The Effect of Mask & Face Shield on the General Discomfort of the Workers in the Food Industry: A Structural Equation Modeling Approach

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Abstract. Using face mask & face shield and practicing hand sanitary measures mitigate the risk of getting COVID-19. However, different types of discomfort have been long associated with these especially among healthcare workers. An online survey with 255 respondents was conducted to investigate the discomfort felt by another group of frontliners: food & beverage company workers. Based on the SEM, it was found that exposure to PPE & sanitary protocols significantly explains general discomfort. Visual discomfort, skin irritation, and breathing difficulty contribute most to general discomfort. This study linked overall discomfort to work difficulties. Parts of the face that are most prone to discomfort were identified: ears, nose, and cheeks. For demographics, age, department, and role could affect the severity of specific types of discomfort. This study aims to be the basis for more SEM models and creation of more ergonomic PPE & sanitary protocols in the F & B industry.

1 Introduction

COVID-19 is a respiratory disease caused by the novel SARS-Coronavirus-2 [1] (Hu et al., 2020). It is characterized by viral pneumonia-like symptoms [2] (Huang et al., 2020) with risk of multiple organ failure [3] (Yang et al., 2020). To prevent the spread of the virus in the workplace, companies in the Philippines follow either skeletal workforce or work-from-home schemes [4] (Philippine Department of Labor and Employment [DOLE], 2020). However, these set-ups are not applicable to food & beverage (F&B) manufacturing companies. Even before the COVID-19 pandemic, F&B personnel wear personal protective equipment (PPE) such as gloves, safety shoes, goggles, hair nets, and area uniforms to comply with Good Manufacturing Practices (GMP). PPE promote both food and employee safety [5] (Nakat & Bou-Mitri, 2020). Proper handwashing, use of disinfectants, and cleaning-in-place (CIP) are practiced for sanitation. During the pandemic, F&B companies imposed more stringent measures such as wearing of additional PPE like face masks & face shields and more frequent disinfection in the form of handwashing and use of hand sanitizer. These measures are also done to reduce any possible risk of food-borne coronavirus transmission [6] (United States Center for Disease Control [CDC], 2020). While these anti-COVID measures protect both products & workers, different accounts of discomfort, pain, and exertion have been raised.

Several types of sanitary protocols and PPE-related inconvenience were previously reported especially in the healthcare sector. Often, these discomfort lead to poor work performance and exposure to additional hazards such as exposure during temporary removal of PPE, accidentally dropping objects, and falling. Face masks have been reported to cause neck strains; skin irritations; and contact dermatitis [7, 8, 9] (Atzori et al., 2020; Foo et al., 2020; Ong et al., 2020); chest discomfort and difficulty in breathing if worn longer than 4 hours [10] (Xia et al., 2020); headaches [9, 11] (Lim et al., 2006; Ong et al., 2020); and even nasal bridge injury [12] (Hu et al., 2020). Face masks and/or face shields cause ocular dryness and irritation [13] (Moshirfar et al., 2020); fogging, especially for those wearing...
eyeglasses or goggles [14] (Chaturvedi et al., 2020); and restrict peripheral vision; which contribute to diminished visual acuity [15] (Kal et al., 2020). In addition, either may interfere with vocal communication and speech intelligibility [16] (Goldin et al., 2020). Increased effort in speaking to compensate with the interference could lead to muscle fatigue, throat pains, and reduction of voice use [17] (Ribeiro et al., 2020). PPE in general have also been reported to induce heat stress manifested by increased sweating and thermal discomfort [18] (Davey et al., 2020). Consequently, some workers slow down their pace to prevent too much heat build-up [18] (Davey et al., 2020) and some even remove PPEs temporarily to relieve themselves from the tensional and thermal stress. Frequent use of alcohol-based sanitizers and handwashing may compromise tissue integrity [19] (e.g. Lan et al., 2020), thereby increasing the risk of infections other than SARS-CoV-2 [20] (e.g. Faghihi et al., 2020). Having been discouraged by the Philippine Department of Health [21] (DOH, 2020) and the World Health Organization [22] (WHO, 2020) due to ineffectiveness and false sense of security [23] (e.g. Gardezi et al., 2020), misting could have similar effects on skin areas.

