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Research trends in mining accidents study: A systematic literature review

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ABSTRACT

Mining is well known as a high-risk industry with high accident rates. However, there is a scarcity of material that aims to investigate and understand the research trends in mining accidents and the current scenarios related to this topic. Therefore, the objective of this systematic review was to investigate the research trends in mining accidents. By applying a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) review method, a systematic literature review (SLR) identified 57 studies related to mining accident issues from 2015 to 2019 from the ScienceDirect and Scopus databases. Based on these 57 studies, four main themes were developed: the main causes of mining accidents (46%), the prevention of mining accidents (20%), and the challenges of (17%) and impacts of post-mining accidents (17%). The four themes produced a total of 35 sub-themes. Mechanical failure was identified as the main cause of mining accidents and the application of software or safety models is essential to minimize the number of mining accidents. Mine owners have the responsibility to provide a safe working environment for mine workers, and face substantial challenges to achieve this. Moreover, the impact of post-mining accidents led to adverse impacts on the environment. This systematic review study aims to assist mine owners by providing a better understanding of mining accident issues. The study also addresses miners, government and policymakers so all groups can collectively target the reduction of mining accidents in the future.

1. Introduction

Mining is a high-risk occupation and considered one of the oldest industries in the world (Jiang et al., 2017). Mining accidents, hazards, and disasters have a number of similarities in terms of their significant impacts on the victims (Lyra,2019), mine owners (Li et al., 2019), mine workers (Aliabadi et al., 2018; Li et al., 2019), governments (Pons, 2016; Lyra, 2019), policy-makers (Kong et al., 2018; Düzgün & Leveson, 2018), economy (Fu et al., 2019; Xiao et al., 2019; Shao, 2019), and local communities (Lyra, 2019), as well the environment and human health (Dam et al., 2018; Shao, 2019; Cordeiro et al., 2019). The development of various acts, policies and regulations related to mining industry are aim to manage the mineral exploitation in a responsible manner, ensure the mining activities can operate smoothly and avoid mining accidents or disaster. For example, the Directorate General of Mines Safety (DGMS) was established in India has served the country for more than 119 years in mining industry. This organization aims to regulate enforcement of the Mines Act 1952 and the legislations related to it (https://dgms.gov.in/). Moreover, National Mineral Council in Malaysia has launched the National Mineral Industry Transformation Plan (TIM 2021–2030) to develop mining and mineral industry in a comprehensive manner and to ensure the sustainability of mineral industry in Malaysia (https://www.ketsa.gov.my/) All these efforts also aim to prevent the mining accidents or disasters by providing a proper guideline or standard operating procedure during mining operation. Despite having various mine acts, policy and regulations, there is scarce systematic literature review (SLR) conducted that reviews or highlights the current research trends in the mining industry worldwide. The main research question guiding this systematic review is: what research trends have been identified in studies of mining accidents? In fulfilling the objective of this study, such domains and variables derived from this study could contribute new knowledge for future scholarly work. It is important to understand this, and make suggestions to improve this sector, especially in relation to mining accidents. Therefore, the study

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aims to analyze the research trends in studies of mining accidents by applying a systematic literature review with an approach using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method.

2. Methodology

Kitchenham (2004) states a systematic literature review is “a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest”. Systematic literature review research can be differentiated from traditional narrative reviews in that it adopts a replicable and detailed methodology (Cook et al., 1995). The objective of a systematic literature review (SLR) is to locate, search, and synthesize literature systematically related to previous studies or research in a well-organized and transparent process, using replicable procedures throughout each step. Systematic reviews can also be called meta-narrative reviews (Wong et al., 2013) or mixed studies reviews.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to establish a systematic literature review (SLR) of recent trends in mining accident studies. PRISMA is well known in environmental management studies, social sciences, safety studies and many other fields. The ScienceDirect and Scopus databases were chosen for this SLR study, and the PRISMA procedure was applied, that is, the steps of the review process included the identification, screening, eligibility and exclusion criteria process. The data abstraction and analysis were included, as shown in Fig. 1. Furthermore, three advantages of using PRISMA in SLR (Sierra-Correa and Cantera Kintz, 2015) studies are: 1) PRISMA states a clear research question, 2) it screens inclusion and exclusion criteria, and 3) it uses the scientific literature databases within a required timeframe. PRISMA is a very well-known approach to conducting SLR in various fields, such as social sciences (Shaffril et al., 2019), medicine and healthcare (Danielli et al., 2021; Chinwah et al., 2020; Vásquez-Cárdenas, et al., 2019), business and management (Cubric et al., 2020), safety research (Adaku et al., 2021; Nyoni et al.,2019) and many others. The four main steps involved in PRISMA are identification, screening, eligibility, and data abstraction and analysis. Therefore, the PRISMA approach benefits an SLR study because it utilizes systematic steps to achieve the objective of the study. Moreover, there are few systematic literature reviews of recent research trends in the mining industry.

2.1. Identification phase

The first phase in the systematic review process is identification, which was performed in September 2020. The process involved

