Research Article

THJPH



# Safety Culture Assessment in Three Automobile Assembly Plants in Thailand

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## Abstract

The automotive industry in Thailand is at the turning point with digitalization, lean and advanced manufacturing technological development, transforming the structure and system that drive this industry. In the meantime, rapid change over assembly lines is forcing workers at risk of injury and illness from working with collaborative robots (cobots) and being exposed to dangerous machinery and chemicals. Objective: This study aimed to draw and compare the pictures of safety culture in three Japanese automobile assembly plants in Thailand, broadly recognized as a strong corporate safety culture. Method: This was a cross-sectional study conducted on three automobile assembly plants, with 719 respondents, mostly male 686 people (94.5 %). This study used the questionnaires which consist of two parts, personal data and the safety climate assessment developed by the UK Health and Safety Executive (HSE). Descriptive statistics were used to describe the safety climate score and the characteristics of the respondents. Inferential statistics were used to describe the comparison of personal factors, workplace location and find the correlation to the safety climate. Result: This study found that there was no shared vision of management commitment between the managers and subcontractors ($p$=0.04). The subcontractor perceived the safety rules and procedures differently compared to the manager ($p$ = 0.001), supervisor, and operational staff ($p$ = 0.00). In addition, the subcontractor's perception of the work environment was different between the supervisor ($p$ = 0.01) and operational staff ($p$ = 0.04). The older workers perceived the safety rules and procedures differently compared to the

younger generations ($p$ = 0.00). The differences between Plant C compared with Plant A and B were communication, involvement, priority of safety, safety rules and procedures, supportive environment, and work environment ($p$ = 0.00).

Conclusion: This study explored the differences factors that are embedded in these three plants by using the Safety Climate questionnaires. Recommendation: The method of this study can be applied to other corporates to perform multiple plants assessment to measure their safety climate periodically.

**Keywords:** Safety, Culture, Climate, Automobile assembly plant

**What was Known**

- Safety culture is the product of collective perceptions, beliefs, and values of safety that are shared within the organization.
- The safety culture can be influenced by organizational context.

**What's New and Next**

- The worker is willing to take risks in some circumstances.
- The specific local sub-culture groups' characteristics to be explore.

## Introduction

The automotive industry in Thailand is very essential to the Thai economy, worth USD 27 billion in 2016 contributed to 12% of GDP, and employed more than 700,000 Thai workers[1]. As of 2021, the automotive industry in Thailand was recognized as the fifth largest in Asia[2] and the tenth largest in the world[3]. Most of the vehicles built in this country are developed and licensed by foreign countries. On top of the list of automotive manufacturing countries in Asia were China followed by Japan, India, South Korea, and Thailand respectively. Japanese-car brands are the largest foreign investment in the automotive industry in Thailand, assembly production for local market and export base to around the world.

Although according to safety statistics, the accident rate of the automotive industry was very low compared to the rest of the industries in Thailand[4]. In the automotive industry, the assembly processes are congested and consist of separate functional compartments for programable robots and automatic equipment. Not only containing moving machinery but also

thousands of workers, both machines and humans are working in collaboration[5]. In this complex workplace, the health and safety of workers are challenging, where workers are exposed to a variety of health and safety risks daily such as being hit or trapped between machines and exposure to noise and vibrating machines and also slip trips and falls. Furthermore, more serious incidents such as fire and explosions can also occur in the automotive industry as an explosion in Suzuka city, Mie Prefecture in Japan resulted in serious burns to two men. The blast occurred at the electrical power distribution board where the two men were checking the switchboard[6].

The automotive industry is more and more complicated, involving new technologies such as 3D, Augmented Reality (AR) headsets, Artificial Intelligence (AI) algorithms, Welding Robots, and Lifting and Stacking Robots. While workers are becoming more stressed to deal with more complicated health and safety risks as part of the manufacturing process, incorporating new technologies and inherent electrical hazards, manual handling, chemical exposure, etc.[3,5].

Since, the safety climate is a product of shared perception and attitude among members at given time and place. Therefore, the safety climate assessment can be conducted to find the current state of safety culture or proxy indicators of an organizational safety culture. This study aimed to draw pictures of the safety culture in three automotive assembly plants in Thailand, owned by the same parent Japanese company which broadly recognized safety culture. The corporate safety philosophy cascades to the ground floor by training that helps build-up a group-wide safety culture from the grassroots-up. In the center of each plant, they have a cell dedicated to safety training, called a 'safety dojo'. It is lined with PPE, instructions, charts, and training gear which gives the opportunity for the trainees to feel how safety hazard can harm them. This regards safe work as the door to all works.

## Materials and Methods

*Data*

This study was a cross-sectional study that utilized UK Health and Safety Executive (HSE)'s safety climate assessment tools, developed by Loughborough University[7] to draw the safety culture in each automotive assembly plant. This study involves three automotive assembly plants, the first plant (plant A) is in the Bangkok suburb area, the second plant (plant B) is located

around 40 km away from plant A and the third plant (plant C) is located around 100 km away from plant A.

