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Research paper

Factors management for workplace safety compliance in fossil power generation: comparison between assessed worldwide and Moroccan fossil fuel power plants

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Abstract

Majority of workplace incidents are attributed to unsafe behavior. Despite all the implemented control measures, accidents still reoccur in the energy industry. Thus, the primary objective of this study is to identify the influencing factors on the employees' behavioral safety compliance in Moroccan and worldwide Fossil Power Generation. The study analyses safety behavior and highlights the change trend by identifying the influencing factors on workers Safety-Related Behavior (S-RB). Therefore, the data were collected through the survey questionnaires of a five-point Likert scale, which have been dealing out to safety practitioners of sixteen Fossil Fuel Power Plants (FFPPs) that are located across nine countries. The inter-items consistency and reliability were measured by using Statistical Package for the Social Sciences (SPSS version 20) software. Besides, countermeasures were part of the survey. The study illustrates that the job factors are the most influencing of all other analyzed factors on workplace safety performance through their direct effects on workers S-RB, particularly the Workload which was revealed as the major affecting factor on S-RB in all the assessed 16 power plants (PPs). Furthermore, Worker Cooperation/Involvement and Training were found as the most common selected countermeasures in both conducted analyses (Worldwide and Moroccan PPs) in order to tackle effectively the identified influencing factors and reduce PPs accidents and critical safety behavior that contributes to injuries and losses.

Keywords: *Countermeasures; Fossil Fuel Power Plants; Influencing Factors; Safety-Related Behavior.*

1. Introduction

The power generation service plays an indispensable role in driving the world economy as it presents one of the key lifeline-functions upon which all the other crucial infrastructure sectors count, whilst the energy sector is one of the most suffered sectors from the adverse events at the workplace [1] [2]. Oil/Oil products and Natural Gas come as the first two main chemicals involved in accidents and incidents [1], some other studies have disclosed that fatality rate is lower for natural gas than oil [3] [1]. Therefore, the Fossil Fuel Industry (FFI) has been recognized as one of the main contributors to man-made disasters. However, people in favor of rapid industrialization have not always been aware of the price to pay in terms of human suffering and environmental degradation. This can be attributed to:

- The fact that oil, coal, and natural gas exploration or exploitation industry has a complex structure, particularly in the operating system such as the PPs and the highly evolving hazardous working environment. In particular, the industries in developing countries are extremely suffering from a high percentage of occupational work-related incidents [4]. The complex structure of industry makes it difficult to accurately assess and measure the safety performance and reliability posture of the sector as emphasized previously [5] [6].
- The risk of human failure which has a significant impact on H&S in the workplace. Since the workers sometimes do not behave as they are supposed to all the time in the workplace, they break rules and working procedures deliberately and are subject to Human Error (HE).
- the failure of the international standards which do not focus on the "Human Factors" in the working environment when developing and implementing the desired process and procedures [7].

As result, the implemented H&S standards will be influenced by workers behavior. In other words, H&S management is the way that workers behave. This means that the disregard of workers S-RB will lead to increasing behavioral safety non-compliance with OSH (Occupational Safety and Health) requirements [8] [9]. Wherefore, the number and severity of work accidents which occur all over the world, particularly in the energy sector will remain highly startling in terms of human and property losses [1] [10]. This corroborates that a good S-RB really does contribute to accident reduction [11] [9] [12] and benefits both in cost and time saving [13] [14], for accidents are costly in terms of losses and time consuming while dealing with the investigation [13 - 16].

Many researches corroborate that over than half of work accidents refer to the poor S-RB of workers. A study revealed that human behavior is the cause of all directly or indirectly occurred incidents [17]. According to Heinrich on the foundation of 75,000 of industrial accidents, 88% of workplace accidents were caused by human unsafe acts [18]. Likewise, another earlier study, which was carried out in 2007 [19], has confirmed that 80% of all industrial accidents are assigned to the similar cause. When it comes to the energy sector in the mining industry, Liu has also emphasized that employees unsafe behavior presents 97.67% among the direct

causes of generated fatal accidents as well [20]. Besides, human reliability is contributing to major accidents since it has been identified as the most important antecedents of many reported OSH occurrences [21].
Meanwhile, it is quite hard to change human behavior overnight to meet all safety requirements of workers with limited skills who are more likely to be involved in an incident [22]. Many researchers have attempted to tackle the issue of occupational accidents where there is a good understanding of the trends and patterns of the occurred accidents in the FFI; however, there are only limited studies on the behavioral safety analysis (Behavior-Based Safety [18]), notably in FFI worldwide experience involving developed and developing countries. In Morocco, no similar study has been carried out to analyze workers behavior in this particular sector, whilst the country has the highest fatal industrial accident rate in the region of the Middle Eastern Crescent [23]. Furthermore, Morocco is coming on new FFPPs that will remarkably go up to be the vast dominant energy supply (48%) by 2030 [24] which will afterwards involve the Moroccan worker in such new hazardous working environment of FFI where accidents of the workers can be fatal and costly [1] [2] [25].
Therefore, the process of comparing assessment results of safety performance-shaping factors is known as benchmarking process between the worldwide and local assessment which will clearly demonstrate adequate countermeasures that may pave the way for enhancing H&S performance in the existing and the future energy power generation. Safety issue cannot be effectively tackled without determining the patterns of behavior which are considered as paramount criteria needed to alter workers behaviors. Hence, they are substantial for understanding the Human Factors (HFs) and their relationship with occupational accidents and safety compliance by examining how HFs influence working practices of the workers in the worldwide and Moroccan FFPPs. This can be achieved by a questionnaire survey to define the factors that influence the workers behavioral safety compliance and simultaneously those which contribute to improve quality and safety environment in the workplace of FFPPs. Hence, it may be possible to:

- Comprehend why workers behave unsafely in the workplace;
- Rectify the unsafe act when it is identified by removing the cause of that behavior;
- Foresee poor behavior in advance before it takes place and tackles it by introducing the necessary changes to minimize the likelihood of it occurring;
- Improve the quality and safety environment in the workplace of the power plants.

2. Literature review

2.1. Safety-related behaviour

Safety behavior describes the behavior that supports safety practices and activities such as safety compliance in the workplace, safety leadership, safety communication, safety awareness, worker safety involvement and consultation. Behavior is determined by motivation, competence and attitude [14] [26], but it is determined more by motivation because in normal work situations, the prerequisite competence and attitude needed will be usually present as an outcome of training, experience and safety climate of the organization. However, motivation is the incentive at work which can be provided by the safety culture of the organization, group norm, management commitment and leadership, worker consultation and involvement, bonus, and so on. If the worker does not have enough motivation to do a task safely or to participate in safety activities, then she or he will not choose to carry out these safety actions in day to day business [26] [27].

2.2. Safety-related behaviour and their relationship with safety compliance and work accidents

Good H&S practice often relies on the safety behavior of the workers who sometimes do not behave safely as they are supposed to all the time. H&S standards are re-affected by workers behavior [14];therefore, the presence of good S-RB does reflect good safety compliance in the workplace [26] [28]. Subsequently, the workers S-RB is the key element to reducing the workplace injuries since it indirectly affects the outcomes of the adverse event before it occurs [28] [29].

2.3. Human factors

The HFs refer to a range of issues in form of a chain of causes in which the individual psychological factors (that is, momentary inattention, forgetting, etc) are the last and least manageable links [30]. Human Factors may be simply divided into three basic taxonomies: the job, organisational factors and the individual characteristics.