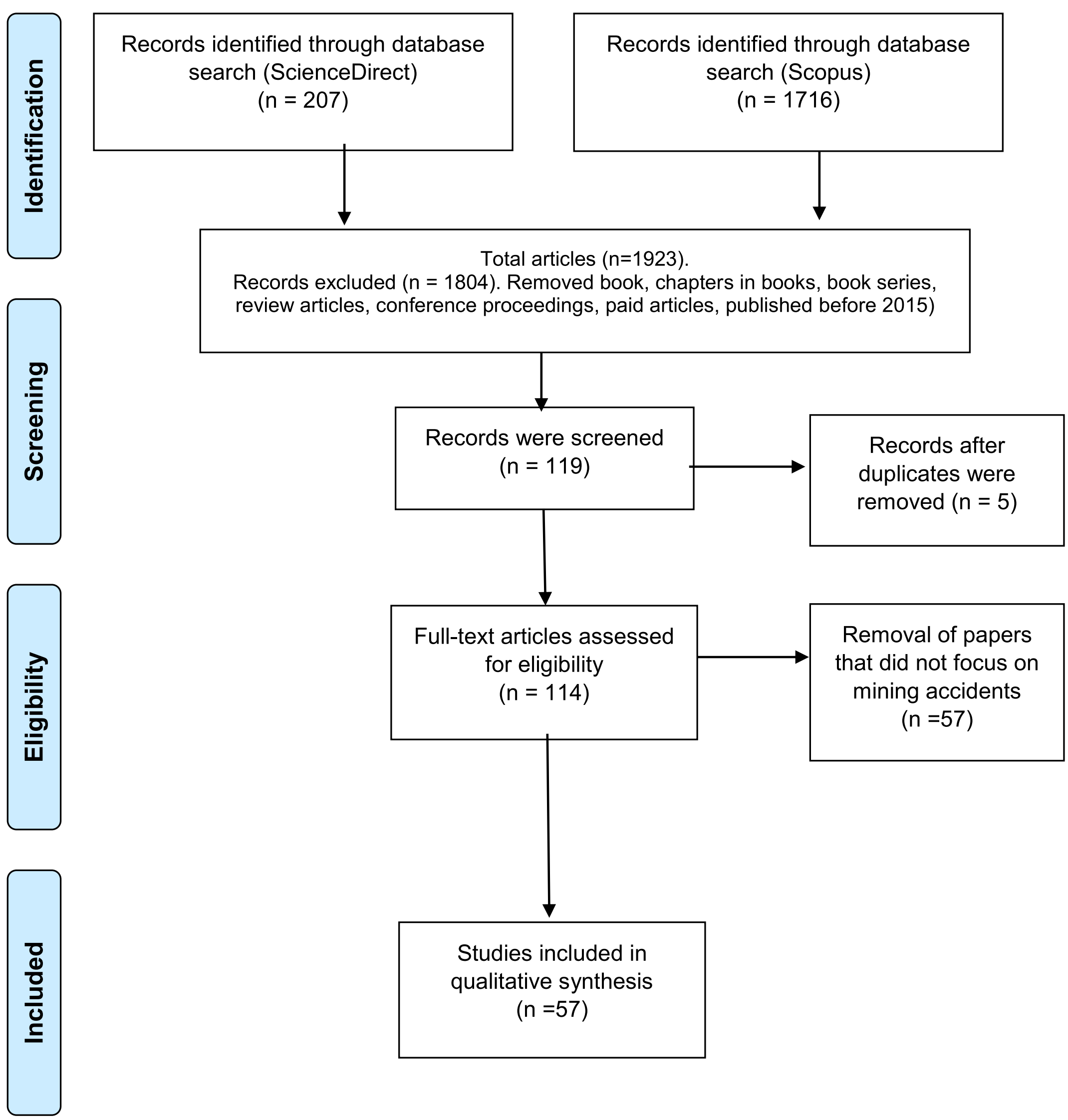

Fig. 1. The flowchart of the PRISMA approach used in the SLR study. (Adapted from Moher et al., 2009; Shaffril et al., 2019).

keywords identification for information searching purposes. According to Moher et al. (2009) at least one database should be presented. In this case, two leading indexed databases were used for this review: ScienceDirect and Scopus. They were chosen since both are considered the leading indexing systems for citations and have great reputations for publishing scientific articles. ScienceDirect consists of more than 18 million articles and chapters and over 2,500 academic journals (https://www.elsevier.com/solutions/sciencedirect). Scopus is a well-known database containing over 7000 publications from various fields, including medicine, arts and humanities, social sciences, science, and technology (https://www.elsevier.com/solutions/scopus). Because of their prominence, these two indexed databases were selected, a vital step to ensure the quality of the articles reviewed in this paper. The current review relied on several relevant information sources, such as encyclopedias, dictionaries, and thesauri. It also used keywords from previous literature and those suggested by Scopus and ScienceDirect as keyword synonyms, possible related terms, and other variations on the term 'mining accidents'. The search string used for both databases was;

> TITLE-ABS-KEY ("mine accidents" OR "mining accidents" OR "mine accident" OR "underground mine accident" OR "surface mine accident" OR "mine disasters" OR "mining disasters" OR "mine hazard" OR "mine casualty")

This process yielded 207 documents from ScienceDirect and 1716 documents from Scopus.

2.2. Screening phase (Inclusion and exclusion criteria)

The 1923 identified articles from the two databases, based on the search strings (refer identification phase), underwent the second phase, as shown in Fig. 1. Screening is a process of including or excluding articles according to criteria determined by the authors and with the assistance of the specific databases. In the screening process, the eligibility, inclusion, and exclusion criterion were determined to find suitable articles to be included in the systematic review process. The criteria for inclusion and exclusion were set by the authors in the SLR study as shown in Table 1.

First, a publication timeline between 2015 and 2019 was selected, based on the total number of related publications retrieved and to be reviewed. The second inclusion criterion was based on types of documents. From both databases, article journals were chosen as this criterion. Review articles, books, chapters in books, and conference proceedings were excluded because they were not considered primary sources. The third criterion for inclusion and exclusion was language. All non-English language documents were excluded to avoid confusion and difficulties in translation (see Table 1). After the identification process, the 1923 articles were screened. After the screening stage 119 articles had been obtained (see Fig. 1).

2.3. Eligibility and duplication exclusion (Manual screening)

Eligibility is a process that includes or excludes articles manually according to the authors' specific criteria. The articles retrieved were thoroughly reviewed in the process, excluding any articles that did not meet these criteria. Before the eligibility process was performed, duplicate documents were removed. Five similar articles in both databases were excluded from the next phase, which left 114 documents for the eligibility process. These were screened manually for literature focusing on mining accidents and the criteria from the earlier screening processes (inclusion and exclusion criteria). The review finally obtained 57 selected articles for the systematic literature review of research trends in mining accidents.

Table 1
The criteria for inclusion and exclusion.

Criteria	Inclusion	Exclusion
Publication timeline	2015–2019	2014 and before
Document type	Journal (research articles)	Conference proceedings, Journals (systematic review), chapters in book, book series, books, etc
Language	English	Non-English

2.4. Data abstraction and analysis

The fourth phase is data abstraction and analysis. The remaining articles were evaluated, reviewed, and analyzed; the 57 selected articles (studies) are discussed in detail in this paper, as tabulated in Table 2. The reviews were based on specific studies that matched and focused on the research question. The studies were then extracted to identify relevant themes and sub-themes for the current study by reading the titles and then the abstracts, before a thorough (in-depth) reading of the full article texts. An integrative review was conducted, which is a kind of review synthesizing different types of research designs (qualitative, quantitative, and mixed methods).

In order to identify themes related to the research trends in mining accident studies, a thematic analysis was carried out. The main issues, similarities and differences highlighted and portrayed in the 57 articles were identified and categorized; this is known as thematic analysis. To construct themes in this SLR study, six steps were followed in the thematic analysis and were suitable for the qualitative analysis, as proposed by Nowell et al. (2017). The steps include:

i. Familiarization with the data (understand and analyze the 57 articles),
ii. Generating initial code (identify the similarities and differences of the issues discussed in the 57 articles),
iii. Creation of identifiable themes (create the suitable themes based on the identified similarities and differences in the 57 articles)
iv. Reviewing themes (ensure the proposed themes and subthemes are within the main context of each article)
v. Defining and naming themes (four main themes and 35 sub-themes were created in this study based on the 57 articles)
vi. Producing a report (in this case, this refers to the SLR study)

3. Results

3.1. Research trends in mining accident studies

The review managed to obtain 57 selected articles from ten countries, which are China, Turkey, India, Ghana, Spain, New Zealand, Brazil, South Africa, Iran, and the United States of America. The SLR study obtained nine articles published in 2015 and eleven published in 2016. Other articles were published in 2017, 2018 and 2019 with a total of six, thirteen and eighteen studies, respectively. The number of mining accident studies from various countries from 2015 to 2019 was established. China was a leading country for published articles, with 36 articles (studies) relating to mining accidents, followed by Brazil (5 studies). South Africa and Spain contributed three studies each. Iran, the USA, India and Turkey contributed two papers each, while one paper was from Ghana and one from New Zealand. Six main types of mining accidents were reported in both databases, which occurred in coal, copper, gold, platinum, lead–zinc, and iron ore mines between 2015 and 2019. Most accidents occurred in coal mines, such as those reported in China (34 studies), followed by iron ore mines (4 studies) in Brazil and platinum mines (2 studies) in South Africa. Furthermore, fourteen studies were qualitative articles while another twenty-three studies used a mixed-method (qualitative and quantitative) approach. The remaining studies (20 studies) were quantitative articles, as shown in Table 3.

By applying a thematic analysis, four main themes and thirty-five sub-themes were created. These were the main causes of mine

Table 2
Results for the SLR study from 2015 to 2019.

