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Quantitative Assessment of Resilient Safety Culture Model Using Relative Importance Index

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Abstract. Resilient safety culture (RSC) is a socio-technical safety system that is made up of the employee's capabilities as well the protocols and systems in an organization to deal with hazards. Oil and gas industry sites in Kuwait were chosen for this study. Both urban and rural sites were chosen to gauge the level of resilience in their respective safety cultures. Employees in remote sites experience high stress which may lead them to develop mental health disorders over time. High stress can also be caused due to loneliness of being aloof from the social circle and from an urban surroundings. Expatriates or employees in remote work sites experience greater stress at work due to these factors as compared to urban settings. Stress and mental illness have been identified to affect safety negatively. This, in turn, impacts on safety culture which is the focus of this paper. This study ranks constructs and indicators based on data analysis to show which constructs play important part in this case study.

Keywords: Safety Behaviour, Mental Health, Resilient Safety Culture, Remoteness

1 Introduction

Understanding RSC within an organization through modelling is important as it allows for identifying major drivers of safety culture. This can help identify weak links that can lead to future compromise of safety. Remoteness on job location has been previously linked with mental distress of employees. However, its effect on RSC has not been studied. In this paper, we briefly describe the RSC model that the authors have conceptualized in a previous study [1] and demonstrate how that can be applied to measure the impact of remoteness of job location on RSC. This study also assists in further validating the various constructs associated with the RSC model.

1.1 Resilient Safety Culture Model

RSC is a safety culture with resilience, learning, continuous improvements and cost effectiveness [2]. It is based on three constructs: 1) Psychological/cognitive capabilities 2) Behavioural capabilities and 3) Managerial/contextual capabilities to anticipate, monitor, respond and learn in order to manage risks [1],[3]. The psychological/cognitive capabilities enables an organization to notice shifts, interpret

unfamiliar situations, analyse options and figure out how to respond. It relates to sustaining pressures in a company environment and is a personality trait. Behavioural capabilities is comprised of established behaviours and routines that enable an organization to learn more about the situation, implement new routines and fully use its resources [4]. Managerial/contextual capabilities are a combination of interpersonal connections, resource stocks and supply lines that provide a foundation of quick actions [5]. These three capabilities are then divided into various factors or indicators as shown in table 6. They are 42 items in total.

1.2 Remoteness, Mental Health and Safety Behaviour

Remoteness in the current study is defined as physical isolation combined with the condition of being a worker in isolation from one's family, friend and familiar surroundings. It has been found that working in an intensive and pressured work environment involves demands that can lead to psycho-social problems, including sleep disorders, stress, anxiety and depression [6], [7]. Anxiety and depression, in particular, are found to be two major causes for mental health disorders. Mental illness has been identified directly to affect safety negatively [8], [14]. Alroomi and Mohamed (2018) developed a conceptual model in order to better understand the relationship between remoteness, mental health and safety behaviour [9].

Study done by Haslam *et al*., [10] found effects of anxiety and depression, and of their treatment on both performance and safety in the workplace [10]. The study revealed an association with impaired work performance and safety for workers with anxiety and depression, both treated and not currently treated. In the oil and gas industry, a study found that an offshore environment increases the anxiety of workers compared with an onshore one [11]. Chen *et al*., [12] reported that 19% of offshore workers had obsession and phobic anxiety [12]. Another study concluded that health and safety of workers were affected by offshore work due to restrictions which include isolation from family and community [13]. Loneliness and being aloof from the social circle and working in remote areas lead to feeling more stressed at work as compared to urban settings. Number of indicators of isolation which lead to poor health are living alone, having small social network, low participation in social activities, lack of social support and feelings of loneliness. In another investigation in Hong Kong, the psychological distress (depression and anxiety) level was found to predict accident rates, with direct mediating effects on accident rates and a negative relation with safety attitudes [14].

The foregoing studies points to reduction in level of safety behaviour and perception (safety climate) which can cause reduction in an organization's safety culture resilience levels for remote sites more than urban ones. This reduction in resilience reduces the effectiveness of an organization to deal with risk in a dynamic scenario. This study thus focuses on job location either remote or urban as an important parameter to test the hypothesis that the resilience of safety culture changes with change in workplace location. A survey was generated to understand how the various constructs and indicators of RSC respond with respect to change in work sites, and how it effects the resilience levels. It is assumed that the resilience variation in various

organizations is not due to difference in organizations but due to its urban or rural settings.

