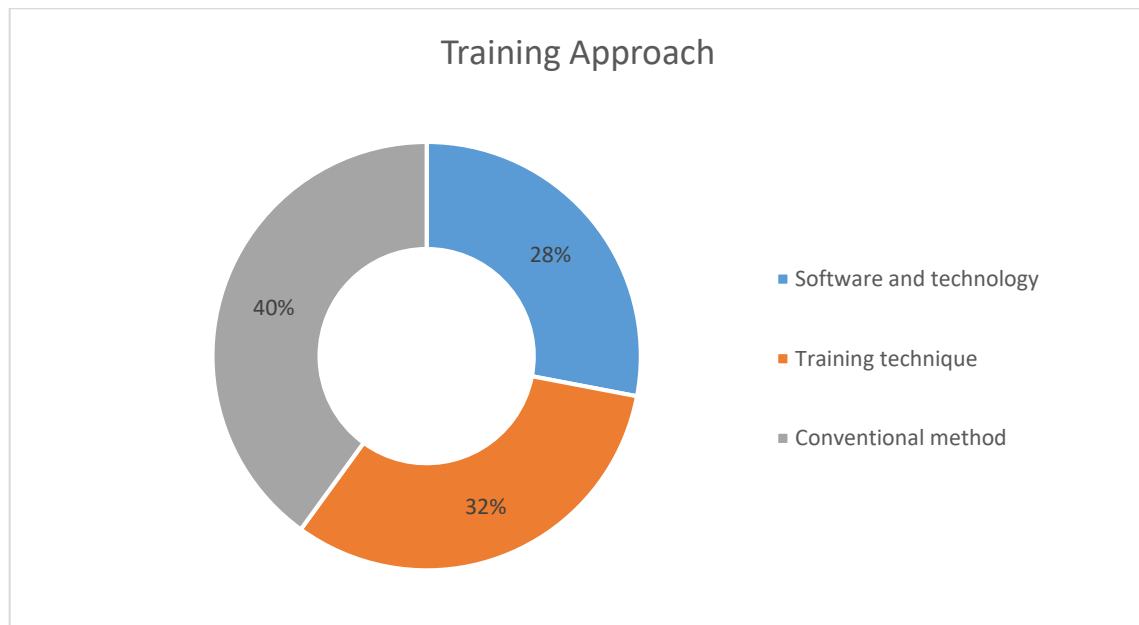


Figure 3.4 Training Approaches for benefits studies

Groups identified in table 3-3 and figure 3.4 are defined according to the approach of the training method used by the authors on their publications

Software and technology: Training methods that use tools developed to simulate work conditions and improve worker's recognition of warnings, hazards and the quality of response. Also web based training is used to continuously educate workers.

Training technique: Training methods that are modifications of conventional methods to increase the level of knowledge acquired, worker's change of behaviour and most import to maintain the effectiveness of training through time. Reminders are provided through tool-box meetings, e-mail or as a feedback provided by an automatized system.

Conventional method: Training methods that use theoretical presentations and classrooms training.

Authors conclude that their methods had increased worker's knowledge level, crew safety behaviour, safety climate, and risk perceptions. But as mentioned by Taylor E.L. (2015) there is weak evidence for improved safety outcomes due to training programs.

From the methods used, some interesting results were obtained principally with simulation tools (Guo et al, 2012), (Nazir et al, 2015) and (Grabowski et al, 2015), where a desirable situation awareness was achieved and comparatively faster than using a conventional methods, also they show an efficient method to involve workers on non-routine tasks and abnormal situations. Moreover, these methods seem to be advantageous when training under real situations is not possible due to hazards or threats to human health and life; the limitations of these methods are cost, time and relatively difficulties to implement specific and detail simulation software and 3D technology for every industry.

To increase the effectiveness of training through time, authors evaluated methods that use notifications, tool-box meetings, reminders and rehearsals after the formal training session. Robertson et al. (2009) reached an important conclusion that reminders provided periodically to workers affect positively on patterns associated with behavioural changes.

3.1.2 Evaluation of OSH Education

Publications belonging to this group describe and perform a method to evaluate a least one of the following safety outcomes related to safety efficacy: safety perception, training level received, learning satisfaction, injury experiences and their causes. The evaluation is done on organizations where training/education procedure had been implemented in the past.

Types of institutions evaluated on training and education efficacy are shown in table 3-4.

Evaluation of training practices in	Publications
University, high school or vocational institutions	5
Workplace industry	8

Table 3-4. Type of Organization evaluated

Authors collected data (i.e. interviews or surveys) to analyse and understand what are the principal problems that OSH training face under regular conditions.

- There is a student response positively associated with years of teaching and industry experience of the trainer, while a younger teacher (<46 years) was negatively associated (Pisaniello et al, 2013).
- Workplace training programs may not support young worker's self-advocacy on knowledge, communication and leadership (Chin et al, 2010).
- Training may be more effective if it is tailored to specific industry and task demands. (McDermott et al, 2012).
- Lack of systematic approach to pupil's training in work environment. Moreover, pupil's training don't reach required levels established by laws and the state-of-art of OSH. (Andersson et al, 2014).
- Immigrant worker's background education and culture impact in the perceived level of learning satisfaction. (Lee et al, 2015)
- Improving worker knowledge does not necessarily lead to correct behaviors, and motivational interventions may be needed to achieve lasting behavior change. (Sigurdsson et al, 2012)
- Inappropriate teaching methods in the workplaces, lack of adequate literature on safety and inadequate time to conduct safety training at the workplaces. (Kintu et al, 2015)

3.1.3 Theory research

From the corpus selected for the literature review, seven articles are under the category of Theory research. Authors of the articles focus their work on evaluating procedures, methods and laws to detect weakness or to accept hypothesis regarding Occupational Safety and Health.

From the articles some interesting results and conclusions are highlighted:

- Safety training is commonly aimed to new and young workers. However, experienced workers have lower levels of hazard perception than workers properly and regular trained. Expertise doesn't mean optimal level of hazard perception. (Horswill et al, 2013)
- Vidal-Gomel (2017) proposes to “consider training in occupational risk prevention as situated at the crossroads between regulated safety (based on prescribed safety rules and procedures) and managed safety (based on operators' knowledge and experience)”. Moreover, the study reveals conflicts between respecting safety regulation and performing a task required by the company (fail to deliver or complete a task could put the operator under pressure).
- Factors that positively affect the transfer of training are good trainers' capability, short training sessions, sessions focus on irregular safety behaviours and refresh knowledge. Moreover, OSH trainers revealed that often companies provide safety training because the company is under certification process. (Freitas et al, 2017)
- Training sessions have impact in workers' “risk perception” and “change in behavior” but these improvements are not correlated with the reduction of accidents. (Brahm et al, 2013)
- Workers attitude towards Occupational Safety and Health learning is negatively impacted by the amount of years worked or experience. Highest percentage of strong negative attitude is among the people who have worked for more years, while employees who have worked for fewer years have a marked positive attitude. (Cecchini et al, 2017)

3.1.4 Literature Review

Two articles perform systematic reviews of training or education in Occupational Safety and Health field. Some important results from these articles are described next:

- Ergonomic training was described in 73% of the documents reviewed. The training was most often received in decreasing order by workers, supervisors, team members and senior managers. The time devoted to training varied from 2 hours to 100 hours. Principally, training covered general ergonomic information (including mechanisms of injury, risk factors, identification of hazards and strategies for reducing hazards). (Van Eerd et al, 2010)
- Key facilitators/ barriers for an effective training are identified to be related with:

- Support of intervention.
- Resources.
- Ergonomic training/knowledge.
- Creation of appropriate team.
- Communication.
- Organizational training/knowledge. (Van Eerd et al, 2010).
- Results obtained by Hogan et al. (2014) indicate a need for further research in the area of training transfer during training and subsequent behavioral change of employees following training, findings suggest that transfer of knowledge to employees occurs, however, not to the level expected and there was no evidence of employees behavioral change.