Authors	Country	Type of mine	Main study design	1. Main cause																2. Prevention							3. Challenges						4. Impact					
				HUE	USB	UNA	LST	LSE	INW	LBS	OZD	MEF	GEO	PWE	PSC	PSA	PSR	LRR	PSM	TEC	SAM	EDU	REG	TRG	IMS	GPY	MOW	MEN	GOA	STE	POM	COM	HUH	ENV	SOC	IOG	ECL	LLO
(Liu et al., 2015)	China	Coal	MM							√	√							√									√	√	√	√	√		√			√		
(Ozkazanc and Duman, 2015)	Turkey	NG	QL																			√		√														
(Prasad et al., 2015)	India	Coal	QL																														√	√				
(Tianwei et al., 2015)	China	Coal	QN									√	√							√	√																	
(Chen et al., 2015)	China	Coal	MM							√											√				√	√	√											
(Sanmiquel et al., 2015)	Spain	NG	QN	√	√		√		√		√	√							√		√		√	√				√	√	√	√		√			√		
(Geng and Saleh, 2015)	China	Coal	MM	√			√		√		√	√		√	√		√	√		√	√		√	√		√	√	√	√	√	√					√	√	√
(Zhu et al., 2015)	China	Coal	MM	√	√			√	√		√			√		√			√		√						√	√										
(Clarke, 2015)	Ghana	Gold	QN									√		√								√		√									√	√				
(Zhang et al., 2016a)	China	Coal	QN											√			√			√																		
(Dash et al., 2016)	India	Coal	QL	√							√	√	√						√			√																
(Bonsu et al., 2016)	USA	Coal	QL	√	√		√			√	√			√				√																				
(Spada & Burgherr, 2016)	Turkey	Coal	QN														√				√										√							√
(Zhang et al., 2016b)	China	Coal	QN		√		√	√	√	√		√	√	√	√			√	√																			
(Chen et al., 2016)	China	Coal	QN																						√		√	√										
(Huang et al., 2016)	China	Coal	QL																									√									√	
Wang et al., 2016a)	China	Coal	QL																√	√	√						√											
(Nie et al., 2016)	China	Coal	MM																					√									√					
Wang et al., 2016b)	China	Coal	QN	√						√	√	√	√	√					√				√														√	
(Pons, 2016)	New Zealand	Coal	QL							√	√	√							√					√	√	√	√									√		
(Gil-Jiménez et al., 2017)	Spain	lead–zinc	QL							√		√																					√	√				
(Bonsu et al., 2017)	South Africa	Platinum	MM	√	√	√	√		√	√		√		√					√																			
(Grande and Science, 2017)	Brazil	Iron ore	QL									√																	√		√		√	√	√		√	
(Engelbrecht and Thomas, 2017)	South Africa	Platinum	MM																√											√								
Shi et al. (2017)	China	Coal	QN	√								√									√				√													
(Jiang et al, 2017)	China	Coal	MM			√		√																														
(Dam et al., 2018)	Brazil	Iron ore	QN									√																						√				
(Wang et al., 2018)	China	Coal	MM	√	√		√	√	√	√	√	√	√	√	√	√		√	√			√		√	√		√	√										
(Yu et al., 2018)	China	Coal	QN									√	√							√	√																	
(Qiao et al., 2018)	China	Coal	MM		√		√	√	√		√											√	√	√	√													
(Shi et al., 2018)	China	Coal	QN									√									√																	
(Aliabadi et al., 2018)	Iran	Iron	QN	√	√	√				√	√			√					√			√	√	√	√												√	
(Liu et al., 2018a)	China	Coal	MM	√	√	√			√	√	√			√	√				√																			
(Liu et al., 2018b)	China	Coal	MM																	√																		
(Find et al., 2018)	South Africa	Gold	QL									√									√																	
(Kong et al., 2018)	China	Coal	QL																							√												
(Xu & Xu, 2018)	China	Coal	MM				√					√							√		√		√	√				√										
(Düzgün & Leveson, 2018)	USA	Coal	QL				√		√	√	√	√		√	√		√	√	√		√			√		√	√		√		√							
(Zhu et al., 2018)	China	Coal	MM											√		√																			√		√	√
(Wang & Zhang, 2019)	China	Coal	QN									√	√							√	√																	
(Shao, 2019)	China	Coal	QL										√							√			√											√			√	√
(Qiao et al., 2019)	China	Coal	MM		√	√	√	√	√	√	√	√	√					√	√		√				√	√												
(Francini-Filho et al., 2019)	Brazil	Iron	QN									√																						√				
(Morisson et al., 2019)	China	Iron	MM									√																						√				√
(Xiang et al., 2019)	China	Coal	QN	√			√			√	√	√		√					√	√					√			√										
(Li et al., 2019)	China	Coal	QN	√				√		√						√			√		√	√		√	√		√											
(Tong et al., 2019)	China	Coal	QN	√	√					√		√									√	√	√	√	√		√	√										

(continued on next page)

Table 2 (*continued*)

Authors	Country	Type of mine	Main study design	1. Main cause																2. Prevention							3. Challenges						4. Impact					
				HUE	USB	UNA	LST	LSE	INW	LBS	OZD	MEF	GEO	PWE	PSC	PSA	PSR	LRR	PSM	TEC	SAM	EDU	REG	TRG	IMS	GPY	MOW	MEN	GOA	STE	POM	COM	HUH	ENV	SOC	IOG	ECL	LLO
(Sanmiquel-Pera & Bascompta, 2019)	Spain	Coal	QN		√		√	√		√		√		√				√	√					√														√
(Aliabadi et al.,2019)	Iran	Iron	MM		√	√	√		√							√								√			√											
(Chen et al., 2019)	China	Coal	MM	√	√				√			√				√					√																	
(Nie et al., 2019)	China	Coal	MM		√					√															√													
(Fu et al., 2019)	China	Coal	MM		√	√		√				√			√	√			√		√			√													√	
(Qin et al., 2019)	China	Coal	MM									√								√																		
(Xiao et al., 2019)	China	Coal	MM									√									√																√	√
(Lin et al., 2019)	China	Copper	MM																		√																	
(Lyra, 2019)	Brazil	Iron	QL								√	√															√		√	√	√	√	√	√	√	√		
Cordeiro et al., 2019)	Brazil	Coal	QN									√																						√				

Theme 1: Main causes		Theme 2: Prevention	Theme 3: Challenges	Theme 4: Impact	Study Design
16 sub-themes;		7 sub-themes;	6 sub-themes;	6 sub-themes;	QN = Quantitative QL = Qualitative MM = Mixed-Method
HUE= Human error	PSC= Poor safety culture	TAD= Technology advancement	MOW= Mine owner	HUH= Human health	
MEF= Mechanical failure	INW= Inexperienced worker	SAM=Software and Model	MEN = Mine enterprise	ENV= Environment	
USB=Unsafe behavior	PSA= Poor safety awareness	EDU= Education	GOA = Government action	SOC= Social impact	
GEO=Geological factor	LBS= Leadership behavior of supervisor	REG = Regulations	STE=Stakeholder engagement	IOG= Impact on government	
UNA=Unsafe act	PSR= Poor safety record	TRG= Training	POM= Policy-maker	ECL= Economic Loss	
PWE =Poor workplace Environment	LRR= Lack of rules and regulations	IMS= Improve mine supervision	COM= Community	LLO= Life Loss	
LST= Lack of safety training	OZD=Organizational deficiency	GPY = Government policy			
LSE=Lack of safety education	PSM = Poor safety management				