2 Research Methodology

2.1 Survey

In this study, two organizations X and Y were surveyed. Both are working in the oil and gas sector in Kuwait with sites located remotely and urban areas. The surveys were completed by employees (i.e. engineers, supervisors, managers) who were English language conversant. There were 42 items in the survey. Nine items were for "psychological capability", 15 items were for "behavioural capability" and 18 items were for "managerial capability". The items were inferred using the various indicators of RSC model [1]. Likert scale from 1-5 was used, where 1 on the low side or lower expectancy and 5 on the higher side or higher expectancy. A total of 139 complete survey sheets were collected. Out of 139, 117 were remote data and remaining 22 was urban data. It should be noted that oil and gas industry in Kuwait is generally located in remote areas so getting more urban data was rather difficult. For comparison between remote and urban sites, companies X and Y data was first analysed using t-tests since the sample size was small for both urban and remote and then an analysis of variance (ANOVA) test was done for all remote data.

2.2 Un-paired T test

Unpaired t-test was performed for companies X and Y which provided comparable sample size data for urban and remote sites. The unpaired t-test is used if the population means estimated by two independent samples differ significantly. For unpaired t-test for company X, the two tailed P value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant. Table 1 shows unpaired t-test results for company X.

Table 1: Unpaired T-test of Company X for Remote and Urban Sites

Group	Remote	Urban
Mean	3.032	3.662
Std Dev.	0.478	0.423

Company X data can be used to decipher conclusions based on t-test significance. Data was further analysed for company X based on resilience safety culture constructs between remote and urban data. Table 2 shows urban capabilities in all the three constructs of RSC higher average mean as compared to remote data. The standard deviation was lower for remote on an average as compared to urban showing more consistency in answers in remote sites as compared to urban sites. This may be due to

employees in remote sites being generally from same department or occupation where as in urban sites the occupations may be different which can increase the spectrum of answers. It can be seen that remote sites show that RSC indicators are impacted by site location and hence it can be inferred that resilience level in remote sites is less as compared to urban sites.

Table 2: Resilient Safety Culture Construct Data of Company X

	Remote		**Urban**	
	Average mean	Average Std Dev	Average mean	Average Std Dev
Psychological capability	3.4	0.341	3.7	0.445
Behavioural capability	2.7	0.493	3.6	0.487
Managerial capability	3.1	0.341	3.7	0.376

For the unpaired t-test of company Y, the two tailed P value equals 0.0023. By conventional criteria, this difference is considered to be highly statistically significant. Table 3 shows unpaired t-test results.

Table 3: Unpaired T-test of Company Y for Remote and Urban Sites

Group	**Remote**	**Urban**
Mean	3.083	3.302
Std Dev.	0.235	0.385

Company Y data can be used to decipher conclusions based on t-test significance. Hence, data of company Y was further analysed based on resilience safety culture constructs between remote and urban data.

Table 4: Resilient Safety Culture Construct Data of Company Y

	Remote		**Urban**	
	Average mean	Average Std Dev	Average mean	Average Std Dev
Psychological capability	3.0	0.217	3.4	0.455
Behavioural capability	3.1	0.195	3.1	0.242
Managerial capability	3.1	0.264	3.5	0.357

Table 4 shows urban capabilities in “psychological” and “managerial” show higher average as compared to remote data whereas for “behavioural capability” data was

similar. Comparing X and Y results, it is found that they have a similar trend, hence it can be inferred that remote sites have less resilience capacity as compared to urban ones.

2.3 ANOVA

To further analyse the remote site data, ANOVA test was performed. ANOVA test focuses on difference of variances. ANOVA is the best method to use (Kim, 2017) for finding differences in the mean for two groups or more that are mutually independent and satisfy the normality and equal variance assumptions. This ANOVA is called one way because the two or more samples being compared in the analysis differ on a single independent variable [16]. There were 42 items asked in the survey.

The null hypothesis in comparison of all the groups would be that the population means of all groups are the same whereas the alternative hypothesis is that at least one of the population means of all groups is different. Therefore, among the 42 group of items, if the means of any two groups are different from each other, the null hypothesis can be rejected. When the null hypothesis is rejected from a single comparison, then the entire null hypothesis can be rejected. There are two types of variability in the data. One is within group variance and other is between group variance. Within group variance variability is observed within any group given group's distribution. The means of all groups differ. This variability between means is referred to between group variance. Examining the data, results of ANOVA are obtained and as shown in table 5. The F test or ANOVA test shows the F distribution which is formed by variance ratios. F statistic provides a numerical index that reflects the amount of separation between the group's frequency distribution.