While numerous studies have been published on the discomfort felt by medical workers due to COVID-related PPEs and sanitary protocols, none has been conducted on F&B manufacturing sector. Among the few PPE and health protocol studies within food production, the focus has only revolved around the effectiveness and not on the tolerability [24] (Moore et al., 2006). Therefore, the purpose of this study is to assess the effect of wearing COVID-related PPE and practicing additional sanitary protocols to the level of discomfort, pain, and exertion felt by F&B manufacturing employees. It also aims to determine specific parts of the face which experience most discomfort and to assess the contribution of different types of inconveniences to the general discomfort. The researchers would like to evaluate the effect of general discomfort on overall work performance. Furthermore, this study aims to explore correlation of accounts of discomfort to demographic characteristics like sex, age, department, role, and product type. This study could contribute to baselining the experiences of workers in the field of F&B manufacturing. Information from which could be the basis for creating more comfortable personal protective equipment & disinfectant and more ergonomic sanitary policy in light of the current pandemic and in preparation for future ones as well.

2 Methodology

2.1 Participants

The respondents of this study are employees of F&B companies in the Philippines who are directly involved in manufacturing. They all consented to complete the survey after being assured of confidentiality regarding their answers and information.

2.2 Questionnaire

An original questionnaire, found in Appendix A.1 of this article, was developed for the purpose of this study. A google form was set up for the self-administered, three-part online survey from January 20 to 24, 2021. The form was propagated through social media connections and platforms like Reddit, Facebook groups, and Messenger.

The objective of the first part of the questionnaire is to obtain information such as the workers' age, sex, type(s) of product being manufactured, assigned department(s), role(s), department, and amount of exposure to COVID-related PPE & sanitary measures as part of the sample population's demographics. For the second part, a cartoon image of a human face was presented with labels on six areas of the face: forehead, temples, ear lobes, nose area, cheek area, and chin. Respondents were to indicate which of those areas they would feel a certain facial discomfort. The third part is a Four-Point Likert scale featuring questions that assess how extremely or frequently a certain type of discomfort is felt. Four-Point Likert scale was ideal in this study to extract opinion from respondents and remove the safety of neutral options. This part was composed of a few negative statements to check the consistency of the participant's answer.
2.3 Statistical analysis

The researchers utilized Structural Equation Modelling (SEM) using R in the lavaan package to confirm multivariate relationships between measured variables and latent variables [25]. Here, the effect of exposure to PPE and sanitary protocols to overall discomfort and the effect of the overall discomfort to work performance were evaluated. Alpha is set at 5% level of significance. Specific areas of face which are mostly affected by discomfort are analyzed using descriptive statistics (mode) and reported in terms of percent. To test if demographics influence the severity of specific discomfort, both chi-square test for association and Fisher Exact test were used. Cramer’s V test was applied to determine the strengths of association for those variables which were determined to be significant.

3 Results

3.1 Demographics

Exactly 255 respondents participated and completed the three-part questionnaire about discomfort due to COVID-related PPE & sanitary protocol. All responses were considered valid. The summary of the respondents’ demographic profile is shown in Table 1.

| Table 1. Demographic data |
|---------------------------|
| **Frequency** | **Percent** |
| Sex | | |
| Male | 150 | 58.8 |
| Female | 105 | 41.2 |
| Age | | |
| <20 years old | 2 | 0.8 |
| 21-30 years old | 90 | 35.3 |
| 31-40 years old | 103 | 40.4 |
| 41-50 years old | 47 | 18.4 |
| 51-60 years old | 13 | 5.1 |
| Number of work hours | | |
| Less than 8 hours | 5 | 1.96 |
| 8 hours | 117 | 45.88 |
| 8 to 12 hours | 126 | 49.41 |
| More than 12 hours | 7 | 2.75 |
| Department | | |
| Production (process, bottling & packaging) | 109 | 42.7 |
| Engineering (utilities, maintenance & support, EHS) | 48 | 18.8 |
| Full goods / warehouse | 17 | 6.7 |
| Quality assurance | 56 | 22 |
| Research & development | 13 | 5.1 |
| Others | 12 | 4.7 |
| Product | | |
| Beverages | 109 | 42.7 |
| Solid foods | 109 | 42.7 |
| Condiments | 13 | 5.1 |
| Others | 24 | 9.4 |
| Role (nature) | | |
| Supervisory | 29 | 11.4 |
| Managerial | 34 | 13.3 |
| Operational | 192 | 75.3 |