accidents (sixteen sub-themes), prevention of mining accidents (seven sub-themes), challenges presented by post-mining accidents (six sub-themes) and the impact of post-mining accidents (six sub-themes). The results from the thematic analysis of the research trends in mining accident studies are shown in Table 3. A total of 57 articles were obtained and analyzed based on the PRISMA approach. The results are presented in statistical form, such as the percentages of the four themes and how frequently the subthemes appeared in the articles, according to the four main themes and 35 subthemes, as shown in Table 2 and Fig. 2, respectively. The sixteen sub-themes encompassing the main cause theme accumulated 45.7%; meanwhile, those of prevention, challenges and the impact of mine accidents resulted in 20.1%, 17.1% and 17.1%, respectively, as shown in Fig. 2. Fig. 3 illustrates the distribution of the articles by main themes and sub-themes, based on the thematic analysis. The highest reported numbers emerging under the theme of the main causes of mine accidents involved mechanical failure, with a total of 32 studies, followed by poor safety management (19 studies) and leadership behavior of supervisors (18 studies). The subthemes of utilizing software and models (21 studies), followed by training (14 studies) and improvements in mine supervision (12 studies) were among the studies reported under the prevention of mine accidents main theme. The detailed results of the SLR on research trends in mining accident studies are summarized in Table 2.

4. Discussion

4.1. Main causes of mine accidents

The theme of the main causes of mine accidents has 16 main sub-themes, consisting of human error (15 studies out of 57), unsafe behavior (16 studies), unsafe acts (7 studies), lack of safety training (13 studies), lack of safety education (9 studies), inexperienced workers (12 studies), leadership behavior of supervisors (18 studies), organizational deficiencies (16 studies), mechanical failure (32 studies), geological factors (9 studies), poor workplace environment(15 studies), poor safety culture (6 studies), poor safety awareness (7studies), poor safety record (4 studies), lack of rules and regulations (8 studies) and poor safety management (19 studies).

The most common main cause of mining accidents was mechanical failure. Thirty out of 57 studies reported mechanical failure as a significant cause of mining accidents. This is quite surprising because most industries, such as construction (Kim et al., 2021) and manufacturing (Guo et al., 2020), put the blame on human factors as the main contributors to accidents. In contrast, mechanical failure was the dominant factor contributing to accidents in the mining industry, according to the SLR results. Poor mechanical design of features such as tailing dams, the structure of underground coal mines, ventilation systems and shaft systems contributed to the number of accidents in the mining industry. Moreover, the failure of blasting and explosives equipment could also lead to mining accidents. Mining activities also involved heavy-duty work and the use of machinery or transportation, such as lorries, trucks and excavators. All these require proper inspection and maintenance. The age and poor quality of machinery and transportation could lead to mining accidents or disasters. Table 3 shows examples of mechanical failure in coal, gold, iron ore and zinc-lead mine accidents. Other key contributors to mining accidents are highlighted in Table 4. For example, management commitment is critically required to ensure the use of high standard safety practices. The management must also understand and implement the concept of 'safety first' among mine workers to ensure accidents can be avoided. In addition, the most important actions the management could take are to allocate money for, or invest in, safety activities.

4.2. Prevention to reduce the occurrence of mining accidents

The second theme of the SLR study is prevention to reduce the

Table 3
Examples of mechanical failure in various types of mine.

Type of mine accidents	Country	Author	Examples of mechanical failure that caused mine accidents
Coal mine accidents	China	Tianwei et al., 2015)	Poor mechanization
		(Geng and Saleh, 2015)	Roof collapse, Water inrush, machinery failure
		(Zhang et al., 2016b)	Mine refuge chamber (MRC) failure, unsafe conditions of the equipment, no safety device, alarm, safety signs, etc. No protective measures (such as non-safety device, no alarm signs, no safety sign, etc.). Flawed equipment, tools, facilities, and accessories; defective protective equipment
		(Wang et al., 2016b)	Problems in mining mechanization, ventilation equipment, dust proof equipment, drainage equipment lifting and transport equipment, mechanical and electrical equipment, gas drainage equipment
		(Wang et al., 2018)	Machine & equipment failure
		(Yu et al., 2018)	Shaft lining failure
		(Shi et al., 2018)	Electrical, blasting and friction spark
		(Xu & Xu, 2018)	Mechanical injury, electric shock, crashing from the high roof-fall, wall collapse, vehicle injury, mechanical injury
		(Wang & Zhang, 2019)	Rock burst
		(Qiao et al., 2019)	Gas explosion caused by electric spark, roof failure
		(Tong et al., 2019)	Ventilation problem, faulty ventilating equipment, blasting problem, electrician working problem
		(Chen et al., 2019)	The pillar strength was insufficient
		(Fu et al., 2019)	Blasters problem
		(Qin et al., 2019)	Rock burst due to drilling cuttings
		(Xiao et al., 2019)	Electromechanical accidents.
		(Xiang et al., 2019)	Explosion-proof equipment and facilities failure, failure of explosive equipment, overload in demand for replacement subsystem, failure of multiple subsystems, explosive mixture in the drift, problem of controlling equipment.
	Brazil	Cordeiro et al., 2019)	Poor design of mine tailing/dam
	Spain-	(Sanmiquel-Pera & Bascompta, 2019)	Insufficient safety guard for electrical equipment, spark in the electrical light system, ventilation system problem
	New Zealand	(Pons, 2016)	Poor design of underground ventilation system Mine ventilation was not working well. Misplaced main ventilation fan underground
	India	(Dash et al., 2016)	Inrush of water/inundation
	USA	(Düzgün & Leveson, 2018)	Inadequate system control constraints, ventilation problems, inadequate precautions against methane explosion, mine monitoring systems failure, support systems failure
Gold mine accidents	Ghana	(Clarke, 2015)	Entrapment from collapse of mine pits, crushing, explosions, fires
	South Africa	(Find et al., 2018)	Pillar collapsed
Iron ore mine accidents	Brazil	(Francini-Filho et al., 2019)	Ore tailing dam ruptured (mechanical design)
		(Lyra, 2019)	Tailings dam failures (mechanical design)
		(Dam et al., 2018)	Mining dam collapsed due to improper design (mechanical design)
		(Grande & Science, 2017)	Mining dam collapsed due to improper design (mechanical design)
	China	(Morisson et al., 2019)	Mining dam failure (mechanical design)
Lead-zinc mine accidents	Spain	(Gil-Jiménez et al., 2017)	Dam failure/ dam burst
Platinum mine accidents	South Africa	(Bonsu et al., 2017)	Equipment failure

occurrence of mining accidents. Seven sub-themes emerged here, including technology advancement (10 studies), software and models, education, regulations, training, improvement to mine supervision and government policy. Most mining accidents were reported in underground coal mines; for example, a rock roof collapsed, or there was a methane gas explosion or flooding (Liu et al., 2018b). In terms of the sub-theme of technology, few researchers have reported on the latest

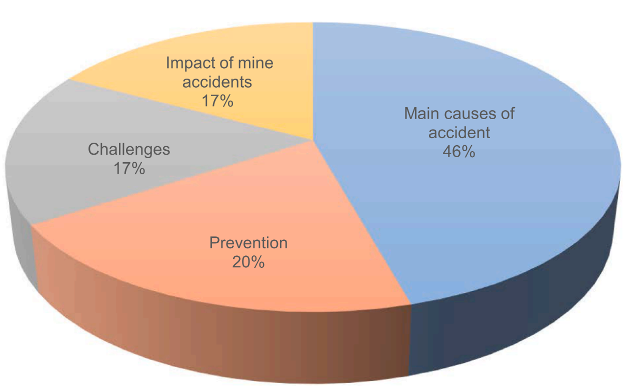

Fig. 2. Percentage distribution of themes.

technology that can be used to prevent coal mine accidents, as shown in Table 5. Technology can help improve mining activities, increase production and prevent mining accidents.