The participants include permanent and contract employees who work daily. There were 4,414 people in Plant A and 4,081 people in Plant B, and 5,151 people in Plant C, a total of 13,646 people.

The sample size was calculated based on the following formula[8].

$$n_{\mu} = \frac{N Z^2 \sigma^2}{Ne^2 + Z^2 \sigma^2}$$

$$n = \frac{13646 \times (1.96)^2 \times (0.59)^2}{13646 \times (0.05)^2 + (1.96)^2 \times (0.59)^2}$$

$$n = 400$$

n = Sample size

N = Population size (plant A =4,414, plant B =4,081, plant C =5,151)

e = Error tolerance level of sample size that acceptable 5% at confidence level 95%

$Z^2$ = Confidence level 95% (Z = 1.96)

$\sigma$ = Standard deviation of the sample by reference the related research[8] was 0.59

By reserving the samples for an error of 10% (40), a total including 440 samples calculated, by simple stratified type which breaking the interest population into strata. Thus, samples were selected from all strata in all three plants (plant A = 140, pant B = 140, and plant C = 160). The researcher decided to distribute 750 questionnaires to all 3 plants because the population proportion was unknown and made sure that enough completed questionnaires returned. However, 718 questionnaires were returned from all three plants and since the researcher is also one of the employees in this firm, the researcher known that was no

questionnaire without a representative returned. Thus, all 719 returned questionnaires are accepted as true representations.

*The Questionnaire*

An anonymous confidential questionnaire distributed to the permanent employees and the sub-contractors who work on shift and daytime basis during 07.30 – 16.30, 19.30 – 04.30 and 08.00 – 17.00 in three manufacturing plants from October to December 2016.

The questionnaires were divided into 2 sections.

Part 1: The data on personal factors consisted of information on sex, status, age, position, department, function, education, work experience, and experience related to the accident.

Part 2: The UK HSE's questionnaires[7]

There was a preliminary study set up to test the validity of the items in the questionnaire with the appropriate group. The pilot questionnaire developed to include 47 items covering the areas of management commitment (MC), communication (CO), priority of safety (PS), safety rules and procedures (SRP), supportive environment (SE), involvement (IN), personal priorities and need for safety (PPS), personal appreciation of risk (PAR) and work environment (WE). This pilot questionnaire applied to offshore platforms in two locations where the offshore personnel were asked to complete the questionnaire and provide feedback on the content. Sixty questionnaires returned from offshore personnel with comments on specific items which finally four items deleted, and two items reworded. The revised version of the questionnaire includes 43 items and was consequently tested on a larger pilot population of 350 employees on three offshore platforms. Two hundred twenty one questionnaires returned (63% response rate) without any evidence showing that this sample was unrepresentative of the total population. The statistical test of confirmatory factor analysis (CFA), internal-scale consistency and alternate forms reliability tests were applied to this data[9].

To ensure the reliability of the questionnaires to be used in this study, testing in the same sample size conducted and then calculating by Alpha Coefficient Reliability. The result of the questionnaires was secured by the Cronbach Alpha Coefficient of 0.694.

The UK HSE's questionnaires consisted of 43 questions consisting of four factors as follows.

1. Organizational Context (Cronbach Alpha=0.754)
    - Management commitment: 7 questions (0.845)
    - Communication: 5 questions (0.722)
    - Priority of Safety: 4 questions (0.715)
    - Safety Rules & Procedures: 3 questions (0.734)
2. Social Environment (Cronbach Alpha=0.655)
    - Supportive Environment: 6 questions (0.606)
    - Involvement: 3 questions (0.705)
3. Individual Appreciation (Cronbach Alpha=0.569)
    - Personal Priorities & Need for Safety: 5 questions (0.607)
    - Personal Appreciation of Risk: 4 questions (0.531)
4. Work Environment (Cronbach Alpha=0.779)
    - Physical Work Environment: 6 questions (0.779)

The questionnaire was answered on a 5-point Likert scale, rating value of 5 in the "strongly agree" category, 4 in the agree category, 3 in the neither agree nor disagree category, 2 in the "disagree" category, and 1 in the strongly disagree response. The formatted questionnaire items are in random order.

Scores need to be averaged for each dimension and there were two types of questionnaire items, positive and negative. For the negative words type of question, the score needs to be reversed by subtracting the item score from 6 to reverse the scoring as follows.

- Positive Question, from score 1 - 5 (respond score) = Actual score
- Negative question can calculate the score by (6 – respond score) = Actual score

These averaged scores of each dimension, which have different numbers of items, can be achieved by dividing the actual score by the total possible score of each dimension. The dimension scores need to be standardized before plotting to compare all nine dimensions, by

converting the scores to a 1 to 10 scale by multiplying the average score by 10 as follows. Then the score of all nine dimensions can be presented graphically on the radar diagram.

$$\text{Dimension score} = \frac{[\text{Summation of average score}]}{\text{Total of the full score}} \times 10$$

After collect the data, the researcher was analyzed the data by using statics Package for Social Science program (SPSS) on PC windows, the data were analyzed by using the descriptive analysis statistics including the personal factor by percentage, mean, median, min-max and standard variation and the safety climate score by percentage, mean, and min-max. Inferential statistics to find the correlation between factor and safety climate score by using the ANOVA test for compare personal factor and safety climate score, Pearson Product Moment Correlation Coefficient for correlation between safety climate factor and Multiple Regression analysis by using the confidence was 95 %.