3.2 Facial discomfort

Discomfort specific to certain areas of the face were determined, as shown in Table 2. Most of the respondents reported having stretch marks and lines on the nose, itching & redness on the ears, pain & pressure on the ears, and rashes & acne on the cheeks.
Table 2. Frequency of discomfort reported per area of the face.

| Type of discomfort         | Forehead | Temples | Ears | Nose | Cheek area | Chin |
|----------------------------|----------|---------|------|------|------------|------|
| Stretch marks and lines    | 76 (29.8%) | 59 (23.1%) | 74 (29.0%) | 152 (59.6%) | 35 (13.7%) | 41 (16.1%) |
| Itching and redness        | 36 (14.1%) | 22 (8.6%) | 138 (54.1%) | 108 (42.4%) | 54 (21.2%) | 63 (24.7%) |
| Pain and pressure          | 71 (27.8%) | 117 (45.9%) | 120 (47.1%) | 55 (21.6%) | 21 (8.2%) | 6 (2.4%) |
| Rashes and acne            | 23 (9.0%) | 1 (0.4%) | 17 (6.7%) | 48 (18.8%) | 75 (29.4%) | 73 (28.6%) |

3.3 The Structural Model

Linear regression and confirmatory factor analysis (CFA) were performed in SEM. Some factors had to be constrained to have equal parameters since CFA requires at least three indicators to be freely estimated [26]. The researcher used Diagonally Weighted Least Squares (DWLS) estimator to make a more robust model of the data which are all ordinal [27]. To generate the model, some factors were excluded due to high rates of “not applicable” response. This reduced the analytical sample size to 233 respondents. Variables that poorly explain latent constructs (eg. questions about communication issues to overall discomfort and wearing gloves on work performance) were also not considered in the final model.

Figure 1 shows the results of the assessment of the relationship of exposure to COVID-related PPE and sanitary protocols to discomfort, specific types of discomfort to general discomfort, and the relationship of discomfort to work performance.

Figure 1. Final model showing factors contributing to general discomfort.

The researchers used a 5% significant level for the entire model. Unstandardized coefficients were considered because the focus will be on the degree of effect of the different physical discomforts to the overall discomfort and less on the intercomparisons of the different types of discomfort. Furthermore, the independent variables have the same unit of measurement [28]. Table 3 shows the list of questions used to assess different types of discomfort felt.
Table 3. Questions used to assess different types of discomfort.

| Code | Question |
|------|----------|
| SF   | I have a sticky feeling due to sweat when wearing a face mask. |
| MS   | Wearing a face shield over face mask makes me more sweaty at work. |
| TO   | I temporarily take off COVID-related PPE's at work to relieve heat discomfort. |
| PM   | I purposefully pull down my mask below my nose area to breathe easier. |
| CA   | I place my face shield on top of my head (like a headband) to catch some air. |
| CP   | I experience chest pains when wearing a face mask. |
| BE   | I can breathe easier when wearing a face mask without a face shield. |
| DC   | I observe dryness/cracking in the skin of my hands since the pandemic. |
| IH   | My hands feel itchy and look reddish after I sanitize them. |
| DI   | My eyes feel dry and irritated when I wear face mask and face shield. |
| PS   | I can clearly see objects at my peripheral (side) when wearing a face shield. |
| SC   | I place my face shield on top of my head (like a headband) to see clearly. |
| BU   | I bump into things when wearing face mask and face shield. |
| CE   | I commit errors at work when wearing face mask and face shield. |
| DT   | I drop things when wearing face mask and face shield. |
| MF   | I can move freely when wearing COVID-related PPE's. |
| HN   | I feel heavier when wearing a face shield especially in my nose area. |
| NS   | My neck feels strained after a day of wearing covid-related PPE like face mask & face shield. |
| HA   | I experience headaches during or after wearing COVID-related PPE. |