For degree of freedom(df)-between is 41 and degree of freedom(df)-within is 4872, the critical value of F marking the upper 1% (alpha which is the confidence level for the individual statement about the parameter of interest) of the sampling distribution is 1.293. Obtained value of F is 5.308 which exceeds this critical value and thus has probability of less than 0.01 of occurring in samples that received identical treatment. It is most probable then that these samples have not been treated identically. The null hypothesis is thus rejected and declare our obtained value of F to be significant at the 0.1 level. This shows that means of resilient safety indicators are not same and they differ.

Table 5: ANOVA Results for 42 groups

Source	SS	DF	MS	F	F critical
Between group	142.29	41	3.47	5.308	1.293
Within group	3185.56	4872	0.654		
Total	3327.85	4913			

2.4 Ranking

Relative importance index method (RII) is used to quantify the relative importance of all the 42 indicators of RSC for remote sites. Various past studies have used RII method in different areas to understand the relative importance for the concerned factors identified and evaluated [17], [18]. Equation 1 shows the RII, and how it is calculated.

$$RII = \frac{\sum W}{(A*N)} \quad (1)$$

Where RII= relative importance index, W= weighting given to each factor by respondents (Likert scale range from 1 to 5), A= highest weight (in this case it is 5) and N=total number of respondents. The RII value has a range of 0 to 1 where 0 is not inclusive, the higher the RII, the more important is the factor or indicator. Table 6 shows the RII calculated and then ranked. Following abbreviations were used in table 6: G#-group number, VLI-very low importance, LI-low importance, MI-medium importance, HI-high importance, VHI-very high importance.

Table 6: RII and Ranking of Resilient Safety Culture Indicators for Remote Sites

G #	RSC indicators	1 : VLI	2 : LI	3 : MI	4 : HI	5 : VHI	RII	Rank
	Psychological capability (just culture)							
1	Sense of purpose	2	6	77	28	3	0.636	2
2	Strong core value	1	41	48	25	2	0.576	17
3	Prevailing vocabulary	1	34	59	21	2	0.581	15
4	Highly visible moral purpose	2	38	55	20	2	0.569	21
5	Having Attitude	0	22	78	14	3	0.597	9
6	Mindset	0	51	44	20	2	0.554	25
7	Ingenuity to develop new skills	3	34	56	21	3	0.578	16
8	Common language	2	38	51	19	3	0.550	27
9	Situation specific interpretations	1	49	51	15	1	0.542	35
	Behavioural capability (reporting culture)							
10	Disciplined creativity	1	26	69	19	2	0.591	10
11	Combine originality and initiative	2	42	50	21	2	0.564	22

12	Ability to follow different course of action	1	17	78	20	1	0.605	8
13	Engaging in non-conforming repertoires	1	49	47	19	0	0.540	38
14	Have varied and complex action inventory	1	12	36	13	1	0.552	26
15	Have diverse competitive actions	0	53	45	18	0	0.530	40
16	Development of useful practical habits	0	00	15	96	1	0.660	1
17	Develop habits of investigation	0	16	58	41	0	0.632	3
18	Develop habits of collaboration	0	19	44	50	0	0.632	3
19	Develop habit of flexibility	2	20	40	52	0	0.632	3
20	Creating robust responses	0	15	59	40	0	0.627	7
21	Ability to spot an opportunity	0	29	27	13	3	0.583	12
22	Developing new competencies	1	43	54	17	0	0.542	35
23	Unlearning obsolete information	7	40	49	19	0	0.530	40
24	Benefit from situations that emerge	0	46	52	16	2	0.550	27
	Managerial capability (flexible and learning cultures)							
25	Respectful interactions within organization	1	12	74	27	3	0.632	3
26	Face to face honest interaction	1	39	54	20	3	0.574	18
27	Disclosure oriented intimacy	2	47	52	14	2	0.544	34
28	Exchanging resources	0	36	54	25	0	0.571	19
29	Sharing tacit information	1	45	49	21	0	0.550	27
30	Cross-functional collaboration	1	46	38	22	2	0.521	42
31	Forging relationships	1	22	69	20	2	0.585	11
32	Relationships with strategic alliances	0	48	48	19	0	0.540	38
33	Bond with various environmental agents	1	45	55	14	2	0.550	27

34	Promote organizational slack	2	54	36	23	2	0.547	32
35	Communicating without getting ignorant label	3	32	53	27	0	0.571	19
36	Communicating without getting incompetent label	7	43	37	28	2	0.557	24
37	Communicating without getting negative label	7	35	40	31	4	0.583	12
38	Communicating without getting time waster label	7	43	38	26	2	0.549	31
39	Sharing decision making	2	36	62	17	0	0.561	23
40	Creating organization structure	3	21	74	16	2	0.583	12
41	Members have discretion and responsibility	1	42	52	16	3	0.547	32
42	Replying on self-organization	3	45	49	18	1	0.542	35