3.1.5 Method development

Articles under this category are those that propose a training or education methodology based on their analysis and for a given industry sector. These methods are proposed, detailed and suggestions for improvement are described. However, an experimental analysis (like in benefits of experimental methods category) is not performed.

The industry propose of the method and the approach suggested is shown below in table 3-5 for the six publications in this category.

From the studies performed some suggestions are found to be common in different industry sectors to increase training sessions' efficacy (Hung, et al., 2013) and (Jeschke, et al., 2017) :

- Give importance to feedback and planning systems
- Increase safety learning motivation among employees.
- Increases focus on the topics by switching from occupational accidents to occupational diseases.
- Increase Trainers' and program credibility.
- Provide physical demonstrations of tasks and procedures.
- Provide equipment demonstrations.
- Provide backup information depending on the background education level of the worker (media files, eLearning tools, hardcopy prints, etc.)

Author	Industry	Aimed to:	Methodology
Kim et al., 2010	Hospitals (nurses)	MSDs	Classroom and slides presentation
Hung et al., 2013	Construction	Fall-protection	Toolbox training (theoretical + practical)
Jeschke et al., 2017	Construction	Occupational accidents and diseases	Toolbox training (theoretical + practical + role play)
Misiurek et al., 2017	Construction	Occupational accidents and diseases	8 steps procedure to reduce human errors
Stuart, 2014	Furniture	Occupational accidents and diseases	Practical training for workers with experience and eLearning methods for unexperienced workers
Crichton, 2009	Deepwater exploration	Improve safety and performance	Workshop around tactical decision games

Table 3-5. Articles and methods (Method development category)

4 TEXT MINING AND LDA

In this section is described how text mining is applied. For this, the TM tool is selected, procedure is explained step by step, results are obtained in terms of frequency of terms used in the corpus and the results are analysed using Latent Dirichlet Allocation technique.

4.1 Software selection

For this literature review, a text mining technique is applied in the 54 articles that are part of the corpus.

There are several options of TM software available in the market. In this review the software “R statistical tool” (The R Project for Statistical Computing) ⁵ has been chosen as it is a free software available to download and install by any institution, it is an open source code that allows creation and instalment of software packages for specific statistical analysis. R statistical tool was used in previous reviews and studies using TM technique (Moro et al, 2015). Version installed:

R version 3.4.2 (2017-09-28) -- "Short Summer"

Copyright (C) 2017 The R Foundation for Statistical Computing

The package selected is called TM and it's also available on the official R statistical tool platform. It has been chosen as it provides variety of functions for manipulating text documents.

Title: Text Mining Package

Version: 0.7-3

Date: 2017-12-06

For performing the topic generation and classification, the Latent Dirichlet Allocation model proposed by Blei et al. (2003) Is used in this review. The package selected is:

Title: Topic Models

Version: 0.2-7

Date: 2017-11-03

⁵ <https://www.r-project.org/>

4.2 Text mining process

First, it is necessary to define where in the text the TM is going to be applied. As TM techniques provided as result a matrix of terms and their frequencies, the full-text will be analysed to improve the probability that frequent terms are relevant. However, terms that appear on citations and titles of references shouldn't be considered, for this reason reference sections will be removed from the text before proceeding with TM technique. This way, terms frequently mentioned are related with the main text of the articles only.

The process followed is described below and shown in figure 4.1:

2. The corpus for the literature review is generated from the 54 articles.
3. Extra white spaces are removed from the corpus. Reduces the length of the corpus.
4. To allow a better computing of terms' frequencies in equally conditions, words in the corpus are converted to lowercase.
5. Numbers inside the corpus are removed as they don't provide any important information for this topic modelling process.
6. Punctuation terms are removed from the corpus.
7. Words that don't provide any important information for the topic model process are removed. These words called stop-words are defined according two conditions:
 - a. Words that are used frequently and their function is related to the language's structure, like articles (a, an, the, etc.), conjunctions (and, or, etc.), prepositions, etc.
 - b. Words that are expected to be mentioned frequently in the articles because of their relation with the main topic of this literature review but don't provide relevant information for generating topics and classifying the articles (i.e. occupational, training, education, safety, osh, etc.).
8. A matrix called Document-Term Matrix is generated where the terms are weighted using their frequency in each article.
9. Terms that are sparsely distributed due to misspelling or lack of importance in the corpus are called Sparse Terms and are removed.
10. Latent Dirichlet Allocation model uses as input the Document-Term matrix and the number of desired topics to generate topics represented by terms associated and provide the likelihood the articles belong to each topic.