The benefits of the application of software or models are undeniable today. Twenty-one out of 57 studies reported on the use of software and models to analyze various causes of mining accidents, and to prevent and predict future accidents. Table 6 shows the SLR results on the application of software and models for mine accident analysis and prevention.

Another important way to prevent mining accidents is by enhancing the education and training of mine workers. This is essential because providing effective safety education can produce knowledgeable and skillful miners. A safety philosophy should become part of the safety culture among miners through the implementation of safety training, safety education, safety inspections, safety meetings, potential risk identifications, information feedback, and safety measures. Moreover, safety education for young miners in China, is necessary to educate workers about preventing accidents in the coal mining industry in China (Li et al., 2019). Meanwhile, studying coal mine accidents in India, Dash et al. (2016) concluded that educating miners to remove the culture of denial from the system, especially when some critical decisions are taken, is important in mine accident prevention. Furthermore, Wang et al. (2018) analyzed 58 coal mining fatal accidents in Shandong,

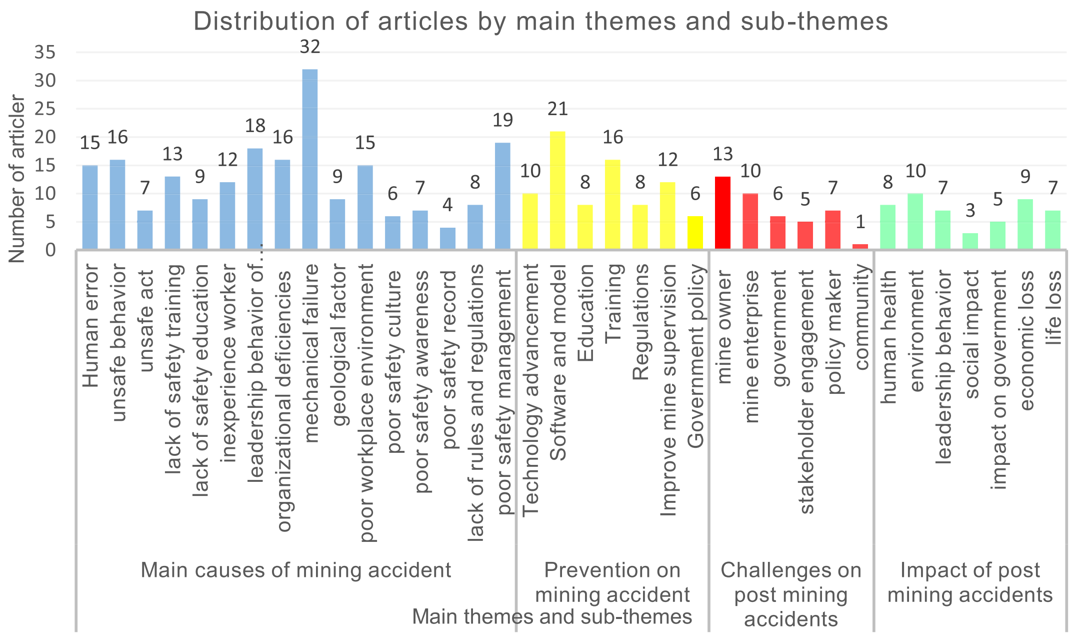

Fig. 3. Distribution of articles by main themes and sub-themes in the SLR study.

China, from 2010 to 2014 and concluded that safety education is important to prevent mine accidents. Moreover, the proper training of staff is a form of investment that mining companies can make in order to prevent mine accidents arising from the rule violations committed by mine workers (Clarke, 2015).

Enforcement of regulations is another way of mine accident prevention. For example, in China, due to the abundance of coal mine accident cases reported, the enforcement of regulations by mine supervisors and mining companies is critical to ensure a safe environment for coal mining operations. According to Pons (2016), officers should ensure they have a system of gathering information on safety incidents, violation actions and the performance of the mining company as an organization. Meanwhile, Wang et al. (2018) recommended the reinforcement of safety policies, including imposing penalties on miners' rule infringements. A Plan-do-check-act (PDCA) can be implemented to monitor the effectiveness of rules and regulations, safety inspections and management. This view is also supported by Qiao et al. (2018) who mentioned the attitude of employees towards complying with the company rules and regulations. Furthermore, violations of rules and regulations contribute to major accidents in underground coal mines (Sanmiquel et al., 2015). Therefore, mining companies should provide adequate training and communication channels to workers, and hire miners in good physical condition to perform specific tasks. Another important mine accident prevention strategy is to improve mine supervision (Xiang et al., 2019; Li et al., 2019; Tong et al., 2019; Nie et al., 2019). A system to collect evidence-based statistics on organizational performance was suggested by Pons (2016) to improve the mine supervision system. The training factor had the greatest impact on unsafe behavior. Therefore, mine supervisors should be required to attend a series of training sessions to improve their knowledge (Qiao et al., 2018). Training, capacity building and the implementation of a safety culture should be imposed in the technical, social and management components of the mining system (Düzgün & Leveson (2018). In addition, Wang et al. (2018) suggested strengthening safety supervision. It is vital to strictly implement safety supervision so as to locate, identify and address safety problems in production in a timely manner. The transparency of government policy can give a clear signal to mining companies to abide by the rules and legally operate their mines. Government policy is the seventh subtheme, with a total of 6 studies reported (Chen et al., 2015; Düzgün and Leveson, 2018; Geng and Saleh, 2015; Kong et al., 2018; Pons, 2016; Qiao et al., 2019). The SLR found no specific names for such policies but, in general, the establishment of legislation for internal and external safety investigations is necessary to identify the actual safety problems (Düzgün & Leveson, 2018). Meanwhile, promotion incentives given by local politicians would significantly increase firm-level employment growth and increase labor investment efficiency (Kong et al., 2018).

4.3. Challenges of post-mining accidents

The third theme of the SLR study is the challenges of post-mining accidents. There are six sub-themes under this theme, involving mine owners (13 studies), mine enterprises (10 studies), governments (6 studies), stakeholder engagement (5 studies), policy-makers (7 studies) and communities (1 study). Mine owners have a great responsibility to ensure continuous improvement in coal mine supervision systems and ensure all the safety regulations are followed by all staff, including mine workers. The challenges of post-mining accidents are summarized in Table 7.

4.4. Impact of post-mining accidents

There were various impacts of post-mining accidents, based on the SLR study and as shown in Fig. 4. These negative effects were on human health and psychology. For example, noxious gases such as sulfur dioxide, and nitrous fumes from explosive dynamite blasts in gold mine accidents can cause post-accident respiratory problems (Clarke, 2015). Arsenic can cause cancer, and cardiovascular and neurological damage, while cadmium can cause kidney damage and create the risk of prostate and respiratory cancer. In addition, when performing manual handling of loads in opencast mines or quarries, it is highly probable that workers will suffer accidents related to the musculoskeletal system, as reported by Sanmiquel et al. (2015) as coal mine accidents in Spain have shown. In contrast, Nie et al. (2016) studied the physiological changes of people trapped in coal mine accidents. The results indicate that these accident victims experience intense physiological and psychological changes, such as systolic blood pressure, pulse pressure and pulse rate changes.