Table 6 shows "development of useful practical habits" indicator in "behavioural capability" construct ranked first. This indicator comes under "practical habits" construct which addresses the development of "practical habits" that are useful especially repetitive, over-learned routines that provide first response to an unexpected threat in an organization [19]. Likewise other ranked indicators are shown. These results show on which indicators, importance need to be focused on by the surveyed organizations. Further, sub-constructs (table 7) and constructs (table 8) relative importance index are calculated and ranked. The sub-constructs heads a set of survey questions and those are tabulated as a column in table 7.

Table 7: RII and Ranking of Sub-constructs

Groups	**RSC sub constructs**	**Survey groups**	**RII**	**Rank**
1	Conceptual orientation	1-4	0.591	2
2	Constructive sense making	5-9	0.564	6
3	Learned resourcefulness	10-11	0.578	3
4	Counterintuitive agility	12-15	0.557	8
5	Practical habits	16-20	0.637	1
6	Behavioural preparedness	21-24	0.551	10

7	Deep social capital	25-30	0.566	4
8	Broad resource network	31-34	0.556	9
9	Psychological safety	35-38	0.565	5
10	Diffused power and accountability	39-42	0.558	7

Table 7 shows "practical habits" as the most important sub-construct which is the same sub-construct where the highest ranked indicator is located as well followed by "conceptual orientation". Table 8 ranks "behavioural capability" as the most important construct followed by "psychological capability".

Table 8: RII and Ranking of constructs

G #	RSC constructs	Sub construct groups	RII	Rank
1	Psychological capability (just culture)	1-2	0.576	2
2	Behavioural capability (reporting culture)	3-6	0.585	1
3	Managerial capability (flexible and learning cultures)	7-10	0.562	3

3 Discussion and Conclusions

For the two surveyed organizations, it was found that overall RSC is lower in remote sites as compared to urban. This can be due to the fact that remoteness effects the mental capability of its employees as learnt in previous studies. Thus, it impacts the safety behaviour leading to low resilience as compared to urban one as shown in tables 2 and 4. The most important construct to focus on is "behavioural capability" which relies on development of "practical habits" which in turn are useful in providing first response to an unexpected threat. This construct has the maximum relative importance index of 0.585 as shown in table 8 followed by "psychological capability" and then lastly "managerial capability".

In the sub-construct category, "practical habits" is ranked first which offcourse comes under "behavioural capability". It is described as organizations which develop values that lead to habit of investigation as compared to assumption, routines of collaboration rather than antagonism and traditions of flexibility rather than rigidity. How these values are developed? This is through the reporting culture and that is the real emphasis which is shown in this research. These results are constrained to remote sites for oil and gas industry and it can differ for other industries and that can be part of

the future research to find if these indicators which are shown as high importance for this sector does change or remains similar for other sectors as well or not. Loneliness thus can be inferred to reduce resilience as habit of investigation and reporting culture is reduced as these characteristics need vigilance and active responses.

"Behavioural capability" refers to how people act which is related to human resources available to the organization. This also shows that some organizations just focus on "managerial capability" which is structure of the organization, its policies, procedures, management systems in place as being presented in section 1.1 as compared to on its human resources. This human resources are employees and expatriates working in remote sites who need to feel satisfied, be in right state of mind, and have some means of reducing their loneliness which gives them impetus to lead the "reporting culture" construct.

Focus should be on "psychological capability" which is the safety climate or perception an employee makes of the organization. RII for this construct was 0.576 and "conceptual orientation" in sub-construct category ranked second. This perception enhancement is when the organization has strong ideological identity, has strong core values, sense of purpose and clear sense of direction along with capability, influence and competence. All these characteristics of an organization, collectively, comprise "conceptual orientation". This "conceptual orientation" seem to be reduced for remote employees due to the fact that safety perception gets somehow reduced for expatriates due to loneliness and depression giving a perception that the company is not doing enough for giving them a good work environment to live.

In conclusion, it is understood that remote sites need to enhance their resilience levels as compared to urban sites. The "behavioural capability" should be the primary focus of remote sites. Also, this study promises to show that the original model conceptualized for RSC does give good pointers regarding where the focus should be in regards to enhancing resilience levels. In this study, loneliness and mental health effect either the "psychological capability" or "behavioural capability" construct of the model.

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