Predictive Model on the Severity of Injuries and Musculoskeletal Disorders Affecting the Restaurant Kitchen Workers in the Philippines

Ma. Janice J. Gumasing and Kim D. Lustañas
School of Industrial Engineering and Engineering Management
Mapua University
mjjgumasing@mapua.edu.ph, kdlustanas@mymail.mapua.edu.ph

Abstract

This paper aims to develop a predictive model on the severity of injuries and musculoskeletal disorders encountered by kitchen workers in the Philippines. Previous studies have proved that workers in the kitchen area are exposed to musculoskeletal disorders and injuries due to several factors such as poor facility design, exposure to awkward work posture, poor work environment and other tasks-related factors (Gumasing and Espejo, 2020). Review of related literature states that improper design of physical environment such as ventilation, lighting and noise can cause discomfort, annoyance and dissatisfaction (Niu, et al., 2011), and improper design of workstation wherein repetitive work activities are performed lead to muscle fatigue and stress (Sripaiboonkij & Taptakarnporn, 2014). Hence, the researchers aim to assess the current condition of the kitchen areas in the restaurant industry in the Philippines in order to determine the risk and exposure of the workers to musculoskeletal disorders (MSD) and injuries in terms of environmental factors and task-related factors. Key findings from the study revealed that workers in the kitchen area experience pain and discomfort in the lower back, thigh, shoulder, upper arm, and lower leg. In addition, result of rapid entire body assessment (REBA) proved that risk for upper limb disorders are common in kitchen workers due to their poor working posture and repetitive tasks like cooking, preparing food and cleaning of dining tables. Similarly, NIOSH lifting equation proved that workers are exposed to risk of MSD and injuries due to heavy lifting of kitchen equipment and food plates and utensils. Risk factors identified in the study were further treated and analyzed using regression analysis. The result revealed that factors such as work posture, lifting posture, temperature and working space significantly affect the risk and exposure of workers to MSD; while risk factors such as kitchen layout, production rate, working space, floor type and lighting level significantly affect the risk and exposure of workers to injuries. Given these conditions, the researchers recommend to redesign the facilities and workstation for kitchen restaurant.

Keywords

ergonomic design, kitchen area, restaurant, musculoskeletal disorders, occupational injuries

I. Introduction

A kitchen layout usually includes a plurality of work areas and devices arranged to promote efficient cooking and handling. The kitchen includes a food cooking area for cooking food items which require further processing and assembly into a finished product. Kitchen workers are important part of a restaurant and food service establishments for they are responsible for the quality of the food being served to the customers. However, kitchen workers such as cooks, waiters and staff are exposed to hazards perform manual tasks covering a wide range of activities, some of which can be hazardous to their safety. Kitchen hazards include slippery and uneven floors, dangerous equipment, heavy lifting, crowded workspaces, burns and food safety (Meason, 2019). Hazardous manual tasks can also represent risks to the health and safety of workers, with approximately half of the serious injuries to kitchen workers arising from muscular stress and repetitive movement (www.sa.gov.au). Musculoskeletal disorders (MSDs) include injuries such as sprains, strains of muscles, ligaments, tendons and joints. MSDs most commonly occur from gradual wear and tear to the body. The parts of the body most commonly affected by working in kitchens include the shoulder, back and wrist.

Previous studies and researchers have revealed that workers in kitchen areas are exposed to risk of occupational injuries and musculoskeletal disorders (Gumasing and Espejo, 2020). Contributing factors to ergonomic risks of kitchen workers include strenuous work, poor work environment and work load (Tae-Hoon et al., 2006). The study of Courtney, et al. (2006) showed that kitchen workers are exposed to risks of injuries such burns, slips and falls due to moisture in kitchen floor coming from the oil in hot pans and fryers. Furthermore, workers are also exposed to cuts and lacerations due to exposure to sharp objects like knives, blades and grinders (Haruyama et al., 2014). They are also exposed to improper postures like awkward bending and manual lifting. Repetitive work activities such as cutting, grinding and washing can also lead to muscle fatigue and stress. Because of these, workers experience pain and discomfort in their wrist, hands and shoulders (Sripaiboonkji & Taptakarnporn, 2014).

For this reason, it is important that ergonomics should be considered. Ergonomics is the study of people working efficiently inside a workspace. For restaurant kitchens, that means having both an ergonomic space itself, good layout design and proper design of physical environment. Ergonomics is a science of fitting workplace conditions and job demands to the capability of the working population. The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, poor posture and repetitive task (www.cdc.gov.).

1.1. Objectives

Although there are numerous researchers that were done in order to assess the risk of kitchen workers for musculoskeletal disorders and injuries, however, only limited amount of study had focused on the facility and workstation design of kitchen restaurant using the principles of ergonomics. Given these conditions, the researchers aim to ergonomically design a kitchen workstation and facilities based on environmental and task related factors that will be identified in the study.