The environmental impacts due to coal mining accidents include soil erosion, water pollution, the shortage of clean water supplies and impacts on local biodiversity. In Ghana, the issue of mercury pollution that

Table 4
Examples of main causes of mining accidents.

Main cause of accidents	Example	References
Human error	• Inadequate safety training • Supervisor's violation • Miners' failure to fully understand the high possibility of accidents • Unskilled miners • Poor workplace • Lack of training	Geng and Saleh (2015); Xiang et al. (2019); Li et al. (2019); Tong et al. (2019; Bonsu et al. (2017)
Unsafe behavior	• Utilized unsafe equipment, • Inappropriate goods storage, • Stayed in an unsafe place, • Stayed under the lifting machine, • Ignored the importance of personal protective equipment, • Ignored warning signs, • Wore unsafe attire • Lack of training factor • Poor attendance factor • Lack of experience factor • Age factor • Poor fitness for duty • Insufficient experience	Zhang et al. (2016b); Qiao et al. (2018); Chen et al. (2019)
Unsafe act	• Unworn respirators • Neglect of gas detection requirements • Failure of underground gas detection • No pre-check done on the equipment Preconditions of unsafe acts include theinadequate planning of • team resources management • personal readiness • mental state • physiological state • physical environment • physical capacity • intellectual limitations • technological environment.	Jiang et al. (2017) Liu et al. (2018a)
Lack of safety training	• Lack of safety course and training • Unaware of safety protocol	Geng and Saleh (2015); Zhang et al. (2016b); Bonsu et al. (2017); Sanmiquel-Pera & Bascompta (2019).
Lack of safety education	• Lack of safety education among mine workers	Qiao et al. (2018), Qiao et al. (2019); Li et al. (2019; Fu et al. (2019)
Inexperienced worker	• Failure to understand production process safety instructions • Failure to recognize the major issues of a process that has high potential for accidents • Unskilled worker handling machine or equipment without first understanding the operating procedure and proper safety precautions.	Zhang et al. (2016b)Sanmiquel et al. (2015)Düzgün & Leveson (2018)
Leadership behavior of supervisor	• Inadequate supervision • Inappropriate operation plan • Unresolved problems and violations of supervisor duties are the common issues of supervisor leadership • Poor production atmosphere • Poor communication and coordination • Improper safety measures led to incorrect decisions by supervisor	Liu et al. (2018a); Aliabadi et al. (2018)Pons, (2016).
Organizational deficiencies	• Poor management • Poor coordination • Poor supervision system in safety management • Lack of preventive system to manage mining accidents	Sanmiquel et al. (2015)Aliabadi et al. (2018)Aliabadi et al. (2018); Lyra (2019).
Geological factor	• The failure to understand underground coal mine structure could lead to mine accidents. • The content of dust, geological feature, Temperature and humidity, physical environment and geological conditions are common contributor for coal mine accidents. • Ground fissures could lead to underground coal mine accidents	Zhang et al. (2016b)Wang et al. (2016b)Shao (2019)
Poor workplace environment	• For underground coal mine; • Poor ventilation system, • Poor mine monitoring systems • Inadequate precautions against methane explosion, • Inadequate escape routes and unsatisfactory support systems	Düzgün & Leveson (2018)Aliabadi et al. (2018)
Poor safety culture	• Poor working environment leading to poor safety culture • Poor implementation and enforcement	Fu et al. (2019); Düzgün & Leveson (2018).
Poor safety awareness	• Safety behavior • Safety attitude • Safety climate • Management safety commitment	Li et al. (2019).
Poor safety record	• Auditing problem • Ignored lessons already learned	Spada &Burgherr (2016)
Lack of rules and regulations	• Lack of coal mine safety inspection conducted on mine site • Lack of rules from local government regulators and township level. • No enforcement or action taken against mining company • Illegal and poorly equipped coal mines were able to escape examination • Deficiency of a safety policy • Safety and production data were hidden and not included in an official report	Geng and Saleh (2015); Liu et al. (2015); Fu et al. (2019)

(continued on next page)

Table 4 (*continued*)

Main cause of accidents	Example	References
Poor safety management	• Incomplete or poor execution of rules and regulations • Lack of coordination among workers • Poor rules and regulations, • Inefficient management, • Lack of supervision and inspection • Managers should provide proper safety equipment • Provide a good communication channel for workers • Improve safety behavior and reinforce safety commitment. • Ineffective safety policy • Poor safety organization structure, inefficient safety management • No safety training system • The lack of a supportive environment is a sign of poor management commitment to safety	Li et al. (2019); Xiang et al. (2019); Fu et al. (2019); Aliabadi et al. (2018); Wang et al. (2018)

Table 5
Examples of technology used for underground coal mine accident prevention.

Technology	Main purposes/benefits	References
Coal seam ascending for underground coal mine in China	• Can increase the recovery rate and upgrade mine safety production • Increases the stope stability. • Capable of preventing hard rock mining from causing deep mine disasters, improving economic and social aspects	Tianwei et al. (2015)
Mine refuge chamber (MRC)	• Prevents gas explosions. • MRC provides 96-hour water supply • Breathable air, food and other supplies for emergency events in an underground coal mine	Geng and Saleh (2015)
Underground continuous impervious curtain (UCIC)	• Prevents failure of the shaft lining, which occurs in deep alluvium of coal mine	Yu et al. (2018).
Microseismic Monitoring Method	• Predicts the occurrence of rock burst by combining the drilling cuttings and releasable elastic deformation energy	Qin et al. (2019)

Table 6
SLR results on the application of software and models for mine accident analysis and prevention.

Name of software or model	Main objective	References
USINH Software and Flac3D	1. To study the feasibility of coal seam ascending mining in order to prevent overlying rock and its deformation characteristic	Tianwei et al. (2015)
Markov model	1. To investigate the policy of the mine safety supervision system	Chen et al. (2015)
Weka v. 3–7-8 software (Waikato Environmental for Knowledge Analysis)	1. To develop suitable prevention policies to reduce injuries and fatalities.	Sanmiquel et al. (2015)
SIMPLIS and SPSS software	1. To study the correlation between employee security and mine accidents. 2. To provide a theoretical foundation for the research of security management.	Zhu et al. (2015)
Bayesian analysis model	1. To analyze the main cause of the Soma mine accident and predict potential similar accidents occurring in future	Spada & Burgherr (2016) Chen et al. (2019)
Fuzzy Analytical Hierarchy Process (FAHP)	1. To determine the safety level of an underground coal mine 2. To avoid methane explosions in an underground coal mine	Shi et al. (2017)
Fuzzy fault tree model	1. To analyze coal mining gas explosions, 2. To provide the basis for the precautions against and prevention of coal mining accidents	Shi et al. (2018)
Human factor analysis and classification system (HFACS) model	1. To identify and analyze the various degrees of workers' unsafe acts as root causes of mine accidents	Aliabadi et al. (2018)
Human factor analysis and classification system for China's mines (HFACS-CM) and analytic hierarchy process (AHP) model	1. To analyze the factors of mine accident quantitatively and qualitatively 2. To provide the basis for accident investigations	Liu et al. (2018a)
Rapid Mass Simulation Software (RAMMS)	1. To 1. To study the geological structure or soil movement	Find et al. (2018)
Bow tie model	1. To perform safety assessments 2. To examine the strategies of risk-management of the mine	Pons (2016) Xu & Xu (2018)
Systems-Theoretic Accident Model and Processes (STAMP) with CAST (Causal Analysis Systems Theory)	1. To connect multiple causes of mining accidents	Düzgün & Leveson (2018)
AMESim simulation analysis and the ABAQUS/Explicit simulation	1. To predict the occurrence of rock burst 2. To study the impact of rock burst	Wang & Zhang (2019)
FRAM, STAMP, and "2–4" model	2. To connect multiple causes of mining accidents	Qiao et al. (2019)
Confirmatory factor analysis (CFA) model	1. To test interconnection between the conceptual model and the survey data 2. To estimate the reliability scale	Li et al. (2019)
Monte Carlo method	1. To quantify the accident losses 2. To establish a risk assessment model by assessing the risk of different working types. 3. To provide a basis for effective control of unsafe behavior in gas explosion accidents	Tong et al. (2019)
24Model	1. To analyze causal factors of coal mine gas explosion accidents	Fu et al. (2019)
Deep Convolutional Neural Networks (DCNN) with Support Vector Machine (SVM)	1. To identify microseismic waveforms automatically for coal mines	Lin et al. (2019)

Table 7
Summary of challenges of post-mining accidents.