2.4. Human factors and their relationship with safety-related behaviour and work accident

The HFs can affect workers S-RB at work in a way that can influence H&S [17] through affecting the effectiveness of human performance and human reliability. This effect reduces the likelihood of the success of performing a task safely whilst it increases the likelihood of HEs [31] (Figure 1). If the error risk management does not take place prior as prevention or post the error as mitigation, the error will certainly lead or contribute to an occupational work accident. Meanwhile, whether the HFs positively influence the human reliability by identifying error-likely situations and avoiding them, this will result in the reduction of recurrent HEs and ensure that they are detected in advance prior the system suffers from an adverse event. Thereby, safety compliance can be achieved and the workers demonstrate the desired performance in the workstation which leads to accident reduction [21] [32]. The predestined contribution of HE to work accidents in hazardous technologies as used in the PPs structure increased fourfold between the 1960s and '90s, from 20% to 90% as the previous study disclosed [30]. Nevertheless, the risks to modern technological systems can be controlled.

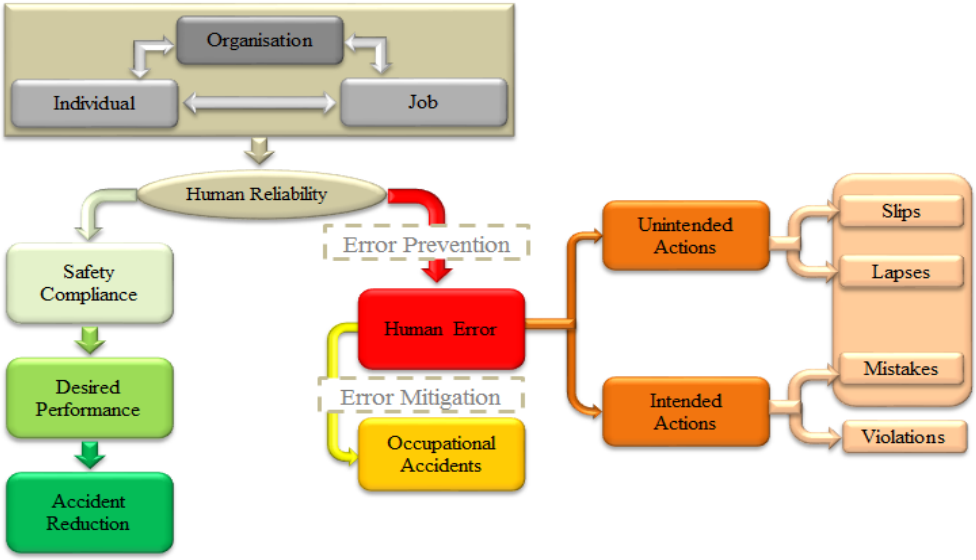

Fig. 1: Diagram of Human Factors with Error Control.

Human Error is a failure of a planned action to fulfil the desired performance [32] and it is divided into two main categories; intended and unintended actions (Figure 1) which both eventually influence a person's S-RB in the workstation [33][31]. In some habitual tasks which can be performed with less conscious attention, slips and lapses can happen. These tasks are very vulnerable to errors if the attention is deviated, even instantly, that is why they are called 'skill-based errors'. Intended actions can produce both violations when the worker is intentionally deviating from a procedure or legal requirement, and mistakes when the worker does the wrong thing believing it the right way to do it. It is noteworthy that the preservation of a good safety compliance in the workstations might be based on the extent of HFs management which is considered as one of the critical barriers [14].

2.5. Behavioural safety compliance factors

2.5.1. Individual factors

Employees bring to their job personal attitudes, motivations, skills, habits and personality which can be strengths or weaknesses according to the task demands. Individual characteristics may positively or negatively influence the worker's behavior in complex and significant ways; hence, it will affect the workplace safety [20] [14] [30] as well as the quality of task performance [32]. Some of these characteristics cannot be changed, but others can. It is needful to identify where changes to these characteristics might be necessary. Some characteristics such as personality are fixed and cannot be changed. Others, such as skills and attitudes, may be altered and improved over time [31] [14]. The individual characteristics were generally confirmed as the causes of unsafe behaviors and accidents in the workstation [33 - 35].

2.5.2. Job factors

Various features of workers job affect their S-RB in the workplace, such as tasks which should be designed pursuant to ergonomic requirements taking into account limitations and strengths in human performance. Assigning the job to workers may first ensure that they are not overloaded such as the amount of work, the rate of work, deadlines and variety of work; however, it should additionally be in accordance with the workers capabilities, but in the meantime effectively contribute to the business results. Any discrepancy between job requirements and workers capabilities increases the chance for HEs. In addition to that, if the design of displays at the workplace, the workplace conditions of that work (lighting, temperature…) and the work procedures are not properly controlled and managed; workers will find the most comfortable way to perform their work; yet, it cannot be the safest way [14]. Thereby, these job factors can affect workers health [36] [37], human performance [31], and workplace safety [12] [38], particularly when they reduce or increase the likelihood of HEs [32]. Therefore, accidents will easily occur [10] [39] [40] [41] [42] [31] [25].

2.5.3. Organizational factors

Organizational factors (Figure 3) have the biggest influence on individual and group behavior [30] [33] [41] [40], through affecting safety culture of the organisation, which lead to HEs or violation [30], which influences both the safety performance in the workplace [12] [43] [44], and accident rate within the organization [12] [45] [28] [31] [33] [46] [34].Yet, they are often disregarded during the investigation of accidents and incidents. Organisations need to establish their own positive H&S culture in order to promote the involvement and commitment of all employees and management [31]. Thereby, H&S should receive high priority than other business issues by emphasising that deviation from established H&S procedures is unacceptable. For example, if the management commitment gives priority to safety during routine management meetings, it will significantly be predictive of lower incident rates [41].

3. Materials and methods

3.1. Identification of survey items with related hypotheses

In order to analyses and measure workers safety behavior; a list of factors that affect the workers S-RB in the workplace has been established to highlight change trend by identifying the influencing factors on workers S-RB in a sampling of worldwide and local FFPPs. The final list of assessment factors (Figure 3) was later embedded into a questionnaire to collect opportunities for improvements which were self-assessed by each individual plant with remote follow-up.

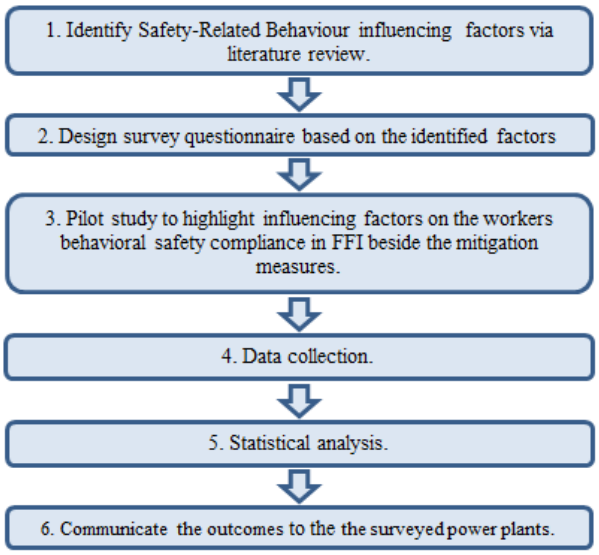

Fig. 2: Flowchart of Methodology.

Factors that have an impact on S-RB for FFPPs (Figure 2) were identified from the guidelines of HFs in OSH [31] [14] [41] [32] [21] as well as from the relevant articles [17] [47] [33] [43] [48] [9] [49]. The factors were selected based on their relevance to FFPPs, processes and work environment classified as antecedents of safety performance.