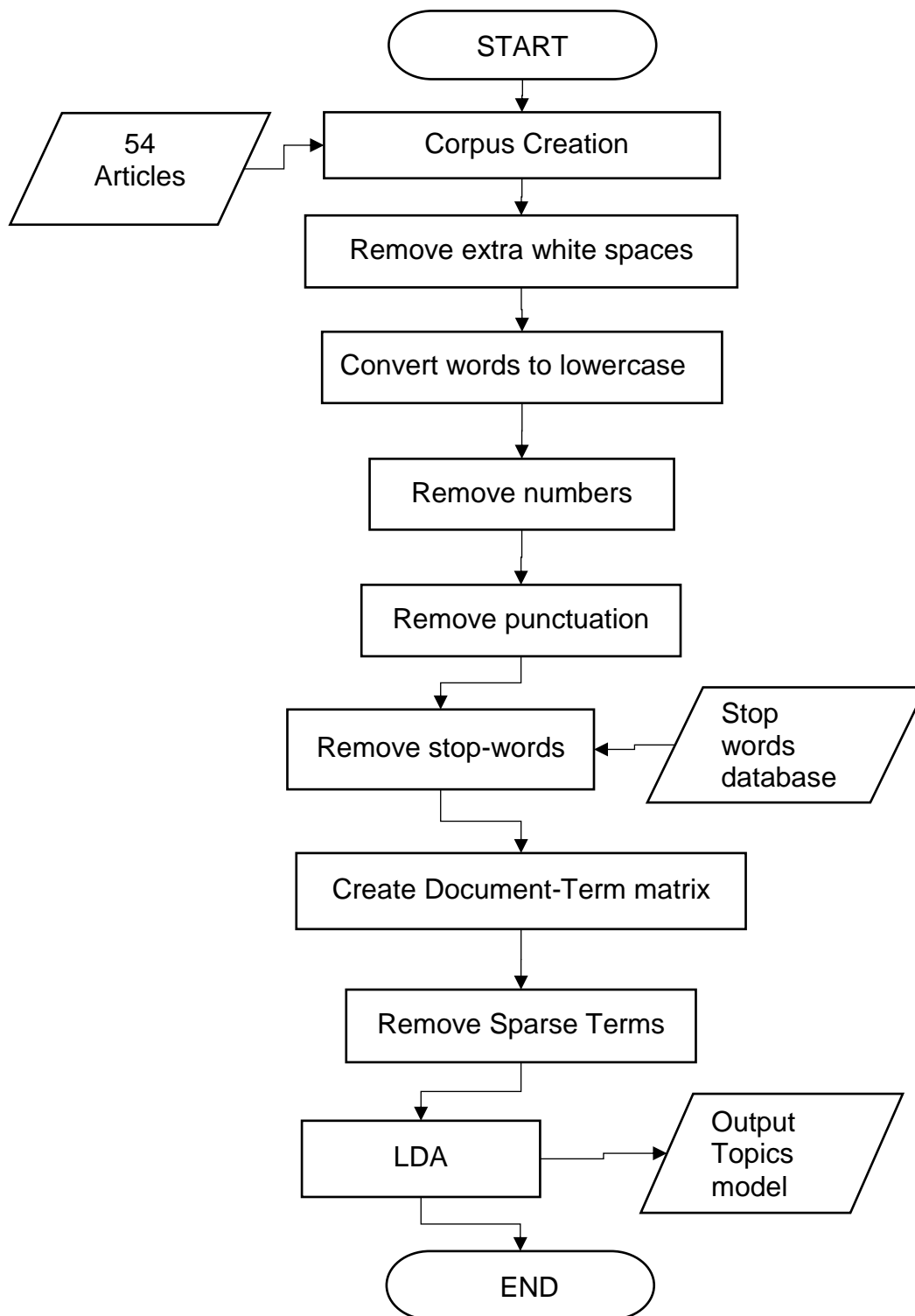


Figure 4.1 TM and LDA Topic modelling process

The process is implemented as code for the software selected. The code is detailed in figure 4.2

```

%% LOADING ARTICLES
path <- system.file("PDF", package="tm")
articles <- Corpus(DirSource(path, encoding="UTF-8"), readerControl = list(language="en"))

%% REMOVING SPACES, PUNCTUATION, STOPWORDS AND CONVERTING TO LOWERCASE
articles <- tm_map(articles, removeNumbers)
articles <- tm_map(articles, removePunctuation)
articles <- tm_map(articles, tolower)
articles <- tm_map(articles, stripWhitespace)
articles <- tm_map(articles, removeWords, stopwords("english"))

%% DOCUMENT-TERM MATRIX CREATION
dtm <- DocumentTermMatrix(articles)

%% REMOVING SPARSE TERMS FROM MATRIX
dtm <- removeSparseTerms(dtm, 0.95)

%% LATENT DIRICHLET ALLOCATION MODEL
lda <- LDA(dtm, method="Gibbs", control = list(alpha = 0.5), k = 10)
topics(lda, k=2, threshold=0.1)
terms(lda, k=5, threshold=0.01)

```

Figure 4.2 Code for TM and LDA

From TM technique a Document-Term matrix is obtained (figure 4.3), the matrix is used as an input to apply LDA topic modelling. A section of the Document-Term matrix is shown in figure 4.3

```

> inspect(dtm)
<<DocumentTermMatrix (documents: 54, terms: 4390)>>
Non-/sparse entries: 48118/188942
Sparsity           : 80%
Maximal term length: 60
Weighting          : term frequency (tf)
Sample            :

```

Docs	control	ergonomics	intervention	knowledge	one	participants	risk	signii	time	workers
2010-Chin.txt	1	0	2	52	15	0	6	0	2	95
2010-Williams.txt	3	1	10	12	17	22	6	8	2	76
2012-Taireb.txt	22	15	78	5	8	23	18	44	22	29
2013-Horswill.txt	24	0	29	2	29	40	14	40	34	0
2013-Hung.txt	6	11	7	10	10	50	0	1	6	55
2013-Pisaniello.txt	1	0	0	32	7	6	1	23	13	5
2014-Hogan.txt	25	11	36	17	14	12	4	0	2	9
2016-Schwarz.txt	50	0	53	5	28	7	8	12	26	0
2017-Freitas.txt	12	0	0	20	8	30	0	0	8	20
2017-Robertson.txt	47	117	86	19	6	18	17	56	81	30

Figure 4.3. Document-Term matrix generated. TM

4.3 Latent Dirichlet Allocation output analysis

Setting the number of desired topics to eight, LDA model compute the probability of one term to belong to a particular topic. In table 4-1 the three terms more likely associated to each topic are listed.

Term	1	2	3
Topic 1	Participants	Test	Perception
Topic 2	Leadership	Injury	Climate
Topic 3	Risk	Operators	Level
Topic 4	Construction	Fall	Foremen
Topic 5	Workers	Program	Analysis
Topic 6	Intervention	Handling	Manual
Topic 7	Students	Skills	Knowledge
Topic 8	Ergonomics	Intervention	Musculoskeletal

Table 4-1. Terms for each topic LDA

The likelihood of one article belongs to one of the eight topics generated is computed and is reported by the software. Figure 4.4 is a display of a section of results from LDA

```

R Console
$topics
              1          2          3          4
2008-Lesch.txt  0.8611497450 0.0294390357 0.0020862309 3.940658e-03
2009-Crichton.txt 0.1584296532 0.0041849342 0.1018333998 6.576325e-03
2009-Robertson.txt 0.0405019060 0.0976810673 0.0007941550 1.747141e-03
2009-Wu.txt      0.0006321113 0.0347661188 0.0448798989 2.739149e-03
2010-Chin.txt    0.0303931712 0.0003879979 0.0143559234 1.357993e-02
2010-Kaskutas.txt 0.0206099196 0.0185991957 0.0521112601 7.454759e-01
2010-Kim.txt     0.0037206640 0.0014310246 0.1107613051 8.299943e-03
2010-Tharmin.txt 0.0295549374 0.4071627260 0.0003477051 3.477051e-04
2010-van Eerd.txt 0.0069637883 0.0082017951 0.0304859177 1.547509e-04
2010-Williams.txt 0.0350392556 0.1109334109 0.0149752835 3.548997e-01
2011-Molesworth.txt 0.7560228665 0.0471621070 0.0798285014 3.470804e-03
2012-Guo.txt     0.0628427788 0.0125685558 0.6944698355 2.582267e-02
2012-Huang.txt   0.0488380537 0.8367828613 0.0009077705 6.354394e-03
2012-Langer.txt  0.1074686431 0.0476054732 0.6228620296 3.705815e-03

```

Figure 4.4. Results display from R-console. Likelihood values

In table 4-2 is detailed the first two topics more likely each article belongs to. The likelihood value is reported from 0 to 1.

Article	Topic	Likelihood	Topic	Likelihood
Lesch, 2008	1	0,86	2	0,03
Molesworth et al., 2011	1	0,76	3	0,08
Huang et al., 2012	2	0,84	5	0,09
Guo et al., 2012	3	0,69	7	0,12
Horswill et al., 2013	1	0,81	2	0,09
van Eerd et al., 2010	6	0,66	5	0,15
Levanon et al., 2012	8	0,73	6	0,13
Meinert et al., 2013	8	0,74	1	0,09
Hogan et al., 2014	6	0,78	2	0,08
Robertson et al., 2009	8	0,75	2	0,09
Kim et al., 2010	6	0,47	7	0,15
Taireb-Maimon et al., 2012	8	0,73	1	0,12
Hung et al., 2013	4	0,31	5	0,31
Szeto et al., 2013	8	0,43	6	0,32
Robertson et al., 2017	8	0,76	2	0,14
Jeschke et al., 2017	4	0,42	7	0,29
Vidal-Gomel, 2017	3	0,76	5	0,09
Misiurek et al., 2017	3	0,79	5	0,11
Freitas et al., 2017	7	0,63	5	0,18
Evanoff et al., 2017	4	0,70	2	0,17
Gummesson, 2016	7	0,63	5	0,19
von Thiele Schwarz et al., 2016	2	0,72	1	0,11
Taylor , 2015	2	0,61	5	0,16
Olivieri et al., 2015	2	0,54	5	0,16
Nazir et al., 2015	3	0,49	1	0,32
Grabowski et al., 2015	3	0,51	5	0,15
Farina et al., 2015	2	0,45	5	0,27
Stuart, 2014	7	0,60	3	0,18
Laberge et al., 2014	5	0,52	7	0,29
Pisaniello et al., 2013	7	0,62	5	0,19
Chin et al., 2010	5	0,72	7	0,22
Crichton, 2009	7	0,64	1	0,16

Article	Topic	Likelihood	Topic	Likelihood
Tharmin et al., 2010	2	0,41	7	0,36
Kaskutas et al., 2010	4	0,74	5	0,09
Williams Jr. et al., 2010	5	0,37	4	0,35
Kaskutas et al., 2013	4	0,73	5	0,09
Brahm et al., 2013	2	0,73	5	0,08
Wu et al., 2009	8	0,50	5	0,37
McDermott et al., 2012	6	0,43	7	0,23
Langer et al., 2012	3	0,62	5	0,13
Ouellet et al., 2014	5	0,60	8	0,20
Elfering et al., 2013	8	0,59	1	0,21
Andersson et al., 2014	5	0,76	3	0,09
Haas et al., 2014	7	0,64	5	0,18
Lee et al., 2015	7	0,40	5	0,24
Suleiman et al., 2015	3	0,45	5	0,32
Terwoert et al., 2016	7	0,37	5	0,22
Cecchini et al., 2017	3	0,35	5	0,30
Pecitto, 2012	6	0,72	5	0,11
Sigurdsson et al., 2012	8	0,65	6	0,11
Kintu et al., 2015	5	0,65	3	0,15
Abareshi et al., 2015	8	0,47	2	0,17
Nie et al., 2017	3	0,50	5	0,18
Bulduk et al., 2017	8	0,55	3	0,25

Table 4-2 Likelihood for each article. Results LDA

4.3.1 Topics generated

Terms related to each topic shown in table 4-3 are obtained through LDA model, nevertheless, this topic modelling process has an important limitation due to document clustering technique used. Document clustering is completely dependent on the technique used for creating the clusters, which is based on term identification. (Moro et al, 2015).

