Assessment of Electrical Safety Beliefs and Practices: A Case Study

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Abstract—**In this paper, the electrical safety beliefs and practices in Hail region, Saudi Arabia, have been assessed. Based on legislative recommendations and rules applied in Saudi Arabia, on official statistics regarding the electricity-caused accidents and on the analysis of more than 200 photos captured in Hail (related to electrical safety), a questionnaire composed of 36 questions (10 for the respondents information, 16 for the home safety culture and 10 for the electrical devices purchasing culture) has been devised and distributed to residents. 228 responses have been collected and analyzed. Using a scale similar to the one adopted for a university student GPA calculation, the electrical safety level (ESL) in Hail region has been found to be 0.76 (in a scale of 4 points) which is a very low score and indicates a poor electrical safety culture. Several recommendations involving different competent authorities have been proposed. Future work will concern the assessment of safety in industrial companies in Hail region.**

Keywords-electrical safety; assessment; statistics; survey; hail region; beliefs; practices

I. INTRODUCTION

Electricity has become essential in modern living, so much attention should be allocated to its potential hazards [1]. Assessing electrical safety practices has to be based first on strong regulations and safety requirements. As example, the study conducted in [2] aimed to implement a practical and adaptive electrical security risk assessment system based on electricity regulation in Guangdong (China) power system. The results show that the studied electrical power system faces a moderate risk. Although the study in [3] is relatively old, it has been reported that, as per the General Civil Defense Administration (GCDA) reports, electrical shock is the major cause of fire accidents. Both the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFHA) are the two organisms responsible of safety in USA. They establish, publish and revise periodically the safety related regulations [4]. Many countries around the world (among them Saudi Arabia) adopt these regulations. In Canada, the NFPA and the Canadian Standards Association (CSA) have recently (in 2016) integrated occupational health, safety management system and risk management principles in a unified framework to enable sustainable prevention of electrical incidents and injuries [5].

The severity of electrical occupational accidents in the primary, secondary and tertiary sectors has been assessed based on 14022 electrical accidents which occurred in Spain between 2003 and 2012 [6]. The obtained results show that the competent authorities must promote actions to ensure agreement between the real workplace equipment and installations safety practices and those indicated by legislation. Moreover, workers have to be educated and trained to their work circumstances. Similarly to the study in [6], the severity of electricity accidents in the construction industry in Spain has been evaluated based on statistics [7]. The findings of the study showed how several variables including age, occupation, company size, etc, are the most related to the electrical accidents severity. Training is proposed as the most practical measure in order to limit the severity of electrical accidents in the construction industry in Spain. Fire safety risk assessment in hotels has been investigated based on qualitative approaches [8]. The paper provides a fire safety code in hotels consisting of 76 items. The electrical part is composed of 14 items (18.42%). This safety code represents a methodical approach that can be followed by safety fire inspectors. Some aspects of safety culture held by subcontractors in the domestic building industry in Australia have been assessed in [9]. The resistance of the subcontractors to safety practices has been found to be caused by seven causes including methods, personal, culture and materials.

The recommendations proposed are particularly built around the integration of OHS in the design stage as well as on providing free training of the subcontractors‘workers. Based on a survey, authors in [10] studied the relationship between the manager’s opinion and the existing safety cultures in N. Cyprus manufacturing companies. It has been concluded that although the safety situation is in a relatively good level, there is room for improvement. Assessing safety beliefs of Australian electrical workers has been investigated using a qualitative methodology. Interviews and focus groups with 46 licensed electrical workers have conducted to classify their beliefs into advantages, disadvantages, referents, barriers and facilitators. This theory is known as planned behavior [11]. The obtained results show that the identified beliefs can inform about the principal factors influencing safe work decisions. Safety on the job site has been assessed in a sample of sites in Saudi Arabia [12]. It has been through filling a safety checklist that large projects have much better safety awareness level. However, both small and large projects generally agree on the safety ranking. Safety practices have been also evaluated in residential buildings in Saudi Arabia. For this aim, a questionnaire has been devised [13]. Unfortunately, the obtained results have shown the design offices to be unaware about the requirements when designing buildings. Number of recommendations is thus reported mainly for involving the necessity of respecting such rules.