Afterwards, Cronbach's alpha was used to measure inter-items consistency and reliability, to determine how closely related a set of items are as a group. It ranges from 0 to 1; therefore, the value of the Coefficient: ≥0.9 indicates excellent inter-items consistency, ≥0.8 indicates good consistency, ≥0.7 indicates acceptable consistency, ≥0.6 reflects doubtful, and ≥0.5 indicates poor and inadmissible consistency [50]. In this study, Cronbach's alpha yielded 0.873 which is good and inter-items consistent.

Table 1: Reliability Statistics – Retention Variables

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
0,873	0,878	26

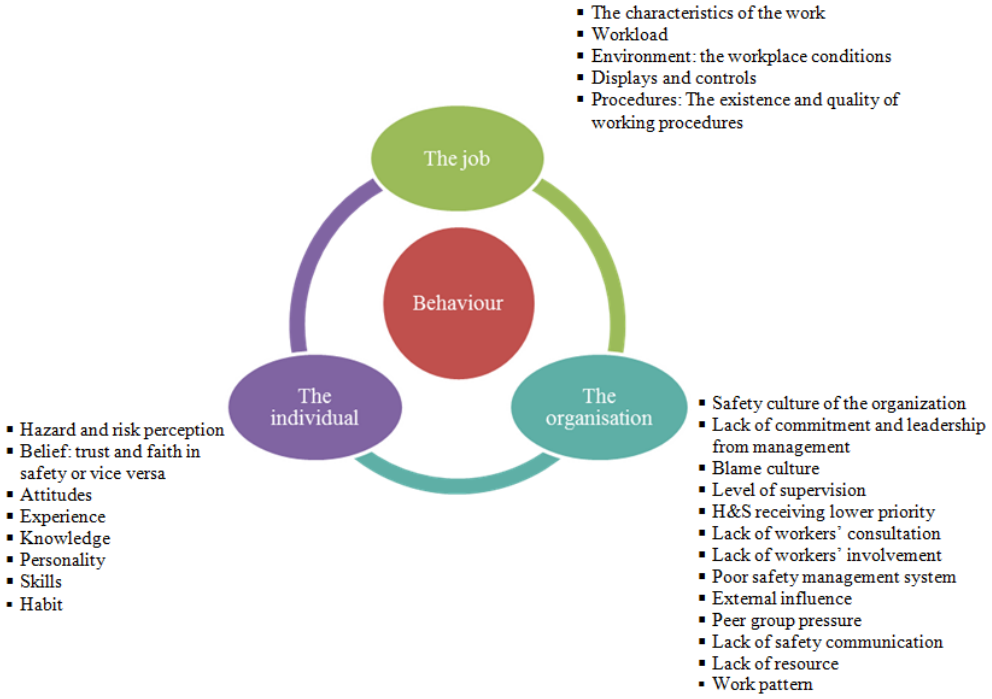

Fig. 3: Factors Affecting Workers Safety-Related Behavior in the Workplace.

Table 2: Proposal of Hypotheses for Testing

N°	Hypotheses
H1	Job factors are the most influential on the workers S-RB.
H2	There are significant relationships between workload and workers S-RB.
H3	There are significant relationships between attitudes and workers S-RB.
H4	There are significant relationships between safety management system/procedures and workers S-RB.
H5	There are significant relationships between safety culture and workers S-RB.
H6	There are significant relationships between Workers Cooperation/Involvement and the workers S-RB.
H7	Training is a vital tool to improve workers S-RB.
H8	Competency has significant relationships with workers S-RB.

3.2. Pilot study

After the identification of the survey items (Figure 3) from literature review, they were validated and improved first with the involvement of in-country industrial EHS experts and second during introducing the questionnaire in the online meeting with the EHS practitioners and managers. During the meeting, the participants provided their feedback on the assessment factors and converged aspects which were subsequently combined and rectified. In this study, the discussion will focus on the three first influencing factors for each assessment area (National and International behavior safety analysis).

3.3. Population study

In order to benchmark the assessment results of the international outcomes with a focused local country (Morocco) in terms of safety performance-shaping factors, the assessment was conducted in 16 FFPPs distributed over 9 countries (Morocco, Algeria, Egypt,

Iraq, Iran, France, United Kingdom, Taiwan, Philippines). Nine PPs were assessed across the world and 7 PPs in Morocco. The enquiry among the EHS practitioners of the assessed PPs has identified various root and underlying causes of the potential mishaps - each having different origins and requiring different countermeasures which are the finality of the current study. Besides, the process of benchmarking will clearly identify the patterns of selected countermeasures among the PPs to effectively tackle the relevant affecting factors by the adequate measures in order to enhance H&S performance. This focused achievement has been promoted by the reliability and accuracy of the obtained outcomes across all the assessed 16 PPs that have the same ultimate goal, which is the power generation to respond to the countries' needs.

3.4. Rollout and collection of data from 16 ffpps distributed in nine countries

The rollout of the questionnaire survey has been carried out as follows:

- For worldwide PPs, a presentation was carried out to introduce the questionnaire and provide the necessary explanation of the meanings and aims of each factor to all EHS practitioners via an online meeting. Afterwards, the same method was used to present and interpret the final outcomes.
- For in-country PPs, various means (telephone, emails, and direct contacts) were used to communicate and explain the enquiry individually for each PP. Afterwards, the same method was used to present and interpret the final outcomes.

3.5. Survey design

In order to achieve clarity and legibility of the outcomes, the questionnaire contained four sections. The first section assessed 8 factors related to the individual and their personal characteristics. The second section assessed 5 factors related to the job; the task that the workers carry out. The third section assessed 13 factors related to the organisation and their characteristics that the employees are working for. The fourth section had 10 improvement suggestions for S-RB that can be adopted in each PP. A total of 26 factors embedded into 3 main categories (Individual, Job and Organisational Factors), were evaluated in the questionnaire in addition to 10 proposals of countermeasures for improvement. In the questionnaire survey, the five-point Likert Scale as stated by Likert in 1932 [51] was used for each influencing factor, which gives the possibility to the assessors to show the extents of their consent and endorsement with the given statement. In this study, the scale values from one for "strongly disagree" to five for "strongly agree".

4. Results and discussions

4.1. Assessment of affecting factors of workers safety-related behaviour

The radar graph underneath clearly shows that Morocco, Egypt and Philippines have close rating number for all the job, individual and organisational factors, compared with the rest of the assessed countries, whose rating values of the influencing factors on workers S-RB distinguished by noticeable differences value between one group factor to another. As a result of this assessment, it is also supposed that the fatality accident rate of these three countries should almost be similar as well, for the value of contributing factors which can lead to an accident are near to each other. This was substantiated in previous research [23] when global estimates of occupational accidents revealed that both Morocco (47.8) and Egypt (24) have the highest fatality rate compared with other countries in the region of Middle Eastern Crescent. Besides, it was corroborated that Egypt (24) and Philippines (20) have a near fatality rate as revealed by global estimates of occupational accidents [23]. It is quite obvious that the rating values between assessed countries are different due to the fact that each society has a different culture, beliefs, practices, etc. This may affect safety performance within the plants [52]. Job factors have a massive impact on the workers S-RB; it can be clearly seen through the radar graph (Figure 4) that the job factors are dominating the other assessed factors for all the countries except Iran and Philippines. As hypothesis H1 emphasises that the job factors are more affecting workers S-RB than the other factors; it can be said that job factors influence human reliability in a way that will increase the probability that a person may do their task ineffectively leading to a potential error. The workers unreliable behavior may result in human error producing adverse events [31] [21]. This can happen when the job requirements get more hard and complicated in the workplace, particularly in such a hazardous working environment, where workers show a low contribution to H&S [53].