## Results

*Personal factors*

Seven hundred fifty questionnaires were distributed with Seven hundred nineteen questionnaires returned from three locations (95.8%). Most respondents were male (95.4%) and age range of 26 – 35 years old. More than half of them were married (67.3%) and working at the operation staff level (G1 – G4) (60.5%) in the production line (27.3%). The most of education levels of employees were high school (48.5%) with work experience of 1.1 – 5 years (29.5%) and 5.1 – 10 years (28.8%) (Table 1).

*The safety climate score*

Table 2 shows the safety climate score of three automotive plants. The highest score in the nine dimensions was personal priorities and the need for safety. The results in plants A and B were similar, 7.77 and 7.6 respectively, while plant C was the highest at 9.25. On the other hand, the lowest score was a personal appreciation of risk. The results in plants A and B were similar, 5.06 and 5.00 respectively, while plant C was the highest at 6.05.

This study found similar characteristics in Plant A and B. In the management commitment dimension, the score was found similar in Plant A and B, 6.58 and 6.72, respectively while the result of Plant C was the highest at 7.96.

The communication dimension score was similar in Plant A and B, 5.92 and 5.94, respectively while the result of Plant C was the highest at 7.22.

The result of the priority of safety dimension was similar in Plant A and B, 7.17 and 6.91, respectively while the result of Plant C was the highest at 8.41.

The result of the safety rules and procedures dimension was similar in Plant A and B, 6.11 and 5.99, respectively while the result of Plant C was the highest at 6.67.

The result of the supportive environment dimension was similar in Plant A and B, 6.42 and 6.48, respectively while the result of Plant C was the highest at 7.77.

The result of the involvement dimension was similar in Plant A and B, 6.29 and 6.49, respectively while the result of Plant C was the highest at 7.18.

The result of the work environment dimension was similar in Plant A and B, 6.58 and 6.55, respectively while the result of Plant C was the highest at 7.33.

*The relationship between safety climate score and position*

Table 3 shows the result of the safety climate score that the difference in means between the group of management, supervisor, operational staff, and sub-contractor is not statistically significant.

*The relationship between safety climate score and age*

Table 4 shows the result of the safety climate score that the difference in means between the age group of 18-25 (A), 26-35 (B), 36-45 (C), 46-55 (D), 56-year-old and older (E) is not statistically significant.

*The relationship between safety climate score and workplace factors*

Table 5 shows the result of the safety climate score that the difference in means between the plan A, B, and C is not statistically significant.

**Table 1:** Participants' Characteristics

| Characteristics | | Number (%) |
|---|---|---|
| **Sex** | | |
| | Male | 686(95.40) |
| | Female | 33(04.60) |
| **Age** | | |
| | 18-25 | 46(06.40) |
| | 26-35 | 382(53.10) |
| | 36-45 | 222(30.90) |
| | 46-55 | 60(08.30) |
| | 55 years or more | 6(00.80) |
| | Not specified | 3(00.40) |
| | Mean (S.D.) = 34.85 (6.82) | |
| **Marital Status** | | |
| | Single | 200(27.80) |
| | Married | 484(67.30) |
| | Windowed | 3(00.40) |
| | Divorced | 21(02.90) |
| | Separated | 4(00.60) |
| | Not specified | 7(01.00) |
| **Position** | | |
| | Management (G6 up) | 10(01.40) |
| | Operation staff (G1 - G4) | 435(60.50) |
| | Supervisory/Group Leader (G5) | 135(18.80) |
| | Sub-Contract | 127(17.70) |
| | Not specified | 12(01.70) |
| **Department** | | |
| | Manufacturing Operation Management | 1(00.10) |
| | Export Parts Packing | 34(04.70) |
| | Part Logistics | 2(00.30) |
| | Quality Assurance | 7(01.00) |
| | Vehicle Logistics | 16(02.20) |
| | Stamping & Parts | 37(05.10) |

| | | |
|---|---|---|
| | Quality Control | 66(09.20) |
| | Plant Administration | 52(07.20) |
| | Production 1 | 170(23.60) |
| | Production 2 | 120(16.70) |
| | Production 3 | 196(27.30) |
| | Safety & Environment Office | 3(00.40) |
| | Corporate Administration | 8(01.10) |
| | Human Resources | 7(01.00) |
| **Education** | | |
| | Primary school | 1(00.10) |
| | High school | 349(48.50) |
| | Diploma | 242(33.70) |
| | Bachelor's degree | 110(15.30) |
| | High bachelor's degree | 13(01.80) |
| | Not specified | 4(00.60) |
| **Work Experience (Year)** | | |
| | 0.6–1 | 26(03.60) |
| | 1.1–5 | 212(29.50) |
| | 5.1–10 | 207(28.80) |
| | 10.1–15 | 146(20.30) |
| | 15.1–20 | 38(05.30) |
| | 20.1–25 | 57(07.90) |
| | 25.1–30 | 22(03.10) |
| | more than 30 | 11(01.50) |
| **Automobile Assembly Plants** | | |
| | Plant A | 226(31.40) |
| | Plant B | 225(31.30) |
| | Plant C | 268(37.30) |