To address the topics and accept or reject topics generated, the article with highest likelihood in each topic is selected to be analyzed and to understand the topics generated by LDA. Articles selected for each topic are listed in table 15.

	Articles in the cluster	Article selected	Likelihood
Topic 1	3	Lesch, 2008	0,86
Topic 2	7	Huang et al., 2012	0,84
Topic 3	9	Misiurek et al., 2017	0,79
Topic 4	5	Kaskutas et al., 2010	0,74
Topic 5	6	Andersson et al., 2014	0,76
Topic 6	5	Hogan et al., 2014	0,78
Topic 7	8	Crichton, 2009	0,64
Topic 8	11	Robertson et al., 2017	0,76

Table 4-3. Article selected in each topic. LDA results

Articles selected as the most relevant for each topic and their associated terms provide a better understanding of the topic. The analysis of each topic is described next:

Topic 1

Terms: Participants; test; perception

Topic 1 is best represented by work of Lesch (2008) that describes the importance and effectiveness of training based on accident scenarios, provides a method based on warning symbols to increase hazard perception among the participants of the test.

Considering the terms more relevant for the group and the analysis from the article more representative. It can be established that topic 1 clusters articles that describe an experiment to evaluate hazard and risk perception before and after interventions.

Topic 2

Terms: Leadership Injury Climate

Topic 2 is best represented by Huang et al. (2012) that studies the factors that affect safety climate in the industry, the study is more focus on the correlation between employee's perceived management commitment to safety and employee's perceived safety training. The study proposes that management commitment to safety is a factor predictor for safety outcomes like injuries and accidents.

Based on terms related with Topic 2 and the most relevant article for this group. Topic 2 can be described as the group that clusters articles that evaluate the

theory that commitment to safety from managers, owners and leaders will impact safety climate and safety outcomes.

Topic 3

Terms: Risk; Operators; Level

The most relevant article for Topic 3 is the one done by Misiurek et al. (2017), the article describes and proposes a method to improve occupational safety by selecting TWI programs that reduce the probability of occurrence of the three main causes of human errors: lack of or poorly led training, badly defined and developed work standards and lack of supervision of employees.

From terms associated to the topic and the most relevant work, Topic 3 can be described as articles that perform studies on the effects of training and safety education provided to workers of indistinct fields on change of behavior, situation awareness and other measures for training efficacy.

Topic 4

Terms: Construction; Fall; Foremen

Topic 4 is best represented by Kaskutas, et al. (2010) that developed a research on the specific field of construction and the risk related to fall from altitudes. The study performs a needs assessment to determine the gaps in the school programs about fall prevention education and actual needs in the industry, conclusions and suggestions are obtained from the research.

From terms and the publication most relevant described above, topic 4 can be inferred as the group that clusters articles that study training methods, needs and provide results on the construction industry.

Topic 5

Terms: Workers; Program; Analysis.

The research performed by Andersson, et al. (2014) has been selected as the most relevant for Topic 5. The article is the report of a study about the level of knowledge and risk awareness of young or unexperienced workers after they have finished their preparation on vocational institutions. Holes and gaps in educational programs are inferred.

Based on terms related to the topic and the analysis performed on the most relevant article, Topic 5 can be described as articles that perform researches on

educational programs about safety for young or unexperienced workers provided in educational institutions.

Topic 6

Terms: Intervention; Handling; Manual.

The most relevant work for the topic is a systematic literature review about handling manual training and its effects on improving employee's behaviour change. The study focus on MSDs as a consequence of work-related conditions and safety training methods or ergonomic interventions (Hogan et al, 2014)

From terms associated and the analysis performed on the most relevant work for the topic, the topic 6 can be described as the group of articles that evaluate interventions programs and conditions to improve safety behaviour for avoiding manual handling related disorders (i.e. MSDs).

Topic 7

Terms: Students; Skills; Knowledge.

The article most relevant for the topic is a report about training method development after a one day workshop team-level decision making had been done. Tactical decision games were used in the workshop by multidisciplinary experts of oil and gas drilling industry and details the benefits on safety and team performance. (Crichton, 2009)

From terms associated and the most relevant work to this topic, topic 7 can be described as articles that are aimed to propose methods to increase workers' knowledge level about occupational safety and industry performance.

Topic 8

Terms: Ergonomics; Intervention; Musculoskeletal.

Topic 8 is best represented by the work done by Robertson, et al. (2017). The article describes an ergonomic intervention for office or computer workers to improve their computing behaviors, postures, and musculoskeletal discomfort.

Based on the most relevant article and terms associated to the topic, topic eight can be described as articles that study intervention methods to improve office workers' well-being and decrease musculoskeletal disorders.

4.3.2 Article's allocation acceptance criteria

Topics are sorted in descending order for each article, where the first ranked topic is the one with highest likelihood for the particular article, for this criteria is consider the first and second ranked topic for each article. Articles and likelihood values for the first two ranked topics are shown in table 4-2.

Articles with likelihood higher than 0.5 to belong to a particular topic are accepted in the cluster assigned by LDA model. Articles with likelihood lower or equal to 0.5 to belong to a particular model are submitted to a process to evaluate the topic allocation according to an acceptance criteria.

Articles with low likelihood to belong to a particular topic or articles where the likelihood for the two first topic allocated according LDA model (table 4-2) are similar, are analysed to confirm them in the first topic option or assign them to the second topic according to the description of each topic detailed before.