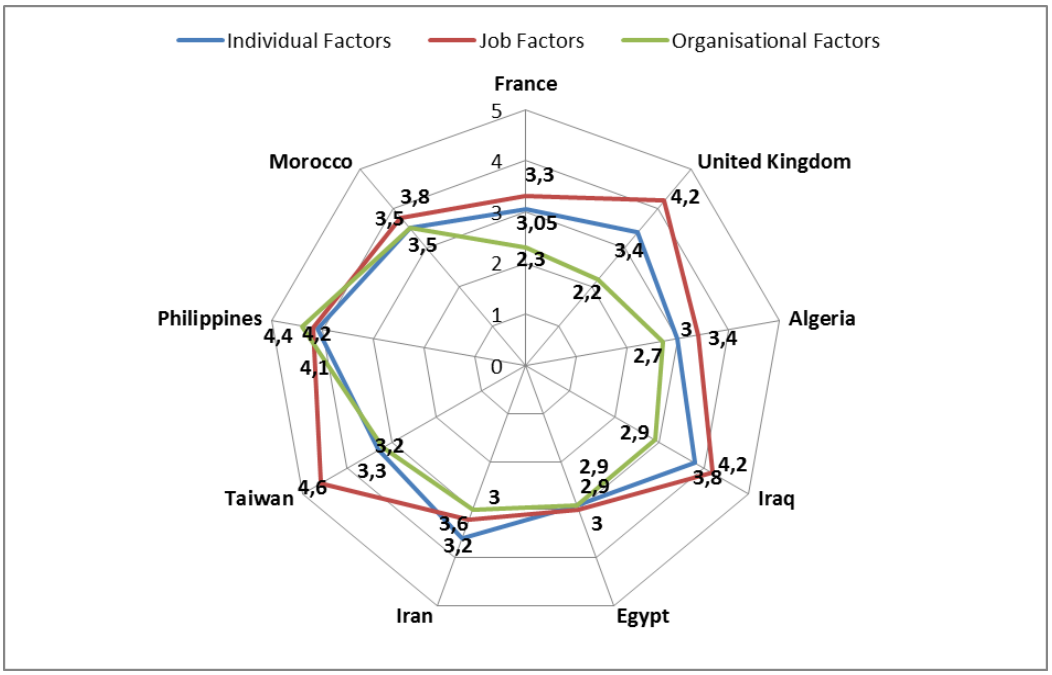

Fig. 4: Assessment of Factors Which Influence Workers Safety Behavior in 16 Power Plants Distributed Across 9 Countries.

4.1.1. Assessment of affecting factors on workers safety-related behavior in worldwide power plants

From the line graph in figure 5, we can observe the extent of how the workers safety behavior can be influenced by the impact of each factor in this assessed area. As expected, the study emphasises the hypothesis H2 that the workload is the most affecting factor on workers safety behavior in the assessed worldwide PPs, thereby substantiating that the workload has a significant relationship with workers safety behavior since it contributes to the commission of HEs and situational violations in the workplace. This outcome, as corroborated in the previous findings [30] [31], discloses that the workload affects human reliability. This can happen when the manpower decreases, resulting in rise of the workload which produces fatigue and burnout, including work-related stress, health depression and worker anxiety. Thus, this behavior influencing factor has continued affecting workers S-RB, making of it the main root cause of many occurred accidents [54 - 56].

Moreover, the behavior safety analysis has also strengthened our hypothesis H3 as the line graph in figure 5 shows that attitudes and procedures come as the second most influential factors on workers safety behavior in all sixteen assessed PPs. Yet, attitudes to safety at the workplace could be constrained by the procedures, regulations and rules that the system has in place [56]. This result substantiates the previous finding, considering workers attitude the most important contributing factor to unsafe acts, accidents, and injuries [29]. We believe that this is an inevitable outcome since there is a strong link between attitudes and behavior in a way that employees' behavior can be influenced by attitude [57] [25]. It is worthwhile to note that procedures deemed out-of-date have little worth to workers and become a dangerous tool if they are implemented in the workplace [41] as well as in certain circumstances such as inaccurate and confusing procedures instructions which increase error likelihood [31], resulting in a high number of incidents, especially in high-risk workplaces [41]. This finding has been further strengthened by earlier studies which revealed that the most substantial underlying causes of many past catastrophic events [39 - 42] [31] [25] were the lack of or inadequacy of operating procedures, inadequate use or misuse of procedures.

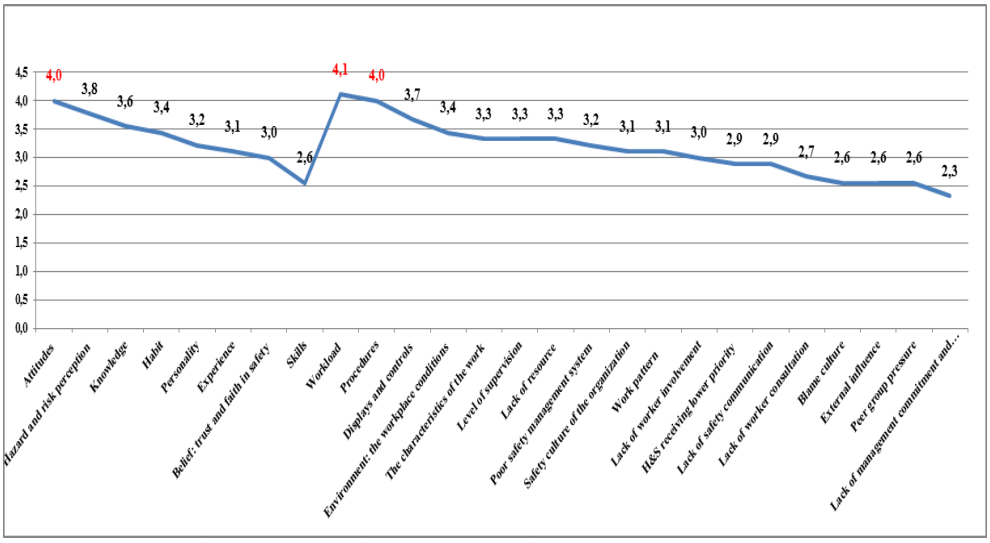

Fig. 5: Assessment of Factors Which Influence Workers Safety Behavior in 9 Power Plants Across 8 Countries.

4.1.2. Assessment of affecting factors on workers safety related behavior in Moroccan power plants

The conducted survey questionnaire across 7 Moroccan power plants has interestingly validated that workload is again the most affecting factor of the Moroccan workers safety behavior. The line graph in figure 6 clearly illustrates that this factor is the common outcome in both carried assessments. This work has proved that the rate of work, the amount of work, deadlines and variety of work that workers have to cope with in the energy sector is significantly affecting the safety performance in the workplace through workers S-RB, and this can lead to serious adverse events [54 - 56].

By returning to the hypothesis H4 posed at the beginning of this study, it is possible to state that the poor safety management system is sharply influencing workers behavior with a similar impact rate of the workload, as displayed in the graph (figure 6). Safety management systems have succeeded in attenuating H&S risks and reducing the number of incidents within the plants [58] through improving the ability of employees to identify the risks they face in day-to-day business, and to properly evaluate, communicate, address and mitigate them. However, in the absence of management guidance and/or enforcement, workers may themselves opt for work shortcuts and get involved in unsafe work practices [52] which impact the workplace safety compliance through affecting the workers S-RB. Wherefore, failure of the safety management system and procedures was clearly the root and underlying causes of many past incidents [39][40]. As this study highlights, Moroccan PPs suffer more from the failure of the safety management system and procedures than other assessed worldwide PPs; and this may be attributed to:

- The implemented risk assessment procedure is the same as in developing countries since the majority of the PPs are multinational companies. Yet, not every safety program or procedure implemented in developed countries can be easy as well to implement it in developing countries such as Morocco. Each country has different hindrances such as culture, beliefs, and practices [52]; hence, a verification of all the potential obstacles is an indispensable step before rolling out any new process so that the proposed safety and modifications will be fruitful and not just an extra pile of paperwork [22]. This means the risk assessment procedure should not necessarily be the same for the same plant in a different location [22].
- The HFs are not fully considered during risks assessment and risks management [22].
- The procedures are not practical and easy to implement [22].
- Moroccan energy industry has a limited experience in H&S management system, this can be observed by the high rate of occurred industrial accidents [23] [59] [60] [58].