**Table 2:** Safety climate score of three automotive plants

| | LOCATION | | | | | |
|---|---|---|---|---|---|---|
| | Plant A (N=226) | | Plant B (N=225) | | Plant C (N=268) | |
| Dimensions | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD |
| MC | 6.58 | 0.64 | 6.69 | 0.75 | 6.71 | 0.67 |
| CO | 5.92 | 0.68 | 5.91 | 0.70 | 6.09 | 0.63 |
| PS | 7.17 | 1.02 | 6.88 | 1.05 | 7.09 | 0.93 |
| SRP | 6.11 | 1.32 | 5.96 | 1.47 | 5.62 | 1.71 |
| SE | 6.42 | 0.58 | 6.45 | 0.53 | 6.55 | 0.52 |
| IN | 6.29 | 1.01 | 6.46 | 1.04 | 6.05 | 1.70 |
| PPS | 7.77 | 1.03 | 7.64 | 0.94 | 7.80 | 0.88 |
| PAR | 5.06 | 1.16 | 4.98 | 1.21 | 5.10 | 1.25 |
| WE | 6.58 | 0.74 | 6.52 | 0.85 | 6.18 | 0.94 |

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

**Table 3:** Safety climate score categorized by position.

| | Management | | Supervisor | | Operational staff | | Sub-contractor | |
|---|---|---|---|---|---|---|---|---|
| Dimensions | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD |
| MC | 6.29 | 0.45 | 6.65 | 0.69 | 6.63 | 0.69 | 6.81 | 0.67 |
| CO | 5.64 | 0.48 | 5.97 | 5.91 | 0.62 | 0.67 | 6.09 | 0.77 |
| PS | 6.75 | 0.86 | 7.04 | 1.04 | 7.12 | 0.93 | 7.08 | 0.96 |
| SRP | 7.13 | 1.14 | 5.89 | 1.49 | 6.36 | 1.24 | 5.30 | 1.79 |
| SE | 6.30 | 0.53 | 6.48 | 0.54 | 6.43 | 0.55 | 6.53 | 0.58 |
| IN | 6.40 | 1.14 | 6.26 | 1.29 | 6.32 | 1.35 | 6.17 | 1.49 |
| PPS | 8.00 | 0.78 | 7.76 | 0.89 | 7.79 | 0.98 | 7.63 | 1.12 |
| PAR | 4.70 | 1.30 | 4.96 | 1.23 | 5.11 | 1.15 | 5.28 | 1.21 |
| WE | 7.20 | 0.77 | 6.44 | 0.83 | 6.53 | 0.85 | 6.20 | 0.98 |

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

**Table 4:** Safety climate score categorized by age group

| | 18-25 | | 26-35 | | 36-45 | | 46-55 | | 56+ | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dimensions** | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD | $\bar{X}$ | SD |
| **MC** | 6.29 | 0.45 | 6.65 | 0.69 | 6.63 | 0.69 | 6.81 | 0.67 | 6.29 | 0.45 |
| **CO** | 5.64 | 0.48 | 5.97 | 5.91 | 0.62 | 0.67 | 6.09 | 0.77 | 5.64 | 0.48 |
| **PS** | 6.75 | 0.86 | 7.04 | 1.04 | 7.12 | 0.93 | 7.08 | 0.96 | 6.75 | 0.86 |
| **SRP** | 7.13 | 1.14 | 5.89 | 1.49 | 6.36 | 1.24 | 5.30 | 1.79 | 7.13 | 1.14 |
| **SE** | 6.30 | 0.53 | 6.48 | 0.54 | 6.43 | 0.55 | 6.53 | 0.58 | 6.30 | 0.53 |
| **IN** | 6.40 | 1.14 | 6.26 | 1.29 | 6.32 | 1.35 | 6.17 | 1.49 | 6.40 | 1.14 |
| **PPS** | 8.00 | 0.78 | 7.76 | 0.89 | 7.79 | 0.98 | 7.63 | 1.12 | 8.00 | 0.78 |
| **PAR** | 4.70 | 1.30 | 4.96 | 1.23 | 5.11 | 1.15 | 5.28 | 1.21 | 4.70 | 1.30 |
| **WE** | 7.20 | 0.77 | 6.44 | 0.83 | 6.53 | 0.85 | 6.20 | 0.98 | 7.20 | 0.77 |