Category	Challenges
Mine owners	The challenges: i. To improve supervision systems of mining companies (Chen et al., 2015) ii. To participate in any mine accident investigation (Chen et al., 2015) iii. To ensure all safety flaws can be prevented and eliminated at regulatory land technical levels (Chen et al., 2015) iv. To prevent culture of corruption, which is a root cause of major coal mine accidents (Geng and Saleh, 2015) v. To ensure the management structure and policy are on the right track (Zhu et al., 2015) vi. To create a healthy relationship between managers and employees (Chen et al., 2016) vii. To change the attitude of coal miners from inactive to active mode, and to ensure unreported dangers can be minimized (Wang et al., 2016) viii. To enhance the risk management process and managerial integrity in handling underground coal mine accidents (Pons, 2016) ix. To change owners' mining practices and foster a safety culture in mining companies. (Pons, 2016) x. To ensure all staff and mine workers follow the safety culture in their normal daily practices at work (Düzgün & Leveson, 2018) xi. To increase safety commitment, ensure good communication with miners and colleagues (Li et al. (2019) xii. To provide sufficient safety equipment and improve safety behavior of miners and mine owners (Li et al. (2019) xiii. To provide a good working procedures and training programs to reduce the possibility of workplace accidents (Aliabadi et al., 2019) xiv. To ensure staff prevent any possibility of harmful or dangerous incidents, or exposure to heavy metals or toxic chemicals (Lyra, 2019)
Mine enterprise	i. Prioritize safety in mine operations (Geng and Saleh, 2015) ii. Improve internal security to reduce coal mine accidents (Zhu et al., 2015) iii. Promote the healthy development of productivity (Zhu et al., 2015) iv. Establish a safety culture to ensure each worker is involved in safety actions (Wang et al., 2018; Xu & Xu, 2018) v. Increase safety investments, such as provision of staff training (Wang et al., 2018) vi. Remove communication barriers. More information on safety can be disseminated through emails, memos, forums, work reports, and public speaking corners (Wang et al., 2018) vii. Strengthen safety education, such as training in survival skills on mine sites, especially underground coal mines (Wang et al., 2018) viii. Have a good operating plan to ensure safety awareness is applicable throughout all mining operations (Wang et al., 2018) ix. Enhance safety awareness among employees and top management (Wang et al., 2018) x. Establish the correct safety attitude by educating miners and workers (Sanmiquel et al., 2015; Wang et al., 2018) xi. Upgrade knowledge and skills related to safety in mine operations. Awards and appreciation can be given to excellent miners to motivate them in the safety context (Wang et al., 2018)
Government	i. To analyze the large database consisting of 70,000 occupational fatality and accident reports in the Spanish mining sector from 2003 to 2012 ii. To develop prevention policies to reduce the number of fatalities and injuries in the mining sector (Sanmiquel et al., 2015) iii. To overcome weak safety management and low value placed on safety issues among miners in the coal mine industry (Geng and Saleh, 2015; Wang et al., 2016b; Wang et al., 2016a)
Stakeholder engagement	i. To improve current polices, rules and regulations (Lyra, 2019 ii. To help mining owners deal with post-mining accidents in the Marikana platinum mining industry (Engelbrecht and Thomas, 2017)
Policy-makers	i. To construct policies related to the mining industry to ensure mining operations run smoothly (Düzgün & Leveson, 2018; Lyra 2019) ii. To establish clear policy, guidelines, and regulations for the coal mine industry in China (Liu et al., 2015) iii. To ensure safety is the top priority, since China is the global leader in coal mine production and coal consumption (Liu et al., 2015) iv. Policy-makers should pay attention to poor communities, countries with a weak natural resource governance, and communities with political dependence on the extractive industry Lyra (2019)
Community/ Villagers	i. The community is required to protect their rights, especially those of the victims and their families (Lyra, 2019) ii. Make communities and activists more aware of the consequences of the extractive industry on environmental, social and political issues. (Lyra, 2019)

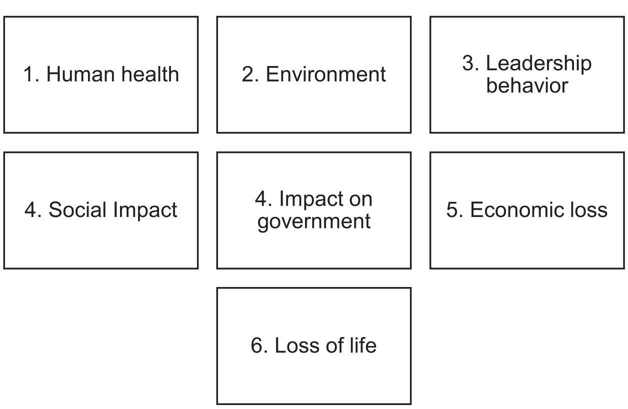

Fig. 4. Impacts of post-mining accidents, based on the SLR study.

arose from accidents in artisanal gold mining activities raised social concerns. This type of pollution can destroy ecosystems as well as damage the environment (Clarke, 2015). Furthermore, a mine tailing spill in Aznalcollar occurred in 1998, which was the largest environmental pollution accident recorded in Spanish history (Gil-Jiménez et al., 2017). It released 4 million m^3 of acidic water and 2 million m^3 of toxic mud containing high amounts of heavy metals and metalloids.

Table 8
Four different categories of coal mine accidents.

Category	**Categories of accidents**			
	Extraordinarily serious accidents	**Major accidents**	**Larger accidents**	**General accidents.**
Life loss	Death: >30 people Injury: >100 people	Death:10–30 people Injury: >100 people	Death: 3–10 people Injury: 10–50 people	Death: <3 people Injury: <10 people
Economic loss	>100 million yuan	50–100 million yuan	51–50 million yuan	<10 million yuan

Meanwhile, in Brazil, the collapse of the SAMARCO Fundão dam in Mariana, Minas Gerais, Brazil on November 5th, 2015 released more than 50 million cubic meters of ore tailings into the environment, representing the world's largest mining disaster. It caused 457.6 ha of riverside forest loss due to the flooding of the ore tailings. A total area of 1176.6 ha was affected by this accident (Dam et al., 2018). Furthermore, Francini-Filho et al. (2019) also reported on the effect of the Fundão dam collapse. A huge volume of mud spread along the river and reached the sea 17 days after the disaster, and destroyed the marine biodiversity along the river. Morisson et al. (2019) and Cordeiro et al. (2019) studied

Table 9
SLR results showing economic losses and lives lost due to post-mining accidents.