II. RESEARCH METHODOLOGY

The main objective of this study is to assess the level of electrical safety in Hail region and to present adequate recommendations to improve it. Five principal activities have been performed:

1. Collecting the main legislative texts, requirements, rules and recommendations related to electrical safety applied in Saudi Arabia.
2. Analyzing official safety reports issued by the local safety authorities.
3. Meeting with officials from the General Civil Defense Administration of Hail region as well as with officials from the SASO. Several interviews and discussion groups have been organized.
4. Analyzing more than 200 photos related to 'bad' electrical safety practices/situations collected from Hail region.
5. Conducting a survey among persons living in Hail region in order to evaluate their electrical safety beliefs and practices.

A. Electrical Safety Legislative Aspects

The Civil Defense Department in Saudi Arabia is the main authority responsible of safety (including electrical safety). The Civil Defense Council has issued in 1990 G/1410 H a code of safety requirements and protections that must be available in Residential Administrative Buildings [14]. In Chapter (Sub-section 2), entitled "Wiring and equipment", it has been reported that "the design and installation of electrical and mechanical devices must follow the Saudi Standards and must be done by specialists". Six general requirements have been defined including wires, equipment, grounding, breaks and lights. During this research, it has been found that all the checklists used for assessing safety used this code.

B. Meetings

Several meetings have been organized with officials from the GCDA. Many aspects including the safety auditing activities have been discussed. Their experiences in the domain of safety was interesting for this study. Moreover, some meetings with safety field inspectors have revealed several key points that helped us in designing the questionnaire.

C. Statistical Analysis

The statistical analysis performed in this section is based on the report collected from the GDCD of Hail region on August 21, 2016. This report is summarized in Table I. For brevity, only the total number of electricity-caused accidents, the estimated costs and the secondary causes are cited. The electrical accidents are classified according to the requirements mentioned in Section II.A. Note that this report includes only the accidents handled by the GDCD. Twelve causes are mentioned in this report. The three important secondary causes are respectively "bad electrical wiring", "High electrical load" and "High wire temperature". According to the estimated costs, the "bad electricity wiring" is the most costly (5401140 SAR) and the "Faulty electrical devices" is the second one (3079750 SAR). It could be also noted that the causes are respectively related to "Safety practices" (1, 2, 4, 5, 6, 9, 10) and "faulty devices" (3, 7, 8, 11). "Bad electrical wiring" is classified first in both number of accidents and cost. An obvious limitation is observed in the GDCD report. In fact, 628 accidents are classified as "other". The estimated cost of this sub-class is relatively high (2746300 SAR).

TABLE I. STATISTICS OF THE ELECTRICAL ACCIDENTS RECORDED BY THE GDCD IN HAIL REGION

#	cause of electrical accidents	number of accidents	estimated cost (sar)
1	bad electrical wiring	919	5401140
2	high wire temperature	270	797522
3	bad quality of devices and wires	127	1345500
4	high electrical load	465	2010100
5	liquid leakage on cables	22	700
6	static electricity	3	1000
7	no existence of automatic breaker	18	215700
8	faulty electrical devices	126	3079750
9	bad maintenance	61	313015
10	high voltage wires touching	40	51500
11	fault in rings	2	0
12	other	628	2746300
	total	2681	15962227

D. Electrical Safety Survey

The objective of the present study is to evaluate the electrical safety level in Hail region. Based on previous sub-sections a questionnaire has been devised. The survey conducted during this study has concentrated on both "beliefs" and "practices" of electrical safety. A total of 36 questions have been included in a checklist where the responses are "Yes" or "No" except of the questions related to some information about the participants (questions 1-10). The questionnaire was distributed via social-media. 228 responses have been received and statistically analyzed. The first 10 questions are related to the responder information (age, sex, nationality, house category, education level, number of rooms, number of persons living in the house and the number of children living in the house). Questions 11-26 are concerned with the electrical safety (at home) beliefs and practices. Questions 27-36 are related to the degree of awareness about electrical safety when buying and using electric and electronic devices. The results of the survey are presented and analyzed below.