The constrained variables were all valid indicators because the standardized path coefficients have strong relationships to the latent construct, so they are safe to use as reference values. All indicators and subfactors are positively related to general discomfort. All variables in the model have p values less than 0.05. For General Discomfort, the most contributing factors are Visual Discomfort ($\gamma=1.858$), Breathing Difficulty ($\gamma=1.571$), and Skin Irritation ($\gamma=1.691$). From Figure 1, it is shown that Exposure is significantly related to general discomfort ($\gamma=0.753$). Relative to the number of hours wearing PPE, handwashing ($\lambda=2.957$) and use of sanitizer ($\lambda=2.390$) contributed greatly to explaining the exposure factor. General discomfort is strongly related with Work Difficulties ($\beta=1.770$). For Work Difficulties, dropping things (DT) and committing errors (CE) are the main contributors.

To test the model fit, Comparative Fit Index (CFI) and Tucker-Lewis index (TLI) were used. A value of 0.755 for robust are obtained in CFI. For TLI, the values are 0.843 for standard and 0.724 for robust.

3.4 Effect of Demographics on Discomfort

Table 4 shows the types of discomforts felt which are significantly related to specific demographic information based on chi-square test for association and Fisher exact test. Using Cramers’ V test, Age
and Department are found to have strong association with dryness and cracking of skin (DC) and Role is strongly associated with headache (HA).

### Table 4. Types of Discomfort significantly related with Demographic Information

| Demographic Information | Discomfort | Test Used                  |
|-------------------------|------------|----------------------------|
| Age                     | HA         | Chi-square                 |
|                         | BU         | Chi-square                 |
|                         | DC         | Chi-square (strong association) |
|                         | CA         | Fisher Exact Test          |
|                         | SF         | Fisher Exact Test          |
| Sex                     | TO         | Chi-square                 |
| Product                 | DI         | Chi-square                 |
|                         | BU         | Chi-square                 |
|                         | DC         | Chi-square                 |
|                         | IH         | Chi-square                 |
|                         | TO         | Fisher Exact Test          |
|                         | SF         | Fisher Exact Test          |
|                         | MS         | Fisher Exact Test          |
|                         | NS         | Fisher Exact Test          |
| Department              | CA         | Chi-square                 |
|                         | SF         | Chi-square (strong association) |
|                         | MS         | Chi-square                 |
|                         | DC         | Chi-square                 |
|                         | TO         | Chi-square                 |
| Role                    | HA         | Chi-square (strong association) |
|                         | SF         | Chi-square                 |

## 4 Discussion

### 4.1 Facial Discomfort

Facial discomfort was mainly observed on the ears in the form of itching & redness as well as pain & pressure. Stretch marks and lines on the nose and rashes and acne on the cheeks also represented common discomfort on the face. These findings are consistent with previous studies. According to Foo et al. [29], acne, facial itch, and rashes were prevalent during the SARS epidemic. Skin on the cheeks is prone to dermatitis [30] and skin in the ears and nose are particularly sensitive to irritation. Friction and contact stress with PPE amplified the risks [31]. Aybala et al. [32] also related facial lines and redness to tissue softening caused by accumulated moisture under COVID-related PPE.