Economic loss	Type of mining accident	Date/ duration	Economic loss *(in yuan or USD)*	References
	Geological disaster - ground collapse in China	1950 s to 2017	4,04.1571 million yuan;	Zhu et al. (2018), Shao (2019)
	Coal mine accident in Xinyao, Shanxi	December 5, 2007	42.75 million yuan	Geng and Saleh (2015); Fu et al. (2019)
	Samarco dam collapsed in Brazil	November 5, 2015	~US$47.7 billion	Grande and Science (2017); Xiao et al. (2019)
Life loss/ injuries	**Type of mining accident**	**Date/ duration**	**Number of deaths**	**References**
	Geological disaster - ground collapse in China	1950s to 2017,	446 deaths	Zhu et al. (2018); Shao (2019)
	Methane explosion in underground coal mine in China	2000–2012	440 deaths and 451 injuries.	Shi et al. (2017)
	Coal mine accident in Muchonggou, Guizhou in China	September 26, 2000	159 death	Geng and Saleh (2015)
	The regional distribution of major coal mine accidents in China	2000 to 2016	7612 deaths in total (Based on 363 major accidents)	Liu et al. (2018)
	Mine accident in coal mine, Shandong Province	(2005–2010)	512 death	Zhang et al. (2016)
	Coal mine accident in Jixi, Heilongjiang, China	June 20, 2002	124 death	Geng and Saleh (2015)
	Coal mine accident in Daping, Henan, China	October 20, 2004	148 death	Geng and Saleh (2015)
	Coal mine accident in Chenjiashan, Shanxi China	November 28, 2004	166 death	Geng and Saleh (2015)
	Coal mine accident in Sunjiawan, Shanxi, China	February 14, 2005	214 death	Geng and Saleh (2015)
	Coal mine accident in Daxing, Guangdong, China	August 7, 2005	121 death	Geng and Saleh (2015)
	Coal mine accident in Dongfeng, Heilongjiang	November 27, 2005	171 death	Geng and Saleh (2015)
	Coal mine accident in Huayuan, Shandou, China	August 17, 2007	172 death	Geng and Saleh (2015)
	Coal mine accident in Xinyao, Shanxi	December 5, 2007	105 death and 18 persons were injured 108 death	Geng and Saleh (2015); Fu et al. (2019)
	Coal mine accident in Liuguantun, Hebei	December 7, 2005		Geng and Saleh (2015)
	Coal mine accident in Xinxing, Heilongjiang	November 21, 2009	104 death	Geng and Saleh (2015)
	Coal mines accidents in Shandong, China,	2010 to 2014	58 death	Zhu et al. (2018)
	Coal mine roof accident in Chongqing Province, China	December 18th, 2010,	2 deaths	Xiao et al. (2019)
	Methane gas explosion in coal mine in Guizhou Province, China	December 25, 2010	5 deaths	Xiao et al. (2019)
	Flooding accident occurred in Dashunfa coal mine, China	December 13th, 2010	2 deaths	Xiao et al. (2019)
	Soma Mine accident/coal in Turkey	May 13, 2014	301 fatalities and more than 80 injuries	Spada et al. (2016)
	Samarco dam collapsed in Brazil	November 5, 2015	20 death	Grande and Science (2017); Xiao et al. (2019)
	Explosion killed 28 miners in a Spanish coal mine, Spain	NA	28 deaths	Sanmiquel-Pera et al. (2019)

the iron mining tailing deposits that spilled out from the failed Fundão dam.

Moreover, a serious social impact occurred when the large mine tailing dam owned by the Samarco Corporation collapsed in Brazil, generating a massive wave of toxic mud that spread down the Doce River, killing 20 people and affecting the biodiversity across hundreds of kilometers of river, riparian lands, and the Atlantic coast. The disaster had serious human and socioeconomic tolls. Unfortunately, there are no clear environmental bond policies in Brazil, which could have severe social and environmental consequences, underscoring the need for effective disaster-management strategies for large-scale mining operations (Grande & Science, 2017). News coverage of mining accidents or mining disasters has a significant influence on society. Research was conducted by Zhu et al. (2018) on 222 coal mining disasters in China between 2004 and 2012. They found several impacts of mining disaster news items on society, such as:

i. The creation of panic among the public; mine disaster news always carries threats to the social value system
ii. News involving mine accidents will overshadow other daily news items
iii. The repetition of news coverage of mining accident issues tends to demotivate the public to listen to and read the news
iv. Over-excessive media coverage on the severest disasters, compared to those that are less severe, may lead to bias among the public

Furthermore, Lyra (2019) studied the impact of the collapsed Fundão tailings dam on Brazilian society. The main conclusion was that society and activists were more aware of the consequences of mining accidents on the environment, social life and politics (including regulators and the authorities). The impact of this accident was clear, especially to the government, because there are no clear environmental bond policies in Brazil (Grande and Science, 2017). In addition, the issues caused by the Fundão dam disaster in Brazil gave the government a negative reputation. When the accident occurred, there was a failure to protect the local community, while the negative impact was that the victims' families lost belief in the Brazilian government's capacity to manage this accident (Lyra, 2019). According to Geng and Saleh (2015), coal mine accidents in China have opened new avenues for the government to encourage the coal mining industry to self-regulate mining operations, since the industry had successfully informed the government that it had the maturity to deal competently with its own risks. Furthermore, economic loss and loss of life were also major impacts of mining disasters or accidents. According to Xiao et al. (2019), there are four different categories of coal mine accidents, as shown in Table 8. Meanwhile, Table 9 shows the SLR results involving the economic loss and lives lost due to post-mining accidents in China, Brazil, Turkey, Spain and South Africa.

5. Future directions and recommendations

This study has bridged the gaps in understanding of research trends in mining accident issues. Domains and variables derived from the findings of this study could contribute new knowledge for future scholarly work. This type of review could overcome the crucial issue of the global lack of studies by replicating the same process, specifically in other mining accident contexts, and other topic areas generally. This systematic review study would ideally assist mine owners in providing a better understanding of, and emphasis on, the issues related to mine accidents. The study is also addressed to relevant miners, governments and policymakers in reducing mining accidents in the future. This review offers several recommendations for future studies. Firstly, utilizing various databases could widen the search of relevant articles and support the research objectives. The possible databases include the Web of Science, Emerald, and many more. Secondly, there is a need to conduct more in-depth qualitative studies on the main causes, prevention, challenges and impacts of post-mining accidents. Particular focus should be on other countries, such as ASEAN members like Malaysia, Indonesia, Thailand, and Vietnam, because the mining industry is an economic contributor to each of these countries. Finally, it is suggested that research is conducted on the roles of government and policy in reducing the number of mining disasters.

6. Conclusion

The SLR examined research trends in mining accidents issues between 2015 and 2019 and successfully developed four main themes. These consist of the main causes of accidents (46%), and the prevention (20%), challenges (17%) and impacts of post-mining accidents (17%). The study produced thirty-five subthemes by systematically reviewing 57 selected articles from the ScienceDirect and Scopus databases using the PRISMA approach. The SLR concluded that the main cause of mining accidents was mechanical failure, while the most promising method of preventing this issue is utilizing software or safety models to predict the potential hazards or risks of accidents. Mine owners are presented with major challenges and responsibilities to provide a safe working environment for all mine workers, thus minimizing the potential for mining accidents. Moreover, the impact of post-mining accidents leads to adverse environmental impacts.

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