1) Survey participants

The general information of the survey's participants is summarized in Table II. By analyzing the survey's participants' general information, the following conclusions should be drawn:

- Male participants are about 86.4% which is beneficial for the study because in Arabic societies, male are in general responsible of all facts concerning the family including the house and its safety. The obtained percentage is highly correlated with the "Yes" response of question 7 ("Are you responsible in the house (father for example)").
- Saudi participants were of 82.9%. This constitutes a positive point of the study. The surveyed sample covered high number of Saudi population. The obtained results will be more significative.
- House owners are of about 64.9% (against house tenants 35.1%). In general, a house owner would be more aware regarding safety questions.
- The majority of surveyed persons live in relatively huge houses (with more than 4 rooms) and a relatively high number of persons living in it (more than 4 persons/house).

TABLE II. GENERAL INFORMATION OF THE SURVEY'S PARTICIPANTS

1	**Age (years)**	Less than 25: 18.4%	Between 26 and 50: 64%	More than 50:17.5%
2	**Gender**	Male: 86.4%	Female: 13.6%	
3	**Nationality**	Saudi: 82.9%	Non-saudi: 17.1%	
4	**Educational Level**	Secondary and less: 12.7%	University: 87.3%	
5	**House**	Owner: 64.9%	Tenant: 35.1%	
6	**House Category**	Independent villa: 65.4%	Apartment: 34.6%	
7	**Are you responsible (father)**	Yes: 76.3%	No: 23.7%	
8	**Number of rooms**	3 or less: 13.6%	More than 4: 86.4%	
9	**Number of persons living in the house**	3 or less: 17.5%	More than 4: 82.5%	
10	**Number of children in the house**	3 or less: 73.7%	More than 4: 26.3%	

2) Survey results

In this paper, the assessment of electrical safety attitudes (practice and beliefs) is based on the positive behaviors. Each question is posed so that it allows to measure one aspect of the considered attitudes. For all questions, the "Yes" response represents the "good" attitude except of questions 20, 21, 22, 24, 29, 31 and 36 (see Table III) where the positive attitude corresponds to the "No" response. In what follows, the electrical safety level (ESL) in Hail region is calculated using the following procedure:

- Each question is assigned a grade and a weight as a 4-point average scale used to assess the results of a university student (see Table III).
- The ESL is calculated using the same formula of a student grade point average (GPA).

Based on the Assessment scale of Table III, the questions 11-36 are assigned a level, a grade and a weight. The details are reported in Table IV.

TABLE III. ELECTRICAL SAFETY LEVEL ASSESSMENT SCALE

grade	meaning	range	weight
A+	Exceptional	95-100	4
A	Excellent	90-94	3.75
B+	Superior	85-89	6.50
C	Very Good	80-84	3.00
C+	Above Average	75-79	2.50
C	Good	70-74	2.00
D+	High Pass	65-69	1.500
D	Pass	60-64	1.00
F	Fail	less than 60	0.00

3) Results Analysis

The questions related to the electrical safety attitudes (practices and beliefs) are divided in such a way that they cover the safety home culture (questions 11-26) and the electric devices purchasing culture (questions 26-36). The overall electrical safety score is found to be 0.76 (using a scale of 4 points). According to Table III classification, this score is poor which incites suitable recommendations to improve it. The sale culture is relatively better (1.45 out of 4) than the home safety culture (0.45 out of 4). However, the two aspects of electrical safety culture are obviously poor. Although 87.3% of respondents have at least one university degree, their electrical safety culture is very poor. Despite that 66.7% of respondents know that the current used at home must be under an allowed value, 57.6% of them did not check the correspondence between the receptacles and sockets and the current to be fed. The "grounding" culture is also poor since almost 50% of the respondents said that some of their domestic appliance is not grounded which can be a source of dangers for them and for their families. A positive aspect has been noticed according to the children electrical safety consideration. In fact, 67.5% of respondents take into consideration their children electrical safety (they cover the switches and sockets and mount them far away from their children).