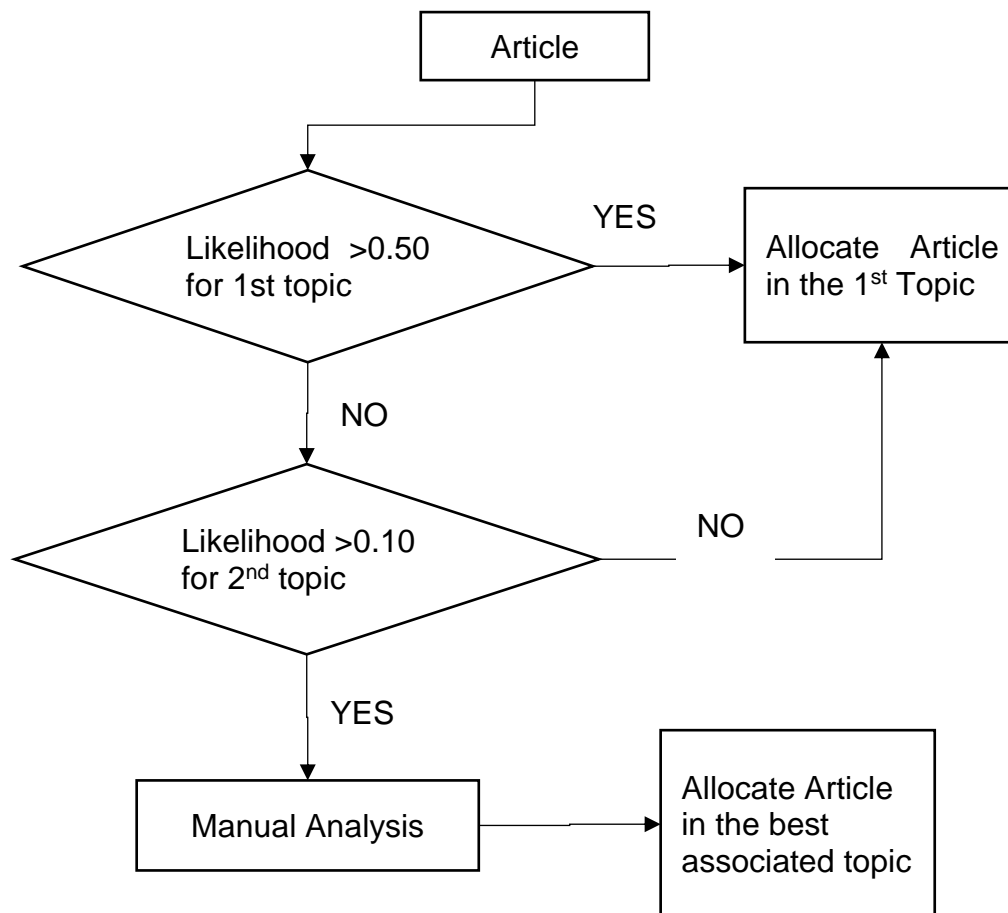


Figure 4.5 Allocation acceptance process. LDA results

The articles to be manually analysed are detailed below in table 4-4.

Article	First Topic	Likelihood	Second Topic	Likelihood
Hung et al., 2013	4	0,31	5	0,31
Szeto et al., 2013	8	0,43	6	0,32
Jeschke et al., 2017	4	0,42	7	0,29
Nazir et al., 2015	3	0,49	1	0,32
Farina et al., 2015	2	0,45	5	0,27
Tharmin et al., 2010	2	0,41	7	0,36
Williams Jr. et al., 2010	5	0,37	4	0,35
Wu et al., 2009	8	0,50	5	0,37
McDermott et al., 2012	6	0,43	7	0,23
Lee et al., 2015	7	0,40	5	0,24
Suleiman et al., 2015	3	0,45	5	0,32
Terwoert et al., 2016	7	0,37	5	0,22
Cecchini et al., 2017	3	0,35	5	0,30

Table 4-4. Articles with low likelihood. LDA

The procedure is done by analysing manually the article and accept or reject the first topic, in case the first topic is rejected, the analysis is done for the second topic.

Taking as example the work done by Hung, et al. (2013), the article has a likelihood of 0.31 and 0.31 to belong to Topic 4 and Topic 5 respectively. A manual analysis is done in the article and it is understood that the research is aimed to identify needs and provide recommendations for fall-protection training to construction workers. Therefore, the article is better associated with Topic 4 than Topic 5. The article is confirmed in Topic 4.

Another example of this allocation criteria is explained with the work done by Szeto, et al. (2013). According to results obtained from LDA topic model, it has a likelihood of 0.43 and 0.32 to belong to Topic 8 and Topic 6 respectively. The research evaluates the benefits of an intervention program to reduce musculoskeletal disorders among nurses, thus is better associated with Topic 6 as it is an intervention program to reduce MSDs for non-office workers.

The results for the Topic acceptance criteria are shown in table 4-5 where the Topic accepted for the article is highlighted

Article	First Topic	Second Topic
Hung et al., 2013	4	5
Szeto et al., 2013	8	6
Jeschke et al., 2017	4	7
Nazir et al., 2015	3	1
Farina et al., 2015	2	5
Tharmin et al., 2010	2	7
Williams Jr. et al., 2010	5	4
Wu et al., 2009	8	5
McDermott et al., 2012	6	7
Lee et al., 2015	7	5
Suleiman et al., 2015	3	5
Terwoert et al., 2016	7	5
Cecchini et al., 2017	3	5

Table 4-5. Topic Acceptation criteria results. LDA

The final allocation resulting from LDA topic modelling technique is shown in table 4-6.

	Articles		
Topic 1 Programs efficacy factors	Lesch, 2008	Molesworth et al., 2011	Horswill et al., 2013
Topic 2 Management commitment to safety	Huang et al., 2012	von Thiele Schwarz et al., 2016	Taylor , 2015
	Olivieri et al., 2015	Farina et al., 2015	Brahm et al., 2013
Topic 3 Methods to improve safety training outcomes	Guo et al., 2012	Vidal-Gomel, 2017	Misiurek et al., 2017
	Nazir et al., 2015	Grabowski et al., 2015	Langer et al., 2012
	Suleiman et al., 2015	Nie et al., 2017	Cecchini et al., 2017
Topic 4 Methods for the construction industry	Hung et al., 2013	Jeschke et al., 2017	Evanoff et al., 2017
	Kaskutas et al., 2010	Williams Jr. et al., 2010	Kaskutas et al., 2013
Topic 5 Programs in vocational institutions	Laberge et al., 2014	Chin et al., 2010	Ouellet et al., 2014
	Andersson et al., 2014	Kintu et al., 2015	
Topic 6 Programs for MSDs industry workers	van Eerd et al., 2010	Hogan et al., 2014	Kim et al., 2010
	Szeto et al., 2013	McDermott et al., 2012	Pecitto, 2012

	Articles		
Topic7 Programs to improve safety knowledge and performance	Freitas et al., 2017	Gummesson, 2016	Stuart, 2014
	Pisaniello et al., 2013	Crichton, 2009	Tharmin et al., 2010
	Haas et al., 2014	Lee et al., 2015	Terwoert et al., 2016
Topic 8 Programs for MSDs among office workers	Levanon et al., 2012	Meinert et al., 2013	Robertson et al., 2009
	Taireb-Maimon et al., 2012	Robertson et al., 2017	Wu et al., 2009
	Elfering et al., 2013	Sigurdsson et al., 2012	Abareshi et al., 2015
	Bulduk et al., 2017		

Table 4-6. Articles allocation

5 RESULTS AND DISCUSSION

This systematic literature review is focused on training and education in occupational safety and health between 2008 and 2017. OSH is considered as a science of anticipation, recognition, evaluation and control of hazards in the workplace that could affect health and wellbeing of workers, its scope has a continuous tendency to evolve responding to social, politic, technological and ergonomic changes and it proposes different remedial measures to eliminate or reduce hazards on the workplace. Remedial measures sorted according to importance and effectiveness are elimination, technical means, warnings, training and personal protective equipment implementation.

Training methods have particularly high importance in industries where hazards couldn't have been completely removed, thus different programs and measures to reduce injuries, diseases and fatalities in the workplace are implemented. Legislations and organization stablish mandatory training programs for workers, nevertheless programs and methods should adapt to industry hazards, worker's background education and culture, technology available, workers motivation to learning, management commitment to safety among other particular factors of each industry. Thus, the main purpose of this literature review is to identified topics of interest, training methods applied, trends of investigation, gaps in the literature and finally to assess the need for further research on education and training in occupational safety and health.

The selection of journals was done according to a detailed selection criteria, from which articles were searched based on terms and query string generated. The articles resulted from the search were submitted to an analysis of their abstracts to confirm or reject their relation to the main topic of this literature review. A total of 54 articles matched the selection criteria.

Corpus formed by the articles were first submitted to a manual analysis of the whole text and then Text Mining technique was used to identify terms and their frequencies in each article. From TM a Document-Term matrix was obtained and used as an input for Latent Dirichlet Allocation topic model. Results of manual analysis and LDA provided information about trends, topics of interest, training methods and more.

From TM and LDA results, a list of eight topics have been identified in the corpus. All the topics are related with training and education on Occupational Safety and Health as this was the main subject of this systematic literature review.

Topic 1: Identification and description of factors that influence training programs efficacy

Topic 2: Impact of leaders and management commitment to safety on OSH training and safety climate

Topic 3: Safety training methods to improve training efficacy outcomes on workers of different fields.

Topic 4: Occupational Safety and Health training methods for construction industry

Topic 5: Occupational Safety and Health educational programs in vocational institutions.

Topic 6: Intervention and training programs to reduce musculoskeletal disorders among industry workers.

Topic 7: Training methods to improve safety workers' knowledge and performance

Topic 8: Intervention and training methods to reduce musculoskeletal disorders among office workers.