These results confirm the hypothesis H5 and support the previous finding [61]; as demonstrated in the line graph below (Figure 6). Safety Culture in the PPs also plays a crucial influencing factor on safety performance in the workplace through their direct effects on the workforce's S-RB in Moroccan PPs. To maintain a safe behavior in the workstations is highly reliant on safety culture. Hence, safety culture is considered one of the most critical factors which should be built in an organisation for accidents prevention as emphasized in earlier studies [62][57]. Because in the analysis of many accidents, it was revealed that safety culture is one of the root causes [42]. This result can be attributed to:

- lack of the leadership which is the key to developing a positive safety culture [63].
- lack or no safety culture in developing countries as substantiated in the previous research [64].

The power plants management should promote the employee's involvement and commitment at all levels from the top level to the shop floor, emphasising that any deviation from the established H&S standards is unacceptable. Thus, the employee's safety behavior can change through reciprocal interaction between organisation and employees [65].

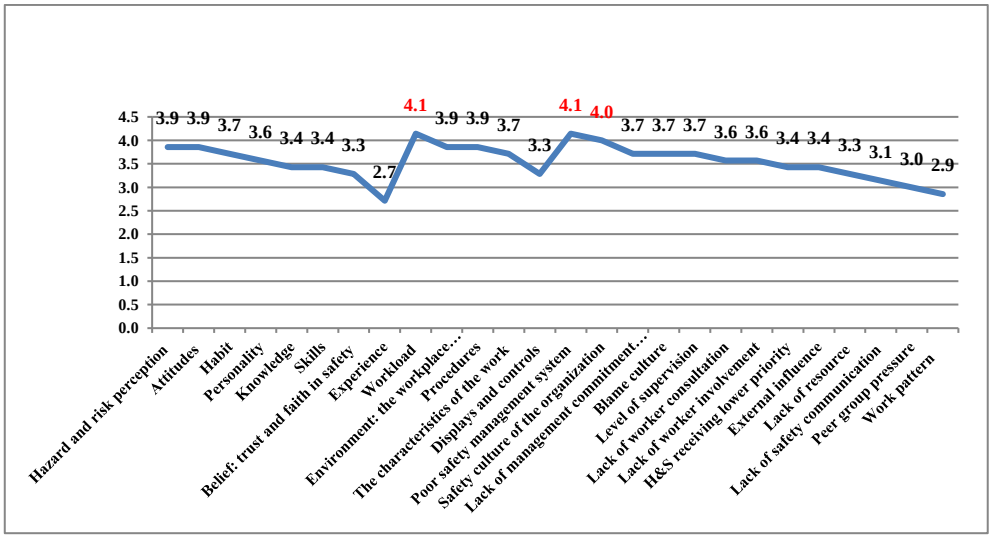

Fig. 6: Assessment of Factors which Influence Workers Safety Behavior in Moroccan Power Plants.

4.2. Adequacy of the assessed countermeasures against the identified safety-related behaviour affecting factors

All the assessed countermeasures are meant to enhance the workers S-RB only by different impact rate of each assessed measure which itself mainly relies on the nature of the activity of particular sectors of industry where the study takes places, and the relevant highlighted problem. As part of the questionnaire survey, each plant representative, therefore, defines the appropriate countermeasures which are seen in their point of view as key features to improve the workers S-RB in their plants. Our study aimed to identify the trends for each assessment area (National and International Assessment) in order to overcome the highlighted issue in this particular sector of activity.

From the radar graph in figure 7, it is crystal clear that the BBS program is the most striking measure that has an important influence on the 9 assessed worldwide PPs. This result confirms that BBS is the most adequate countermeasure to tackle safety noncompliances by changing unsafe behavior to safe behavior of the workers in order to eliminate or reduce the occurring of industrial accidents in the workstations as corroborated in the various earlier studies [18] [66] [67] [68] [47].

By returning to the hypothesis H8, it is possible to state that Competency is the key characteristic of workers personality that influences their S-RB [14]. The line graph in figure 8 shows that competence was selected among the first three countermeasures to improve workers S-RB in Moroccan PPs. It may be assumed that the energy sector in Morocco is experiencing a phase of rapid changes to reduce its energy bill and its dependence on energy from abroad [69]. Hence, a new progressing sector of activity, staff competency may be present as a hindrance for safety compliance in the workplace, especially at the start-up phase of the power plant; that is why employees should be trained in order to improve their work skills as well as their risk perception. In the conducted international assessment (Figure 7), staff competency was given less importance in Likert Scale compared with the national assessment (Figure 8), which corroborates that the majority of the evaluated worldwide PPs have sufficient skills and competencies to run their PPs with an acceptable risk level. Competency is indispensable in such hazardous industrial sector because it brings a person to a level where they are able to perform to an acceptable standard and they are conscious of their own limitations [14]. The more competent the worker is, the better able they will be to do their job safely. Thereby, all employees need to be competent to carry out their designated roles safely while conforming to a certain standard, which may mean training and maintaining awareness, for competences can fade over time through lack of practice. Likewise, training and refreshing training is essential for maintaining a good level of workers competency and skills to forestall potential HEs, system malfunctions and prevent repeated errors [70] before escalating into operating emergencies. In the absence of competence, hazards and risks may be missed and not addressed, thereby accidents may happen [70] [71] [46] as the involved people cannot learn from the occurred accident if their competences are limited [16].

The majority of those surveyed worldwide and Moroccan PPs has underscored that Training is one of the first three selected effective measures that can enhance workers S-RB in order to alter unsafe behavior to safe behavior because training has a dramatic effect on person's S-RB. As hypothesized in H7 and confirmed in previous findings in various studies [12] [30] [18] [28] [56] [45], a formal training, learning, preparedness and awareness can produce substantial improvements in human performance and workers behavior towards H&S compliance while reducing safety-critical errors. Behavior is a reflection of acquired competence and knowledge from trainings, and it can be unintentional or intentional [25]. Therefore, training is considered as one of the communication tools to convey EHS requirements for accident prevention [72] since poor communication was revealed as an underlying and immediate cause of many previous accidents [40] [39] [31]. Without training, workers try to do their jobs to the best of their ability, but they do so either by informally copying others (including copying all the bad habits and unsafe working practices that they see) or by doing the job the way that they think is the best.

Moreover, the results of both assessments illustrate that Worker Cooperation and Involvement was highlighted as one of the first three efficient countermeasures to tackle the affecting factors of workers S-RB (Figures 7 & 8). This outcome substantiates the hypothesis H6 and shows the consistency not only in the conducted surveyed PPs, but in the previous surveys as well [53] [73], for it proved that attitudes on H&S had decreased due to poor safety contribution of workers. Defining unsafe behavior can sometimes be done by the employees themselves who are the best persons in the workplace, cognizant of their work shortcuts and pitfalls. Therefore, this can be achieved by motivating employees through engagement in the safety-related activities [12], which is an essential part of any successful program for identifying, eliminating error-likely situations and reducing the tendency to engage in unsafe behavior [32] [74]. It can be said that the Involvement of the workers is recognized as a fundamental aspect of maintaining high standards of H&S in the workplace as well as a key component to effective OSH management systems [70] [52].