TABLE IV. CALCULATION OF THE ELECTRICAL SAFETY LEVEL (ESL) OF HAIL REGION BASED ON THE DESIGNED QUESTIONNAIRE

#	Question	yes (%)	no (%)	grade	weight
11	Did you know that the current allowed at home must be under a value predefined by the electricity feeder?	51.9	48.1	f	0
12	Did you know that if you exceed the allowed current, harmful danger on human and equipment can occur?	66.70	33.3	d+	1.5
13	Did you have examined the electrical wiring in your home by a specialist?	35.1	64.9	f	0
14	Did you check the correspondence between the socket and the current to be provided from it?	57.6	42.4	f	0
15	Have you ever heard the term "earthing"?	49.8	50.2	f	0
16	Are all your domestic appliances connected to the earth?	43.3	56.7	f	0
17	Are all the switches and sockets covered by plastic covers?	51.9	48.1	f	0
18	Are all switches and sockets far away from children?	67.5	32.5	d	1
19	Are all light lamps well fixed?	91.8	8.2	a	3.75
20	Were you subject to an electrical shock?	61.5	38.5	f	0
21	Did a short circuit occur before in your house?	47.6	52.4	f	0
22	Did you switch on the electricity source after a short circuit without checking for the cause?	43.3	56.7	f	0
23	Did you know that if you don't check for the cause, a high danger will occur?	64.1	35.9	d	1
24	Did an electricity-caused fire occur before in your house or in neighbor or parent house?	47.2	52.8	f	0
25	Are the breaker and the electrical cabinet in your house of high quality?	59.3	40.7	f	0
26	Did you have an extinguisher for electricity-caused fires?	18.2	81.8	f	0
27	Did you check the technical features of an electrical device (provider, country, and model) before buying it?	80.9	19.1	b+	3.5
28	Did you check the maximum current supported by the sockets and switches before buying them?	58.7	41.3	f	0
29	Did you bought before an electrical device from an unknown source?	57.7	42.3	f	0
30	Did you know that the bad quality of electrical devices can cause fires?	93.2	6.8	a	3.75
31	Were you subject of an accident caused by a bad electrical device?	44.7	55.3	f	0
32	Did you know that the overall load of devices connected to the same electrical socket is not allowed to go over the maximum load of this socket?	79.9	20.1	c+	2.5
33	Did you read the technical datasheet (book) of any device you buy?	52.6	47.4	f	0
34	Did you obey to the safety rules included in an electrical device book?	53.2	46.8	f	0
35	Did you consider that the electrical devices you use are of good quality?	91.8	8.2	a	3.75
36	did you let the mobile phone charging for a long time?	79.5	20.5	f	0
ELECTRICAL SAFETY LEVEL (ESL)		**0.76 out of 4**			

Although 64.1% of the survey participants responded knowing "they have to check for the cause of current interruption" (culture aspect), 56.7% practice this safety aspect. 80.9% of respondents have declared that they check the technical features of an electrical device before purchasing it. This practice is clearly good. However, 58.7% have recognized that they did not check the maximum current required by this device (or supported by it). Despite that 93.2% have the culture of purchasing devices with good quality, 42.3% of respondents have recognized buying electrical devices from an unknown source. Finally, the culture of letting the cell phone charging during a long period is spread since 79.5% responded "Yes" to this question.

III. CONCLUSIONS AND RECOMMENDATIONS

The results of the present study have demonstrated that the electrical safety culture (practices and beliefs) in Hail region, Saudi Arabia, is very poor. This fact has been confirmed by the official General Directorate of Civil Defense (GDCD) records of electricity-caused accidents in Hail region, and by the questionnaire we have devised and distributed to persons living in Hail. Therefore, based on the results of this study, plans aiming to improve the electrical safety score are necessary. The competent authorities should promote specific actions following the below recommendations:

- From a legislative point of view, new rules and sanctions have to be included and applied to organisms that do not obey rigorously to the electrical safety requirements.
- The GDCD, as the authority responsible of safety matters, has to intensify the inspections. This requires highly qualified inspectors.
- The safety culture (including the electrical safety) has to be developed during the primary and secondary schools by specialized courses or trainings. This task can be adopted by the Ministry of Education.
- Brochures explaining the dangers of electricity and the rules to be applied in order to avoid accidents should be prepared and distributed.
- Campaigns aiming to improve the awareness level should be organized by the Civil Community associations and the scientific chairs of the University of Hail.
- More research studies on the field of safety should be conducted by Hail University faculty members.
- The culture of occupational safety and Health (OSH) should be improved, particularly in the family level.
- Since fire is the most dangerous consequence of an electrical accident, homes, schools, administrative buildings, hospitals, hotels etc. should be equipped with specific extinguishers (for electricity-caused fires).
- The residents should be provided with free training on safety awareness by the Deanship of Community Service of Hail University in collaboration with the concerned faculties.