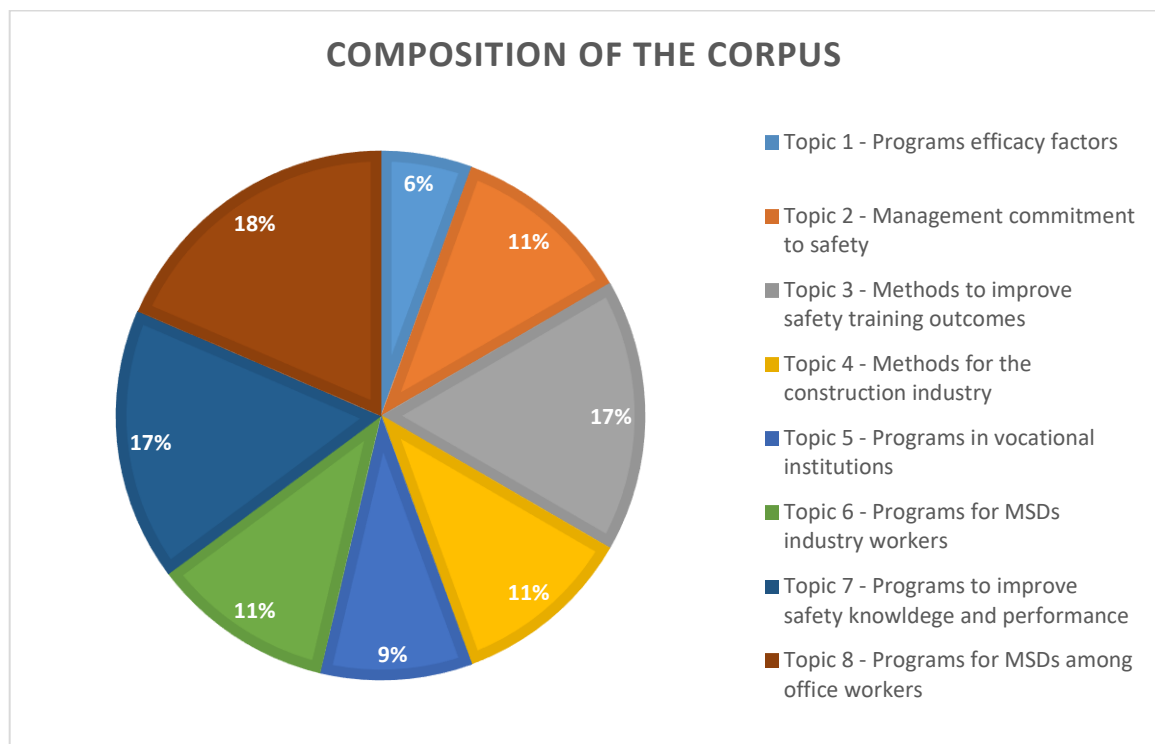


Figure 5.1 Composition of the corpus

The quantity of articles in each topic and their year of publication is shown in table 5-1 and figure 5.2, these are useful to determine trends of researches on training and education in OSH.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	TOTAL
Topic 1	1			1		1					3
Topic 2					1	1		3	1		6
Topic 3					2			3		4	9
Topic 4			2			2				2	6
Topic 5			1				3	1			5
Topic 6			2		2	1	1				6
Topic 7		1	1			1	2	1	2	1	9
Topic 8		2			3	2		1		2	10

Table 5-1. Articles topic vs year

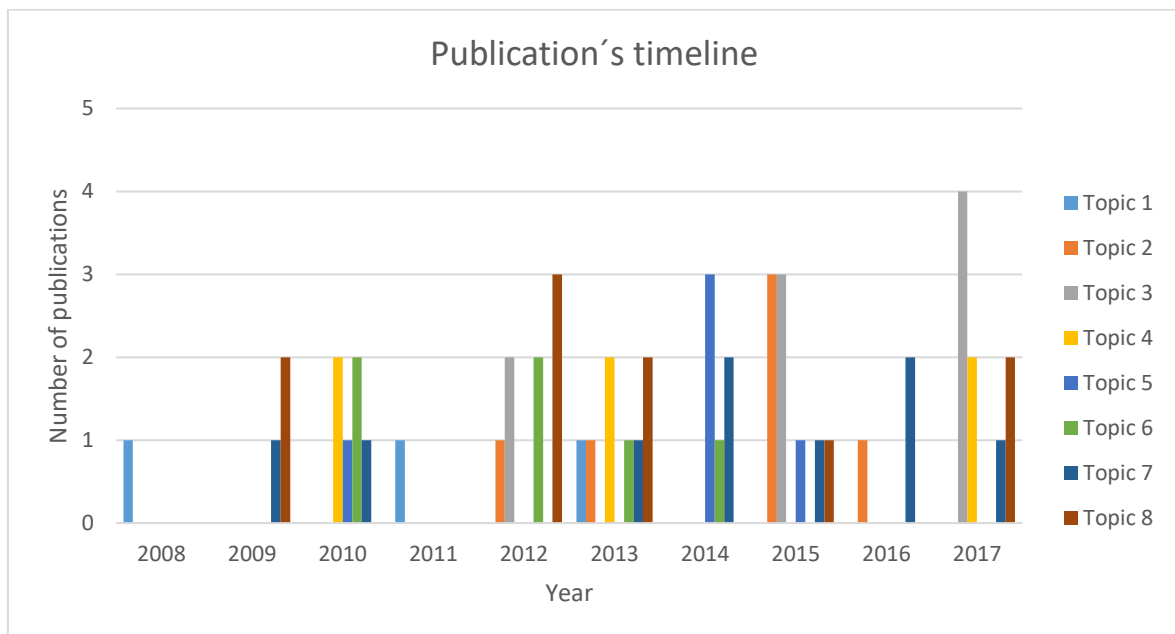


Figure 5.2 Topics publication timeline

From the composition of the corpus (fig. 5.1) it is seen that according to topics generated by LDA model, more articles are related with proposing and testing training methods to improve behaviour change, situation awareness, risk perception, workers' knowledge and other direct indicators of OSH training efficacy.

Figure 5.3 shows the timeline of the publications inside the cluster of topic 1 that is aimed to recognize and describe factors that affect the efficacy of OSH training programs, its trend line shows this topic has had an equally importance for researches over the last ten years, nevertheless this a topic with fewest amount of publications.

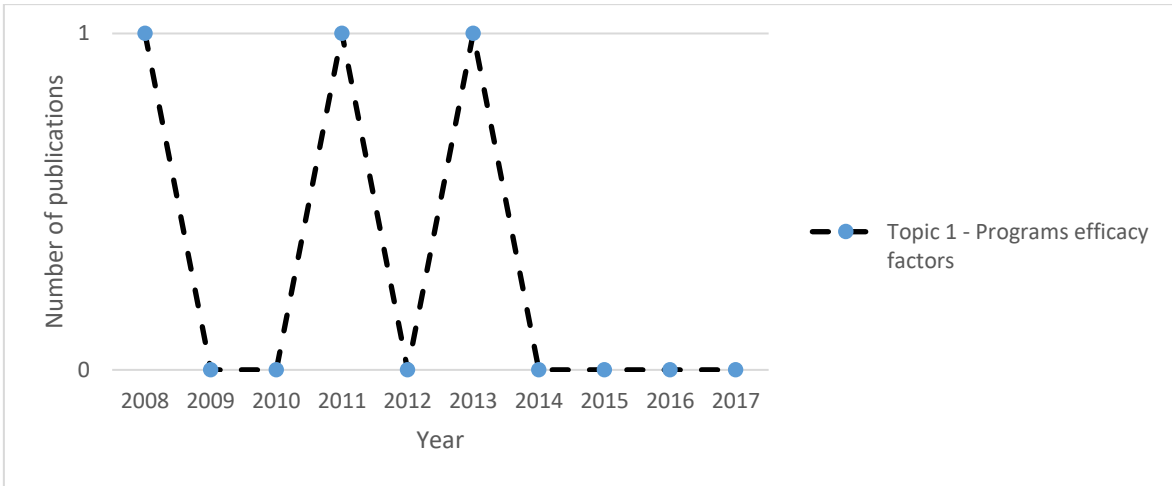


Figure 5.3. Topic 1 Publication's timeline

The Figure 5.4 shows the number of articles published over the last ten years belonging to the cluster of topic 4 that are focused on Occupational Safety and Health training methods for the construction industry workers. The trend line shows researchers have given importance to this topic over the time period studied in this thesis.