### 4.2 Structural Equation Modelling

Path coefficients are the proportionality of changes between explanatory (arrow tail) and the response (arrow head) variables. As shown in the model, collective exposure to PPE and sanitary protocols is related to general discomfort. A one-unit increase in the exposure factor score corresponds to a 0.753 unit-increase in the discomfort score. Results of Caglar et al. [33] also showed that with increasing PPE exposure comes increasing symptoms of discomfort. In this study, Visual Discomfort, Skin Irritation, and Breathing Difficulties were found to contribute most to the overall discomfort. Similar to Yuan et al. [34], two of the top three adverse reactions from participants are facial skin indentation and breathing difficulties – heat stress is the third. Benitez et al. [35] also reported a finding where around two-thirds of health care worker respondents experienced visual problems when treating patients during the
Agreeing with this model’s results, Lan et al. [19] pointed out that increased hand hygiene practices posed more risk to overall discomfort than high exposure to PPE. It should be emphasized, however, that this model must be interpreted with caution. This model improves the fit by only 72.4% relative to the fully saturated model [26].

Based on the results of this study, general discomfort is associated with work difficulties. Davey et al. [18] claimed this first in their study about the effect of PPE on both physical and cognitive performance of healthcare workers. Lack of attentional focus which had led to poorer judgment, restricted movements and decreased efficiency was traced back to overall PPE-induced discomfort. This could be the reason for the increased blunders and dropping of things at the workplace.

With regards to demographics, age has been linked closely to dryness and cracking of skin in this study. In this study, the majority of respondents who experience dryness & cracking of skin belong to the age group 51-60, followed closely by those belonging to 41-50 and 31-40. On the contrary, Xia et al. [10] claimed no significant relationship of age groups with skin injury during the pandemic. Findings in this study may be due to skin changes during the aging process that make older people more vulnerable to dry and cracked skin [36]. From the results of this survey, certain departments particularly those that are most involved in processing of goods (e.g., Production and Engineering) reported sticky sensation while wearing COVID PPE. This sticky feeling could be attributed to the adherence of sweat to the body instead of evaporation and is an indicator of heat stress [37]. The association proved to be strongly acceptable due to more strict protocols of these departments with regards to PPE, intensity of their work and their prolonged stay in-line or inside the production area, analogous to the findings about healthcare workers in the ICU department experiencing thermal discomfort [10]. Role is strongly associated with headache in this study. It is experienced mostly by operational workers who do floor-level tasks and work for more than 8 hours. According to Ong et al. [9], wearing PPE for more than 4 hours per day would increase the chance of de novo headache.

In this study, respondents are limited only to workers of F & B companies who rendered service during the pandemic. The Likert scale is limited to only 4 points, excluding Never and Not Applicable. Some indicators and subfactors were not considered in the final model either due to many “not applicable” answers for the corresponding questions or due to very weak significance. Regarding facial discomfort, specific areas of the face are only determined and severity per area was not investigated. The metrics used in measuring work performance is limited only to accuracy and locomotion. Furthermore, the researcher determined which demographic information could affect specific discomfort felt, not the overall discomfort. For future studies, the sample size should be bigger and respondents should be more randomized to achieve more reliable results. This can be done by increasing the period of survey to more than 5 days and using more online platforms for wider distribution of the questionnaire. Lowering the number of indicators and having equal number of questions per indicator (preferably at least 3 per indicator) of discomfort would likely result in a better model fit. Future research can reconsider inclusion of subfactors which were proven to contribute less to latent variables. Since PPEs are limited to face mask & face shield and sanitary protocols only include handwashing & use of sanitizers, future researchers may expand investigation on other types of new normal GMPs and sanitary protocols like surface disinfection [38] as well as on other industries.

5 Conclusion

The researchers conducted a study on the discomfort felt by workers of food and beverage manufacturing companies during the COVID-19 pandemic. Specific parts of the face prone to discomfort were identified. Stretch marks and lines on the nose, itching & redness on the ears, pain & pressure on the ears, and rashes & acne on the cheeks are found to be the most common facial discomfort. To explain general discomfort, a SEM model was proposed and evaluated. Visual discomfort, skin irritation, and breathing difficulty are found to be the main contributors to the overall discomfort. At 5% level of significance, there is evidence to conclude based on the model that the level of exposure to PPE and sanitary measures significantly explains the level of discomfort. It was also confirmed that general discomfort could lead to work difficulties significantly. Lastly, this study revealed that certain discomfort felt are pronounced by demographic characteristics particularly age, department, and role.
6 References

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