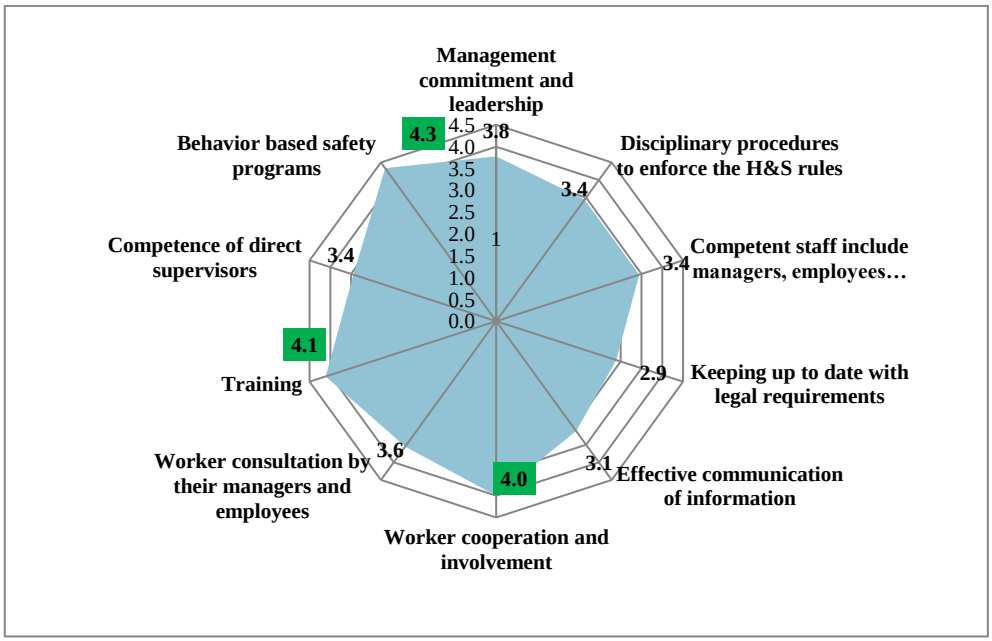

Fig. 7: Countermeasures Rated by Worldwide Power Plants Representatives.

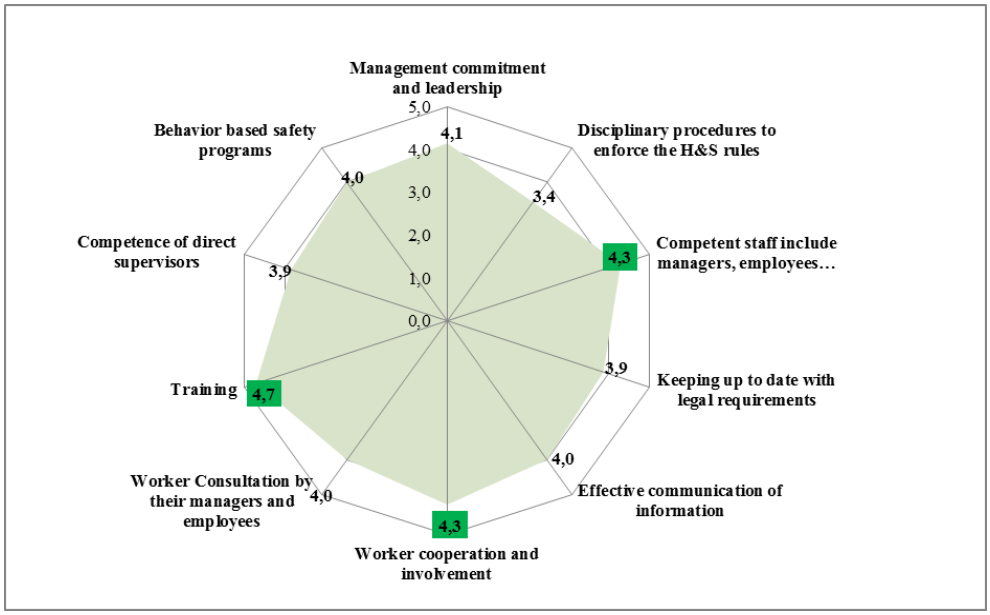

Fig. 8: Countermeasures Rated by Moroccan Power Plants Representatives.

This is the advantage of benchmarking similar sector of activity in various parts of the world. The highlighted common patterns can be explained through the study under scrutiny conducted on one type of industry, whereas the rest of disparity of influencing factors and countermeasures between both the worldwide and Moroccan behavior-based safety analysis, which may be ascribed to different cultures, habits, and beliefs from one country to another. Besides, all the proposed hypotheses of this study are accepted as shown in the table below.

Table 3: Summary of the Tested Hypotheses

Hypothesis N°	Finding
H1	Accepted
H2	Accepted
H3	Accepted
H4	Accepted
H5	Accepted
H6	Accepted
H7	Accepted
H8	Accepted

5. Conclusion

This paper studying the cause and affecting factors of the human behavior in the energy sector has important guiding significance to reduce PPs accidents and critical safety behavior contributing to injuries and losses as well as improve energy production and the efficiency of PPs safety. The study supports the fact that particular behavior analysis is not only adaptable to the energy industry, but also to other industries. All the analysed factors and countermeasures are affecting the workers safety behavior just by different extent rate depending on various criteria. Behavior safety analysis has clearly demonstrated that job factors are more influencing than the other analysed factors on workplace safety performance through their direct effects on workers S-RB, particularly by the Workload which was revealed as the major factor responsible for affecting safety performance in all the evaluated 16 FFPPs. It is apparent that unsafe behavior comes in many forms - intended and unintended actions - each requiring different countermeasures. However, Training and Worker Cooperation and Involvement have been proven in this research as essential workplace enhancements to improve the quality and safety of the working environment in such hazardous industry through inducing and increasing employee safety behavior. Training can be considered as the engine of the other selected effective control measures, for it is highly central to the management of H&S, i.e. it promotes staff competency as well as assists to roll out BBSP, Worker Cooperation and Involvement by trained employees on the importance and role of Worker Cooperation and Involvement.

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References

[1] S. Hirschberg, G. Spiekerman, and R. Dones, Project GaBE: Comprehensive Assessment of Energy Systems. Severe Accidents in the Energy Sector, PAUL SCHERRER Inst. 4 (1998) 98–16.

[2] A. F. Fritzsche, the Health Risks of Energy Production, Wiley Online Libr. 9 (1989) 565–577. https://doi.org/10.1111/j.1539-6924.1989.tb01267.x.

[3] P. Burgherr, P. Eckle, and S. Hirschberg, Comparative assessment of severe accident risks in the coal, oil and natural gas chains, Reliab. Eng. Syst. Saf. 105 (2012) 97–103. https://doi.org/10.1016/j.ress.2012.03.020.

[4] C. Atombo, C. Wu, E. O. Tettehfio, G. Y. Nyamuame, and A. A. Agbo, Safety and Health Perceptions in Work-related Transport Activities in Ghanaian Industries, Safety and Health at Work 8 (2017) 175-182. https://doi.org/10.1016/j.shaw.2016.10.002.

[5] Department of Homeland Security, Energy Sector-Specific Plan, Washington, USA, 2015.

[6] L. Lulić, Governance in the Oil and Gas Industry: Past Approaches, New Challenges, Hrvat. Znan. 15 (2015) 1153–1159.

[7] J. K. Wachter and P. L. Yorio, A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation, Accid. Anal. Prev. 68 (2014) 117-130. https://doi.org/10.1016/j.aap.2013.07.029.