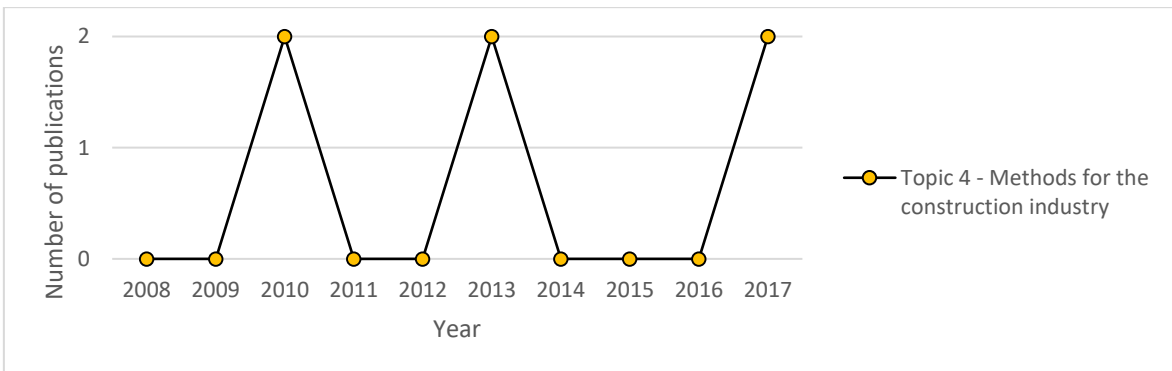


Figure 5.4. Topic 4 Publication's timeline

Figure 5.5. Topic 2 and Topic 5 Publication's timeline shows the number of articles published that belong to topics 2 and 5. Topic 2 is aimed to study the impact of leaders and management commitment to safety on OSH training and safety climate while topic 5 is aimed to evaluate Occupational Safety and Health educational programs in vocational institutions. From the trend lines is seen that Topic 5 has incremented its importance for authors during last years and topic 2 has received a relative equally importance over the same period of time.

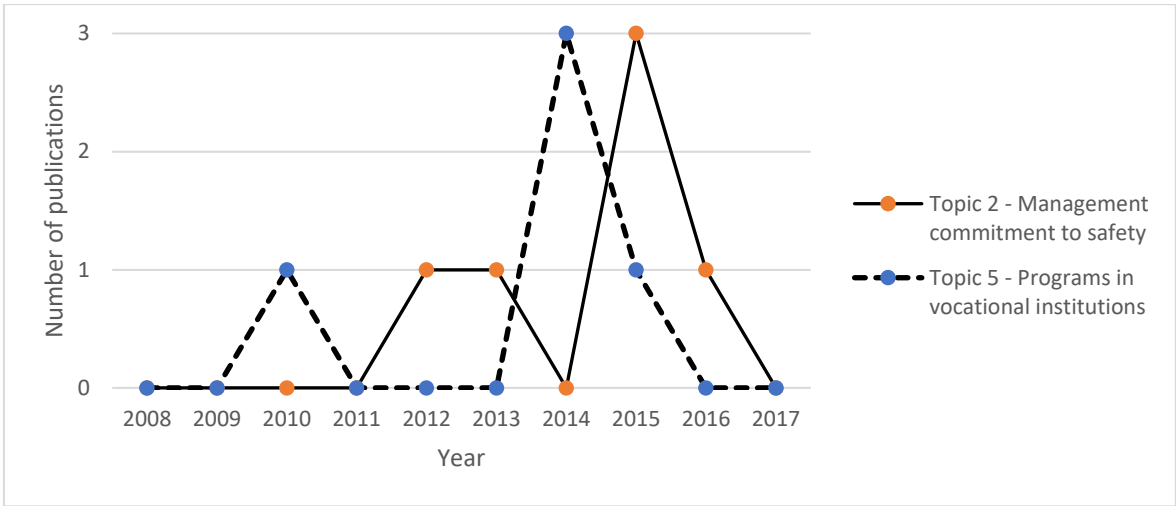


Figure 5.5. Topic 2 and Topic 5 Publication's timeline

Numbers of publications of Topic 3 and Topic 7 according to year of publication is shown in Figure 5.6. Topic 3 and Topic 7 Publication's timeline Topic 3 is focused on Safety training methods to improve training efficacy outcomes on workers of different fields while Topic 7 is focused on Training methods to improve safety workers' knowledge and performance. Trend lines show an increment of authors' interest on study methods that improve safety training outcomes while number of studies on programs to improve safety knowledge are relative constant over the time period studied.

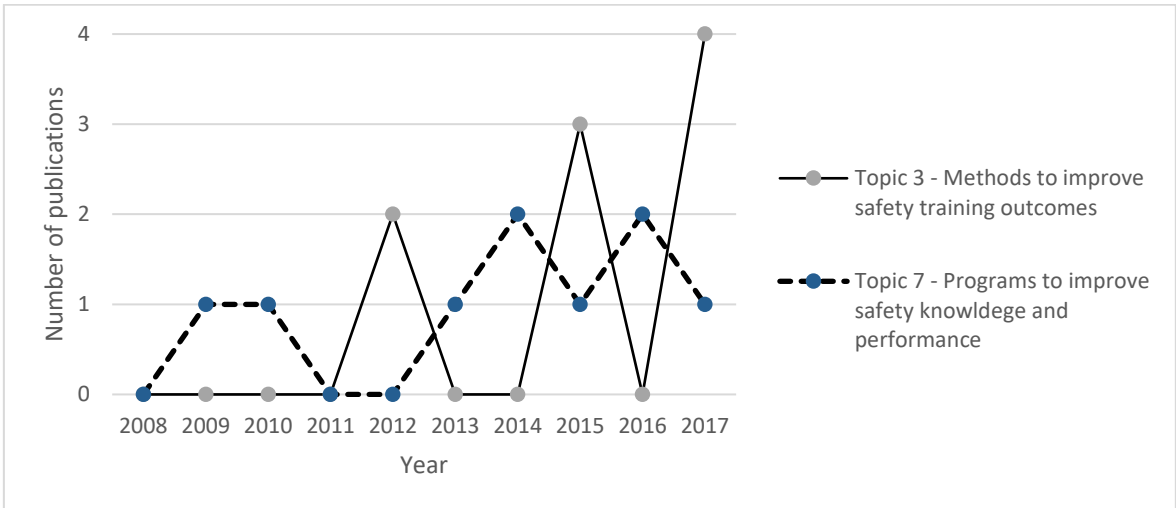


Figure 5.6. Topic 3 and Topic 7 Publication's timeline

Figure 5.7. Topic 6 and Topic 8 Publication's timelines shows the number of publications belonging to Topic 6 and Topic 8 during the last decade. Both topics are focused on targets with an important percentage of accidents or fatalities and MSDs respectively. The trend lines show a relative constant number of publications over the period studied for these topics.