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REFERENCES

[1] D. K. Neitzel, "Electrical Safety Basics for Non-electrical Personnel", 61th IEEE Pulp and Paper Industry Conference, Milwaukee, pp. 1-4 2015

[2] A. Dahai You, B. QingQian Chen, C. Xianggen Yin, D. Bo Wang, "A study of Electrical Security Risk assessment based on Electricity Regulation", Energy Policy, Vol. 39, No. 4, pp. 2062-2074, 2011

[3] M. S. Al-Homoud, M. M. Khan, "Assessing safety measures in residential buildings in Saudi Arabia", Building Research & Information, Vol. 32, No. 4, pp. 300-305, 2004

[4] D. K. Neitzel, "Electrical SafetyUpdate-OSHA 29 CFR 1910.269 and NFPA 70E-2015 Revisions", IEEE Transactions on Industry Applications, Vol. 52, No. 4, pp. 2753-2758, 2016

[5] D. T. Roberts, "Risk Assessment and your Electrical Safety Program: Performance at the organizational and worker levels", IEEE IAS Electrical Safety Workshop, Louisville, pp. 1-6, 2015

[6] J. Castillo-Rosa, M. Suraz-Cebador, J. Rubio-Romero, J. A. Aguado, "Personal Factors and Consequences of Electrical Occupational Accidents in the Primary, Secondary and Tertiary Sectors", Safety Science, Vol. 91, pp. 286-297, 2017

[7] M. Suarez-Cebador, J. C. Rubio-Romero, A. Lopez-Arquillos, "Severity of electrical accidents in the construction industry in Spain", Journal of Safety Research, Vol. 48, pp. 63-70, 2014

[8] M. A. Hassanain, "Approaches to qualitative fire safety risk assessment in hotel facilities", Structural Survey, Vol. 27, No. 4, pp. 287-300, 2009

[9] P. Wadick, "Safety Culture among Subcontractors in the Domestic Housing Construction Industry", Structural Survey, Vol. 28, No. 2, pp. 108-120, 2010

[10] I. N. Isik, E. Atasoylu "Occupational safety and health in north Cyprus: evaluation of risk assessment", Safety Science Vol. 94, pp. 17-25, 2017

[11] K. M. White, N. L. Jimmieson, P. L. Obst, P. Gee, L. Haneman, B. O'Brien-McInally, W. Cockshaw, "Identifying Safety Beliefs among Australian Electrical Workers", Safety Sience, Vol. 82, pp. 164-173, 2016

[12] M. O. Jannadi, S. Assaf, "Safety Assesment in the Built Environment of Saudi Arabia", Safety Sience, Vol. 29, pp. 15-24, 1998

[13] M. S. Al-Homoud, A. A. Abdou, M. M. Khan, "Safety Design Practices in residential buildings in Saudi Arabia", Building Research & Information, Vol. 32, No. 6, pp. 538-543, 2004

[14] Safety Requirement Code & the Safety Rules Required in Residential and Administrative Buildings in Saudi Arabia, Ministry of Interior, Civil Defense Council, 1410 H

[15] Statistics of Electricity-Caused Accidents from 1/1/1431 H to 1/12/1437 H, Internal Report of General Directorate of Civil Defense in Hail Region, 2016

[16] M. H. Noweir, M. M. Alidrisi, I. A. Al-Darrab, M. A .Zytoon, "Occupational safety and health performance of the manufacturing sector in Jeddah Industrial Estate, Saudi Arabia: a 20-years follow-up study", Safety Sciuence, Vol. 53, pp. 11-24, 2013