[8] M. K. bin J. Khan and J. K. Mohamad Khan, Determinant of occupational safety and health performance in small and medium manufacturing setting, Procedia - Social and Behavioral Sciences, Malaysia, 2003, 1–445.

[9] I. F. Zin S, Employers Behavioural Safety Compliance Factors toward, Procedia - Soc. Behav. Sci. 36 (2012) 742–751. https://doi.org/10.1016/j.sbspro.2012.03.081.

[10] Y. Zhang, W. Shao, M. Zhang, H. Li, S. Yin, and Y. Xu, Analysis 320 coal mine accidents using structural equation modeling with unsafe conditions of the rules and regulations as exogenous variables, Accid. Anal. Prev. 13 (2016) 189–201. https://doi.org/10.1016/j.aap.2016.02.021.

[11] J. H. T. H. Andriessen, Safe behaviour and safety motivation, J. Occup. Accid. 1 (1978) 363–376. https://doi.org/10.1016/0376-6349(78)90006-8.

[12] N. C. Skeepers and C. Mbohwa, A Study on the Leadership Behaviour, Safety Leadership and Safety Performance in the Construction Industry in South Africa, Procedia Manuf. 4 (2015) 10–16. https://doi.org/10.1016/j.promfg.2015.11.008.

[13] J. M. Rohani, M. F. Johari, W. H. W. Hamid, H. Atan, A. J. Adeyemi, and A. Udin, Occupational Accident Direct Cost Model Validation Using Confirmatory Factor Analysis, Procedia Manuf. 2 (2015) 286–290. https://doi.org/10.1016/j.promfg.2015.07.050.

[14] National General Certificate Unit, National examination board in occupational safety and health, London, United Kingdom, 2015.

[15] B. Vasconcelos and B. B. Junior, The Causes of Work Place Accidents and their Relation to Construction Equipment Design, Procedia Manuf.3 (2015) 4392–4399. https://doi.org/10.1016/j.promfg.2015.07.437.

[16] L. Drupsteen and P. Hasle, Why do organizations not learn from incidents? Bottlenecks, causes and conditions for a failure to effectively learn, Accid. Anal. Prev. 72 (2014) 351–358. https://doi.org/10.1016/j.aap.2014.07.027.

[17] M. M. Abu-Khader, IMPACT OF HUMAN BEHAVIOUR ON PROCESS SAFETY MANAGEMENT IN DEVELOPING COUNTRIES, Process Saf. Environ. Prot. 82 (2004) 431–437. https://doi.org/10.1205/psep.82.6.431.53206.

[18] D. Chen and H. Tian, Behavior based safety for accidents prevention and positive study in China construction project, Procedia Eng. 43 (2012) 528–534. https://doi.org/10.1016/j.proeng.2012.08.092.

[19] R. Choudhry, D. Fang, S. Mohamed, Developing a Model of Construction Safety Culture, Journal of Management in Engineering 4 (2016) 7.

[20] J. Liu and X. Song, Countermeasures of mine safety management based on behavior safety mode, Procedia Eng. 84 (2014) 144–150. https://doi.org/10.1016/j.proeng.2014.10.420.

[21] N. Offshore, P. Safety, and E. M. Authority, Information paper Human error risk reduction to ALARP, NOPSEMA, Perth, Australia, 2015, 1-11.

[22] M. M. Abu-Khader, Impact of Human Behaviour on Process Safety Management in Developing Countries, Process Saf. Environ. Prot.82 (2004) 431–437. https://doi.org/10.1205/psep.82.6.431.53206.

[23] P. Hämäläinen, J. Takala, and K. L. Saarela, Global estimates of occupational accidents, Saf. Sci. 44 (2005) 137–156. https://doi.org/10.1016/j.ssci.2005.08.017.

[24] Morocco Tomorrow. Morocco Aims High With LNG and Power Plans. Morocco Tomorrow, 2015. http://www.moroccotomorrow.org/morocco-aims-high-with-lng-and-power-plans/. Accessed: 01-Jun-2017.

[25] M. P. Mihai and B. M. Sorin, Behavioral Based Safety Management in Electric Power Industry – Complementary Safety of Workers 2. Safety of the Workers in Electric Power Industry, Behav. Based Saf. Manag. Electr. Power Ind.7 (2015) 303–307.

[26] J. H. T. H. Andriessen, Safe behaviour and safety motivation, J. Occup. Accid. 1 (1978) 363–376. https://doi.org/10.1016/0376-6349(78)90006-8.

[27] A. Neal and M. A. Griffin, Safety Climate and Safety Behaviour, Aust. J. Manag. Aust. Grad. Sch. Manag. 27 (2002) 67–75. https://doi.org/10.1177/031289620202701S08.

[28] S. M. Zin and F. Ismail, Employers' Behavioural Safety Compliance Factors toward Occupational, Safety and Health Improvement in the Construction Industry, Procedia - Soc. Behav. Sci. 36 (2012) 742–751. https://doi.org/10.1016/j.sbspro.2012.03.081.

[29] Y. Liu, Z. Hua, and L. Lei, Motivation mechanism of accident prevention in coal mine, Procedia Eng. 43 (2012) 174–179. https://doi.org/10.1016/j.proenv.2012.01.263.

[30] J. Reason, Understanding adverse events: human factors, Qual. Heal. Care 4 (1995) 80–89. https://doi.org/10.1136/qshc.4.2.80.

[31] Health and Safety Executive, Reducing error and influencing behaviour, HSE Books, Bootle, United Kingdom, 1989.

[32] D. K. Lorenzo, EQE, International Inc., Reducing Human Errors, American Petroleum Institute, Washington, USA, 2001.

[33] Y. Khosravi, H. Asilian-Mahabadi, E. Hajizadeh, N. Hassanzadeh-Rangi, H. Bastani, and A. H. Behzadan, Factors influencing unsafe behaviors and accidents on construction sites: A review, Int. J. Occup. Saf. Ergon. 20 (2014) 111–125. https://doi.org/10.1080/10803548.2014.11077023.

[34] C. D. B. Burt, New Employee Safety Risk Factors and Management Strategies, Springer, Berlin, Germany, 2015, 9-23. https://doi.org/10.1007/978-3-319-18684-9_2.

[35] V. J. Sutherland and C. L. Cooper, Personality, stress and accident involvement in the offshore oil and gas industry, Pers. Individ. Dif. 12 (1991) 195–204. https://doi.org/10.1016/0191-8869(91)90103-I.

[36] Y. Kim, J. Park M, Creating a Culture of Prevention in Occupational Safety and Health practice, Safety and Health at Work 7 (2016) 89-96 https://doi.org/10.1016/j.shaw.2016.02.002.

[37] N. Ulutasdemir, M. Kilic, O. Zeki, and F. Begendi, Effects of Occupational Health and Safety on Healthy Lifestyle Behaviors of Workers Employed in a Private Company in Turkey, Ann. Glob. Heal. 81 (2015) 503-511. https://doi.org/10.1016/j.aogh.2015.08.018.

[38] X. Zhao and S. Ma, Application of man-machine-environment system engineering in coal mine accident, Lect. Notes Electr. Eng. 406 (2016) 601–608. https://doi.org/10.1007/978-981-10-2323-1_67.

[39] D. A. N. Hair-cro and K. Narvaez-, Root Causes / Failures That Caused the Macondo Well Explosion (BP Oil) History of Macondo Well, National Commission on the BP Deepwater Horizon. Oil Spill and Offshore Drilling, Washington, USA, 2011.

[40] J. Hare and M. Johnson, Underlying Causes of Offshore Incidents, Health and Safety Laboratory, Derbyshire, United Kingdom, 2009.