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

**Table 5:** The relationship between safety climate factors and positions

| Dimensions | Source of Variation | SS | df | MS | F | *p*-value |
|---|---|---|---|---|---|---|
| MC | Between Groups | 4.93 | 3 | 1.64 | 3.52 | 0.01* |
| | Within Groups | 333.50 | 715 | 0.47 | | |
| | Total | 338.43 | 718 | | | |
| CO | Between Groups | 2.40 | 3 | 0.80 | 1.79 | 0.15 |
| | Within Groups | 319.98 | 715 | 0.45 | | |
| | Total | 322.38 | 718 | | | |
| PS | Between Groups | 3.97 | 3 | 1.32 | 1.32 | 0.27 |
| | Within Groups | 718.42 | 715 | 1.00 | | |
| | Total | 722.40 | 718 | | | |
| SRP | Between Groups | 80.34 | 3 | 26.78 | 11.93 | 0.00* |
| | Within Groups | 1604.82 | 715 | 2.24 | | |
| | Total | 1685.16 | 718 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| SE | Between Groups | 0.80 | 3 | 0.27 | 0.89 | 0.45 |
| | Within Groups | 214.81 | 715 | 0.30 | | |
| | Total | 215.62 | 718 | | | |
| IN | Between Groups | 1.62 | 3 | 0.54 | 0.31 | 0.82 |
| | Within Groups | 1260.22 | 715 | 1.76 | | |
| | Total | 1261.84 | 718 | | | |
| PPS | Between Groups | 2.35 | 3 | 0.78 | 0.87 | 0.46 |
| | Within Groups | 644.46 | 715 | 0.90 | | |
| | Total | 646.81 | 718 | | | |
| PAR | Between Groups | 10.55 | 3 | 3.52 | 2.41 | 0.07 |
| | Within Groups | 1043.84 | 715 | 1.46 | | |
| | Total | 1054.40 | 718 | | | |
| WE | Between Groups | 8.43 | 3 | 2.81 | 3.73 | 0.01* |
| | Within Groups | 538.12 | 715 | 0.75 | | |
| | Total | 546.55 | 718 | | | |

*The mean difference is significant at the 0.05 level.

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

Post-hoc Tukey Test: Multiple Comparisons

| CO | Management (A) | Operational staff (B) | Supervisor (C) | Sub-contractor (D) |
|---|---|---|---|---|
| Management (A) | - | 0.27 | 0.36 | 0.04* |
| Operational staff (B) | 0.27 | - | 0.99 | 0.07 |
| Supervisor (C) | 0.36 | 0.99 | - | 0.13 |
| Sub-contractor (D) | 0.04* | 0.07 | 0.13 | - |

*The mean difference is significant at the 0.05 level.

| SRP | Management (A) | Operational staff (B) | Supervisor (C) | Sub-contractor (D) |
|---|---|---|---|---|
| Management (A) | - | 0.38 | 0.99 | 0.01* |
| Operational staff (B) | 0.38 | - | 0.01* | 0.00* |
| Supervisor (C) | 0.99 | 0.01* | - | 0.00* |
| Sub-contractor (D) | 0.01* | 0.00* | 0.00* | - |

*The mean difference is significant at the 0.05 level.

| WE | Management (A) | Operational staff (B) | Supervisor (C) | Sub-contractor (D) |
|---|---|---|---|---|
| Management (A) | - | 0.79 | 0.97 | 0.23 |
| Operational staff (B) | 0.79 | - | 0.66 | 0.04* |
| Supervisor (C) | 0.97 | 0.66 | - | 0.01* |
| Sub-contractor (D) | 0.23 | 0.04* | 0.01* | - |

*The mean difference is significant at the 0.05 level.

**Table 6:** The relationship between safety climate factors and age groups

| Dimensions | Source of Variation | SS | *df* | MS | F | *p*-value |
|---|---|---|---|---|---|---|
| **MC** | Between Groups | 2.39 | 4 | 0.60 | 1.27 | 0.28 |
| | Within Groups | 336.03 | 714 | 0.47 | | |
| | Total | 338.43 | 718 | | | |
| **CO** | Between Groups | 2.13 | 4 | 0.53 | 1.18 | 0.32 |
| | Within Groups | 320.26 | 714 | 0.45 | | |
| | Total | 322.38 | 718 | | | |
| **PS** | Between Groups | 2.26 | 4 | 0.57 | 0.56 | 0.69 |
| | Within Groups | 720.14 | 714 | 1.01 | | |
| | Total | 722.40 | 718 | | | |
| **SRP** | Between Groups | 53.94 | 4 | 13.49 | 5.90 | 0.00* |
| | Within Groups | 1631.22 | 714 | 2.28 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Total | 1685.16 | 718 | | | |
| **SE** | Between Groups | 2.89 | 4 | 0.72 | 2.43 | 0.05 |
| | Within Groups | 212.72 | 714 | 0.30 | | |
| | Total | 215.62 | 718 | | | |
| **IN** | Between Groups | 9.29 | 4 | 2.32 | 1.32 | 0.26 |
| | Within Groups | 1252.55 | 714 | 1.75 | | |
| | Total | 1261.84 | 718 | | | |
| **PPS** | Between Groups | 5.42 | 4 | 1.35 | 1.51 | 0.20 |
| | Within Groups | 641.39 | 714 | 0.90 | | |
| | Total | 646.81 | 718 | | | |
| **PAR** | Between Groups | 14.42 | 4 | 3.60 | 2.47 | 0.04* |
| | Within Groups | 1039.98 | 714 | 1.46 | | |
| | Total | 1054.40 | 718 | | | |
| **WE** | Between Groups | 4.16 | 4 | 1.04 | 1.37 | 0.24 |
| | Within Groups | 542.39 | 714 | 0.76 | | |
| | Total | 546.55 | 718 | | | |