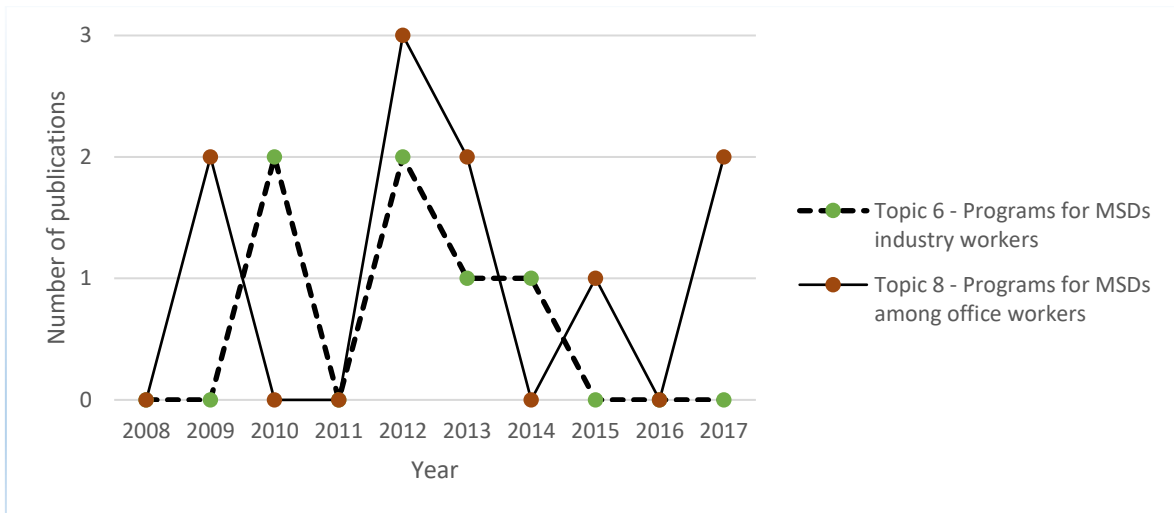


Figure 5.7. Topic 6 and Topic 8 Publication's timeline

Analysing in deep the results is observed that musculoskeletal disorders are subject of high interest for authors. Moreover, two different topics related to training methods to reduce MSDs symptoms are identified, one for training and ergonomic interventions aimed to office workers and other aimed to workers that perform more physical tasks like manual handling.

Authors also show interest on study needs, factors and OSH training methods for construction workers and foremen, due to the high risk this field involves.

The educational programs and methods used on vocational and educational institutions like technical high school, universities and colleges are also subject to study and evaluation to determine needs of improvement, holes, gaps and factors that influence their efficacy.

The importance and influence of management commitment to safety, leaders and owners predisposition to OSH programs on safety climate and safety outcomes is studied by authors.

Analysing the trends for each topic. Studies of OSH training and educational methods to improve safety outcomes have increased during the last ten years; number of publications about evaluation of vocational programs, educational programs and the importance of managers, leaders and owners commitment to safety have also increased in this ten years period reviewed.

At this point a better description of each topic can be provided: Topic 1 generated by LDA refers to publications that are aimed to identify, describe and propose recommendations to control factors that influence the training program efficacy. Authors performed experiments to evaluate factors and knowledge before and after interventions. Publications belonging to Topic 1 evaluate the effects of verbal warnings, rehearsals and experience as factors that could influence safety

training outcomes, finding that last minute rehearsals and the experience of workers don't influence positively on safety knowledge outcomes.

Topic 2 study the importance, correlation and effectiveness of leaders, company owners and managers commitment to safety by evaluating OSH outcomes and safety climate improvement in the industry. Authors propose that higher management commitment to safety affects positively on safety climate in the industry and later on OSH outcomes. Authors have found that focusing training on leaders and managers produce transformational leadership, contingent rewards and safety self-efficacy as proxies for positive control behaviours increased and safety climate improved. Suggesting that leader training is a promising OSH intervention

Topic 3 refers to publications that implement a particular safety training method to improve training efficacy outcomes among industry workers of indistinct fields. Methods are described and experimentally tested by authors, different techniques and approaches are used by authors, methods used are identified on chapter 3 of this thesis.

Topic 4 refers to articles that propose OSH training methods for construction workers, where the hazard with higher severity is to fall from altitudes. Authors use different training and educational methods to improve workers safety commitment, safety knowledge, change behaviour and hazard or risk perception among other factors, most of the programs use tool-box training techniques or conventional training techniques to perform the study. Authors' works principally are aimed to establish factors that influence construction workers to acquire knowledge and safety behaviours from training, considering this work field has commonly a wider diversity of employees' educational and cultural background.

Topic 5 clusters publications that study strengthens, weakness and needs of improvement on OSH educational programs already implemented on a particular educational or vocational institution. Authors focus their work on identify factors that influence transfer of knowledge to young and unexperienced workers. Authors use different techniques to conduct and evaluate their studies, focusing principally on methods and factors that increase safety knowledge acquisition like software and e-learning tools.

Topic 6 is related with articles that focus the work on intervention and training methods to reduce musculoskeletal disorders among industry workers. Principally author focus on work activities that require manual handling and as a consequence employees are under risk of suffering of MDS symptoms. Training methods are proposed and described by authors.

Topic 7 refers to publications that are aimed to propose training methods to improve safety workers' knowledge and their performance. Authors use different training and educational techniques to increase safety knowledge while also

providing information for improving performance. As a result authors haven't found results that significantly have shown positively link between OSH training programs implemented and performance improvement.

Topic 8 clusters articles that are focused on reducing the effects of musculoskeletal disorders among office workers. Publications are aimed to face MDS symptoms for office employees, due to the quantity of office workers this work-related disease is one of the most frequent. Different techniques for reducing this disease are proposed by authors, described and experimentally tested.

From the topics obtained some observations can be made: authors have developed interest on covering and proposing training methods to reduce musculoskeletal disorders among office workers and to reduce injuries and fatalities among construction workers, this is consistent with the fact office workers are most likely to suffer MSDs and construction workers are under hazards of higher severity among employees.

Authors have tested different training methods in their publications. Authors have taken three approaches to develop training programs that are: use of software and technology, conventional training methods and modifications on conventional training methods.

Training methods that are different than conventional classroom training sessions have been tested by authors, where methods that involve e-learning techniques and 3D simulation software have been used specially during last years and they show some promising results on transferring knowledge, improving hazard and risk perception and situation awareness. Nevertheless, further investigation is required following technology improvement to increase the range of industry fields where these techniques could be applied.

Topic 1 shows interaction with the other topics as a better understanding of factors that influence training programs efficacy will impact on safety knowledge outcomes, safety outcomes, behaviour change, situation awareness, risk perception, performance, etc. in the industry.

In a similar way Topic 5 can interact with the other topics as it focus on identifying factors that influence training efficacy and outcomes on young or unexperienced worker. This type of workers are particularly under higher risk that other workers with preparation and experience in the same industry field or related to the same task.

Further investigation is required on techniques to assess long-term efficacy of OSH training. Authors have used reminders techniques provided in periodical toolbox meetings, emails, automated feedback to refresh employees' knowledge, situation awareness and improving employee's behaviour change.

Authors have focused their studies on young and unexperienced workers, by evaluating training and educational methods provided in vocational institutions, technical high schools and universities. Articles identify factors, gaps and needs of improvement for the educational method evaluated.

Articles that evaluate training programs efficacy have used risk perception, situation awareness, behaviour change, knowledge transferred among others as outcome indicators directly related to the training session, but authors have failed or haven't tried to link the training program to a reduction of direct occupational safety and health indicators like number of fatalities, injury frequency rate or severity rate. Further investigation could be required on the correlation between OSH training and OSH outcomes.

Few studies have tried to link OSH training outcomes and performance indicators, as OSH has been studied as an isolated field inside companies' structure. Further studies may be needed to correlate training programs and performance.

Other subject of investigation that has shown a positive tendency during last years is related with the impact of management commitment to safety and training programs provided to leaders, managers and industry owners in training efficacy and safety outcomes.

6 LIMITATIONS OF THE LITERATURE REVIEW

- Articles selected for the review were published between 2008 and 2017. Thus, articles based their studies and training methods proposed on theory and publications made out of this review's scope. As a consequence of the time period selected for this review, important information and articles may be missed.
- Some OSH training programs that use software and technology tools could be published on journals related to education and for this reason, they are not consider in this review.
- LDA topic modelling is completely dependent on number of desired topics, how the terms were identified and what terms where set as stop-words and then removed. Setting a base dictionary could improve LDA results but is required to know what you are looking for.

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