[41] J. E. B. Bldg, Human Factors and Ergonomics in Offshore Drilling and Production : The Implications for Drilling Safety, Ocean Energy Safety Institute, Texas, USA, 2016.

[42] L. Högberg, Root causes and impacts of severe accidents at large nuclear power plants, Ambio 42 (2013) 267–284. https://doi.org/10.1007/s13280-013-0382-x.

[43] I. Mohammadfam, F. Ghasemi, O. Kalatpour, and A. Moghimbeigi, Constructing a Bayesian network model for improving safety behavior of employees at workplaces, Appl. Ergon. 58 (2017) 35–47. https://doi.org/10.1016/j.apergo.2016.05.006.

[44] P. Hoonakker, T. Loushine, P. Carayon, J. Kallman, A. Kapp, and M. J. Smith, The effect of safety initiatives on safety performance: A longitudinal study, Appl. Ergon. 36 (2005) 461–469. https://doi.org/10.1016/j.apergo.2004.07.006.

[45] A. Azadeh, Evaluating the Impacts of Resilience Engineering on Health, Safety,Environment, and Ergonomics Factors by Z-Number Cognitive Map in a Large Petrochemical Plant, Saf. Health Work, 3 (2015) 1–12. https://doi.org/10.1016/j.shaw.2015.08.005.

[46] S. Z. B. A. K. Fatini Hanim Binti Mohamed Taufek, Zulhafiza Binti Zulkifle, Safety and Health Practices and Injury Management in Manufacturing Industry, Procedia Econ. Financ. 35 (2016) 705 – 712.

[47] W. I. Faridah Ismail, Ahmad Ezanee Hashim, Wan Zuriea, Behaviour Based Approach for Quality and Safety Environment Improvement Malaysian Experience in the Oil and Gas Industry, Procedia - Soc. Behav. Sci.35 (2012) 586–594. https://doi.org/10.1016/j.sbspro.2012.02.125.

[48] K. Amponsah-Tawaih and M. A. Adu, Work Pressure and Safety Behaviors among Health Workers in Ghana: The Moderating Role of Management Commitment to Safety, Saf. Health Work 7 (2016) 340–346. https://doi.org/10.1016/j.shaw.2016.05.001.

[49] Y. Bhattacharya, Measuring Safety Culture on Ships Using Safety Climate: A Study among Indian Officers, International J. e-Navigation Marit. Econ. 3 (2015) 51–70.

[50] D. George and P. Mallery, SPSS for Windows Step by Step: Answers to Selected Exercises, A Simple Guide and Reference, USA, 2003.

[51] R. Likert, A technique for the measurement of attitudes, Arch. Psychol., 22 (1932) 1-55.

[52] I. Vickers, R. Baldock, D. Smallbone, and P. James, Cultural influences on health and safety attitudes and behaviour in small businesses, HSE (Health and Safety Executive, Bootle, United Kingdom, 2003.

[53] G. Conference and E. Isbn, Factors Affecting the Health and Safety Behavior of Factory Workers 7 (2011) 1–21.

[54] Y. Bhattacharya, Measuring Safety Culture on Ships Using Safety Climate: A Study among Indian Officers, Int. J. e-Navigation Marit. Econ.3 (2015) 51–70.

[55] J. D. Nahrgang, F. P. Morgeson, and D. A. Hofmann, Safety at Work: A Meta-Analytic Investigation of the Link between Job Demands, Job Resources, Burnout, Engagement, and Safety Outcomes, J. Appl. Psychol. 96 (2011) 71–94. https://doi.org/10.1037/a0021484.

[56] K. Mearns and R. Flin, Risk perception and attitudes to safety by personnel in the offshore oil and gas industry: a review, J. Loss Prev. Process Ind.8 (1995) 299–305. https://doi.org/10.1016/0950-4230(95)00032-V.

[57] M. S. Abdullah, Y. H. Othman, A. Osman, and S. N. Salahudin, Safety Culture Behaviour in Electronics Manufacturing Sector (EMS) in Malaysia: The Case of Flextronics, Procedia Econ. Financ.35 (2016) 454–461. https://doi.org/10.1016/S2212-5671(16)00056-3.

[58] M. I. R. Z. Ali, Health and Safety in Oil and Gas Sector, Bureau Veritas, Pakistan, 2014.

[59] P. Thepaksorn and S. Pongpanich, Occupational injuries and illnesses and associated costs in Thailand, Saf. Health Work 5 (2014) 66–72. https://doi.org/10.1016/j.shaw.2014.04.001.

[60] S. Unsar and N. Sut, General assessment of the occupational accidents that occurred in Turkey between the years 2000 and 2005, Safety Science 47 (2009) 614-619. https://doi.org/10.1016/j.ssci.2008.08.001.

[61] S. G. Clarke, Safety culture : under- specified and overrated, International Journal of Management Reviews 2 (2000) 65–90. https://doi.org/10.1111/1468-2370.00031.

[62] K. I, Gabryelewicz, J, SadłowsNa-WrzesińsNab, E, Evaluation of safety climate level in a production facility, Procedia Manuf. 3 (2015) 5822–5829. https://doi.org/10.1016/j.promfg.2015.07.835.

[63] M. P. Yangho Kim, Jungsun Park, Creating a Culture of Prevention in Occupational Safety and Health, Saf. Health Work 7 (2016) 89–96. https://doi.org/10.1016/j.shaw.2016.02.002.

[64] M. I. Khan, Developing a safety culture in developing countries," Int. Conf. Safety, Constr. Eng. Proj. Manag. (ICSCEPM-2013), Issues, Challenges Oppor. Dev. Countries, 8 (2013) 26–31.

[65] D. Fang and S. Mohamed, The nature of safety culture : A survey of the state-of-the-art, Safety Science 45 (2007) 993–1012. https://doi.org/10.1016/j.ssci.2006.09.003.

[66] J. Liu and X. Song, Countermeasures of mine safety management based on behavior safety mode, Procedia Engineering, 84 (2014) 144-150. https://doi.org/10.1016/j.proeng.2014.10.420.

[67] D. Seo, An explicative model of unsafe work behavior, Safety Science 43 (2005) 187–211. https://doi.org/10.1016/j.ssci.2005.05.001.

[68] R. M. Choudhry, Why operatives engage in unsafe work behavior : Investigating factors on construction sites, Saf. Sci. 46 (2008) 566–584. https://doi.org/10.1016/j.ssci.2007.06.027.

[69] T. Amegroud, Morocco's Power Sector Transition : Achievements and Potential, Inst. Aff. Internazionali 15 (2015) 1–18.

[70] International Labour Organization (ILO), Occupational safety and health and skills in the oil and gas industry operating in polar and subarctic climate zones of the northern hemisphere, Geneva, Switzerland, 2016, 26-29.

[71] A. Rahmani, M. Khadem, E. Madreseh, H. A. Aghaei, M. Raei, and M. Karchani, Descriptive study of occupational accidents and their causes among electricity distribution company workers at an eight-year period in Iran, Saf. Health Work 4 (2013) 160–165. https://doi.org/10.1016/j.shaw.2013.07.005.

[72] J. I. Chang and C. C. Lin, A study of storage tank accidents, J. Loss Prev. Process Ind.19 (2006) 51–59. https://doi.org/10.1016/j.jlp.2005.05.015.

[73] D. Chen and H. Tian, Behavior based safety for accidents prevention and positive study in China construction project, Procedia Eng. 43 (2012) 528–534. https://doi.org/10.1016/j.proeng.2012.08.092.

[74] D. A. Hofmann and A. Stetzer, A cross-level investigation of factors influencing unsafe behaviors and accidents, Pers. Psychol. 49 (1996) 307–339. https://doi.org/10.1111/j.1744-6570.1996.tb01802.x.