*The mean difference is significant at the 0.05 level.

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

Post-hoc Turkey Test: Multiple Comparisons

| **SRP** | 18 – 25 Year-old (A) | 26 – 35 Year-old (B) | 36 - 45 Year-old (C) | 46 – 55 Year-old (D) | >55 Year-old (E) |
|---|---|---|---|---|---|
| 18 – 25-year-old (A) | - | 0.99 | 0.19 | 0.02* | 0.58 |
| 26 – 35-Year-old (B) | 0.99 | - | 0.01* | 0.00* | 0.65 |
| 36 - 45-Year-old (C) | 0.19 | 0.01* | - | 0.48 | 0.97 |
| 46 - 55-Year-old (D) | 0.02* | 0.00* | 0.48 | - | 1.00 |
| >55-Year-old (E) | 0.58 | 0.65 | 0.97 | 1.00 | - |

*The mean difference is significant at the 0.05 level.

| PAR | 18 – 25 Year-old (A) | 26 – 35 Year-old (B) | 36 - 45 Year-old (C) | 46 – 55 Year-old (D) | >55 Year-old (E) |
|---|---|---|---|---|---|
| 18 – 25-year-old (A) | - | 0.53 | 0.92 | 0.99 | 0.85 |
| 26 – 35-Year-old (B) | 0.53 | - | 0.71 | 0.12 | 0.42 |
| 36 - 45-Year-old (C) | 0.92 | 0.71 | - | 0.56 | 0.60 |
| 46 - 55-Year-old (D) | 0.99 | 0.12 | 0.55 | - | 0.92 |
| >55-Year-old (E) | 0.85 | 0.42 | 0.60 | 0.92 | - |

* The mean difference is significant at the 0.05 level.

**Table 7:** The relationship between safety climate factors and locations

| Dimensions | Source of Variation | SS | *df* | MS | F | *p*-value |
|---|---|---|---|---|---|---|
| **MC** | Between Groups | 2.288 | 2 | 1.144 | 2.436 | 0.088 |
| | Within Groups | 336.138 | 716 | 0.469 | | |
| | Total | 338.426 | 718 | | | |
| ***CO*** | *Between Groups* | *4.884* | *2* | *2.442* | *5.508* | *0.004** |
| | *Within Groups* | *317.497* | *716* | *0.443* | | |
| | *Total* | *322.382* | *718* | | | |
| ***PS*** | *Between Groups* | *10.067* | *2* | *5.033* | *5.059* | *0.007** |
| | *Within Groups* | *712.331* | *716* | *0.995* | | |
| | *Total* | *722.397* | *718* | | | |
| **SRP** | Between Groups | 31.586 | 2 | 15.793 | 6.838 | 0.001* |
| | Within Groups | 1653.574 | 716 | 2.309 | | |
| | Total | 1685.160 | 718 | | | |
| ***SE*** | *Between Groups* | *2.625* | *2* | *1.313* | *4.412* | *0.012** |
| | *Within Groups* | *212.990* | *716* | *0.297* | | |
| | *Total* | *215.616* | *718* | | | |
| ***IN*** | *Between Groups* | *20.419* | *2* | *10.209* | *5.888* | *0.003** |
| | *Within Groups* | *1241.423* | *716* | *1.734* | | |
| | *Total* | *1261.842* | *718* | | | |
| **PPS** | Between Groups | 3.448 | 2 | 1.724 | 1.919 | 0.148 |
| | Within Groups | 643.362 | 716 | 0.899 | | |
| | Total | 646.810 | 718 | | | |
| **PAR** | Between Groups | 1.745 | 2 | 0.872 | 0.593 | 0.553 |
| | Within Groups | 1052.652 | 716 | 1.470 | | |
| | Total | 1054.397 | 718 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***WE*** | *Between Groups* | *23.216* | *2* | *11.608* | *15.881* | *0.000** |
| | *Within Groups* | *523.332* | *716* | *0.731* | | |
| | *Total* | *546.547* | *718* | | | |

*The mean difference is significant at the 0.05 level.

MC: Management Commitment, CO: Communication, PS: Priority of safety, SRP: Safety Rules and Procedures, SE: Supportive Environment, IN: Involvement, PPS: Personal Priorities and Need for safety, PAR: Personal Appreciation of Risk, WE: Work Environment, M: Mean, SD: Standard Deviation

Post-hoc Tukey Test: Multiple Comparisons

| **CO** | **Plant A** | **Plant B** | **Plant C** |
|---|---|---|---|
| Plant A | - | 0.98 | 0.02* |
| Plant B | 0.98 | - | 0.01* |
| Plant C | 0.02* | 0.01* | - |
| **PS** | **Plant A** | **Plant B** | **Plant C** |
| Plant A | | 0.01* | 0.66 |
| Plant B | 0.01* | | 0.05 |
| Plant C | 0.66 | 0.05 | |
| **SRP** | **Plant A** | **Plant B** | **Plant C** |
| Plant A | | 0.54 | 0.00* |
| Plant B | 0.54 | | 0.04* |
| Plant C | 0.00* | 0.04* | |
| **SE** | **Plant A** | **Plant B** | **Plant C** |
| Plant A | | 0.80 | 0.01* |
| Plant B | 0.80 | | 0.08 |
| Plant C | 0.01* | 0.08 | |
| **IN** | **Plant A** | **Plant B** | **Plant C** |
| Plant A | | 0.34 | 0.13 |
| Plant B | 0.34 | | 0.00* |
| Plant C | 0.13 | 0.00* | |
| **WE** | **Plant A** | **Plant B** | **Plant C** |
| Plant A | | 0.69 | 0.00* |
| Plant B | 0.69 | | 0.00* |
| Plant C | 0.00* | 0.00* | |

*The mean difference is significant at the 0.05 level.

## Discussion

The shape of the safety climate dimensions was similar in Plant A and B, while Plant C showed the enlarged shape of the low scores. The highest score in three plant is same item that is personal priority and need for safety. So employees of three plant had need for safety is high intention. The lowest score in three plant is same item too, that is personal appreciation of risk. The result of each item in three plant had similar ranking score ( Highest – lowest score) in plant A and B but Plant C had different ranking since forth. Plant C is in the industrial estate area which is close to the authority, whilst plant A and B are located on their land outside of the industrial estate authority control. Additionally, the factories located in the industrial estate which highly competitive in the labor market. Thus, those factories need to make themselves more attractive to be the most preferred employer in that area.

The highest score was personal priorities and need for safety, which corresponds to the organization's culture and workers' perception of safety as fundamental for human needs same as the second and third highest, the priority of safety and the management commitment[10].

The personal appreciation of the risk dimension was the lowest in all three plants. This implies the group climate[11] characteristic which is the strongest norm regardless of geographical difference. The strength of the worker's attitude confirms the management's commitment to the well-established safety culture. Thus, the local arrangement seems to reflect the score of this dimension which is a tangible output of an organization's safety culture. Although the workers perceived the importance of their own safety, deep in their minds, they would be willing to take risks in some circumstances. Each of these factors that affect their mindset does not act on its own, but they act within the context of the other.

95.8% of the respondents in this study were male, indicating that females were underutilized in the automotive industry as same as reported by ILO[3]. This result implied that there were barriers for women to participate in this industry due to manpower supply for this industry mainly graduated from the technical high school which male students vastly outnumber females[12] and males take more risks under pressure than females when they need to make decisions.

**The relationship between safety climate score and positions**

Table 5. Within the four groups of difference position, manager, supervisor, operator, and sub-contractor, there was difference among means of the following dimensions:

**Management Commitment (MC)**

There was no shared vision of management commitment between the managers and subcontractors *(p=0.04).* This implied the gaps within the two groups, the ways the subcontract workers interpreted differently compared to the manager[15,16]. This should be regarded as a room for improvement for senior managers to visibly demonstrate their commitment to the subcontractors by Top down communication to share Mission and Vision of Top management.

**Safety Rules and Procedures (SRP)**

The result indicates that the subcontractor perceived the safety rules and procedures differently compared to manager *(p=0.01),* Supervisor and operational staff *(p =0.01),* Subcontractor and operational staff *(p=0.00),* Subcontractor and Supervisor *(p=0.00),* there was also a difference, so when deploy safety rules and procedures should to closely and two-way communication in order to have an understanding in the same direction in every position.

**Work Environment (WE)**

The subcontractor's perception of the work environment[13,14] was difference between the supervisor *(p=0.01)* and operational staff *(p=0.04)*, indicate the ways they live, and work affects their attitudes towards the work environment[15,16].

**The relationship between safety climate dimensions and age groups**

Table 6. within the five groups of different age-groups, 18-25, 26-35, 36-45, and 46-55 year-old, there was difference in the safety rules and procedures (SRP) factor. The result indicates that the age group of 46–55-year-old perceived the safety rules and procedures differently compared to the younger generations, 18-25 *(p=0.02)*, 26-35 *(p=0.00).* In addition, there was also a difference between the age group of 36-45 and 26-35 *(p=0.01).* These indicate that the level of compliance with safety rules and procedures was different between younger and older staff. For the element of personal appreciation of risk (PAR), there was a difference

perception within the five groups *(p=0.04*) but there was not significant difference when compare group by group of age.

**The relationship between safety climate score and locations**

Table 7. within the three groups of different locations, plant A, plant B, and plant C, there was difference in the following safety climate dimensions:

**Communication (CO)**

The vital roles and consistency of communication were different between Plant C compared with Plant A *(p=0.02)* and B *(p=0.01)* implying that the communication among these three plants on safety issues were differently[16,17].

**Priority of Safety (PS)**

The difference of priority of safety between Plant A compared with Plant B *(p=0.01)* implying that the management just culture of the safety performance interacted and influenced the individual perception[18] in these plants. Thus, affect the individual's priority of safety.

**Safety Rules and Procedures (SRP)**

The difference of safety rules and procedures between Plant C compared with Plant A *(p=0.00)* and B *(p=0.04)* implies that the level of compliance with safety rules and procedures differently among these three plants were not the same.

**Supportive Environment (SE)**

The difference of supportive environment between Plant A compared with Plant C *(p=0.01)* implies that the ways the management demonstrated care and concern toward employees in two plants were difference[19,20,21].

**Involvement (IN)**

The difference of involvement between Plant B compared with Plant C *(p=0.00)* implies that the opportunity for safety issue or concern to be raised [19,20,21] was totally difference. Since, the more involvement in safety activities the more enable all levels to share their concerns and allow all employees to proactively contribute their idea for improvement[22].

### Work Environment (WE)

The difference of work environment between Plant C compared with Plant A *(p=0.00)* and B *(p=0.00)* implying that the perception of the work environment[13,14] was totally difference, indicate the ways the employees live and work in these plants affects their attitudes towards the work environment[15,16].

### Limitation

This cross-sectional study could be involved in the systematic error of the instrumental questionnaire consisting of simple questions, depending on the respondent's judgment to cross on the rating scale, these answers could be contrary to the truth[23].

The group of respondents in the same location may answer the questions together where they may choose the answer as same as their colleagues, for the sake of just completing these questionnaires. This may cause bias errors.

Since there were more males than females on each plant and the sampling was not separated between two genders. Therefore, this study depicted risk appreciation dominantly because most respondents were males and males take more risks under pressure than females[24]. Additionally, the questionnaire may be distributed to the production departments first, which they mostly occupied by operational staff positions. This may also cause biased errors.

This error could have occurred from the selection of the respondents as well, missing some departments such as administrative staff working in the office or only supervisor-level employees selected to answer the questionnaires.

## Conclusion

Three automobile assembly plants in this study owned by Japanese corporate which broadly recognized of Basic Philosophy for safety that builds up its safety culture and resulted in very low injury rate. This study explored the differences factors that embedded in these three plants by using the questionnaires developed by the UK HSE, Safety Climate Measurement User Guide and Toolkit.

Furthermore, this study used descriptive statistics to describe the safety climate score and the characteristics of the respondents. Additionally, inferential statistics were used to

describe the comparison of personal factors, workplace location and find the correlation between safety climate dimensions.

Among the nine dimensions of the safety climate, the highest score was personal priorities and the need for safety. The lowest was a personal appreciation of risks.

It was found that the sub-contract employee has a different perception of commitment, safety rules and procedures, and work environment compared to the operational staff, supervisor, and manager level.

This result showed that the age groups had a significantly different perception of the safety rules and procedures between older and younger generations.

On the contrary, in comparison among three workplace locations, Plant C different from Plant A and B. This result would enlighten the corporate headquarters to investigate local cultural circumstances that can be adapted to Plant A and B[22].

For safety management point of view, this study fulfills the need for a proactive or leading indicator where the corporate cannot rely only on the lacking indicators such as safety audit reports and injury rates. This study can be applied to other corporates to perform multiple plants assessment to measure their safety climate periodically.

**Limitation of the study**

Most of the participants in this study were operational employees in an automobile production line. Only a few managements were involved in this study due to unavailability and the hierarchy of classes in the management structure.

Since very few managers were involved in the study, most of the contribution drew by shopfloor level workers.

**Recommendation for the further study**

The questionnaires should be distributed to the management level and shop floor level in each automobile assembly plant equally to see the difference between the two. The socio-ecological community-based participatory research should be conducted in plant C to find the

influencing factors that support safety culture and shape the safety climate in this plant. The results could be used for developing proper interventions that create reciprocal nature of influences that produce a preferred safety climate in other plants[23].

## Ethical Approval Statement

The study has been reviewed and approved by the ethical committee for the human research faculty of public health Mahidol University, COA. No. MUPH 2016-129

## Author Contributions

SN and DY designed the study and formulated the content of the safety culture questionnaire. DS provided guidance for statistical analysis. SN conducted the study under the supervision of DY. SN conducted reliability testing and the initial statistical analysis of data by following a piece of advice from DS and VB. DY re-analyzed the data and wrote the manuscript and the abstract. All authors read and approved the manuscript prior to submission for publication.

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## Conflicts of Interest

The authors did not have any conflicts of interest.

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