2. Review of Related Literature

According to Meason (2015), being a kitchen employee can be a dangerous job because kitchens are full of potential accidents that are just waiting to happen, from cutting from knives to slipping over on liquids. According to the recent data from Philippine Statistics Authority (PSA), non-fatal occupational illnesses and injuries for food service workers increased to 5% in 2015. Injuries that restaurant kitchen workers suffer include sprains, strains, lacerations and burns. Slips, trips, falling, lifting or repetitive tasks are the most common actions leading to the injuries (PSA, 2017). Therefore, there should be measures in place to minimize kitchen hazards and maximize safety of workers.

According to Restaurant Technologies, Inc. (2018), at quick-service restaurants (QSRs), where food is frequently fried, the most common injury for workers tend to be burns that happen in the back of house (BOH). In the casual-dining segment, where there is more food preparation such as slicing and dicing, cuts is the most prevalent injury. Interestingly, servers and front-of-house (FOH) staff at casual-dining restaurants are often the ones to suffer from kitchen-related injuries. In both of these environments, cuts and burns are typically high in frequency but low in severity.

The Study made by Haruyama (2014) in Japan suggest that kitchen workers in Japan experienced frequent burn and cut injuries and MSD. The study subjects exhibited 15.9%, 23.8% and 37.1% prevalence of frequent burn, cut injuries and MSD. Frequent burn injuries were associated with smaller kitchen size and gas kitchen. Suggesting that adequate working space and utilization of electric kitchen system may reduce the risk of frequent burn injuries. LBP was found to be associated to female gender, taller persons, and a large number of meals cooked per kitchen worker.

Similarly, according to the study of Huei-Sheng (2008), the annual incidence of MSDs in Chinese kitchen workers was around 25% and 20% for cooks and references, respectively, and the cook-to-reference risk ratios ranged from 1.29 to 1.35 ($p<0.001$). The most frequently affected body part was the low back, but the epicondyle was at higher risk ($OR>2$) than other sites for the cooks. Cooks are at higher risk of having MSDs complaints and MSDs related to the elbow show the highest risk. Musculoskeletal disorders (MSDs) are common complaints in industry, particularly among workers with intensive manual labor, as a leading cause of work related illness. In many countries, MSDs are also the leading cause of work-related illness.

3. Methodology

3.1. Data Gathering

The researchers conducted the study among the nine (9) restaurant kitchens in Metro Manila wherein large number of workers are located. A total of 140 respondents were involved in the study that includes 120 kitchen workers, 20 supervisors/managers and 6 restaurant owners. The researchers have conducted review of related literature, direct observation, surveys, interview and actual measurement of tools, equipment and materials used by kitchen workers. Devices such as light meter, noise dosimeter, and digital psychrometer were used to obtain the measures for environmental factors. Postural analysis was also done in order to gather data for task related factors. The researchers used Rapid Entire Body Assessment (REBA) to evaluate whole body postural MSD and measure risks associated with the task of kitchen workers. NIOSH lifting equation was also used to assess the manual material handling risks of workers associated with lifting and lowering tasks in their job. The researchers also used Cornell Musculoskeletal Disorder Questionnaire (CMDQ) in order to determine the discomfort location and common types of musculoskeletal disorders experienced by kitchen workers and gather historical data to determine the different types of injuries experienced by the workers in their task.

3.2 Statistical Analysis

Descriptive measures were used to provide an analysis of summary of factors obtained from data gathering. This helped the researches to come up with analysis and draw appropriate conclusions without bias. Collected data from survey, interview and observations were arranged in a manner of which the data can be easily interpreted through the use of frequency count and percentage distribution. In addition, the factors considered in the study were statistically treated and analyzed using correlation analysis and regression method. The researchers also used Quality Function Deployment (QFD) tool to transform the customer's demands into the technical requirements of the workstation design. The researchers also applied ergonomics principles such as anthropometry in order to identify the physical dimensions of the proposed design. The researcher needs to match all these considerations and come up with a proposed workstation. For the design of facilities, systematic layout planning (SLP) was used to arrange the workplace in a layout by locating areas with high frequency and logical relationships close to each other. This process permits the quickest material flow in performing the task.

4. Result and Discussion

4.1. Result of Cases of Injuries

Shown on Table 1 is the result of cases of injuries for the Year 2017-2019. The data were gathered from 9 restaurant kitchens in Metro Manila comprised of 120 kitchen workers. The results of data gathering shows that the most prevalent type of injury is slipping over followed by skin burns, knife injuries, lower back injury and scalding.

Table 1. Cases of Injuries of Year 2017-2019

Summary of Accidents for Year 2017-2019				
Types of Injuries	**2017**	**2018**	**2019**	**Total**
Knife Injuries	10	21	33	64
Slipping Over	43	40	52	135
Scalding Boiling Water/Oil	9	10	1	20
Burns	19	34	37	90
Lower Back injury	10	14	30	54
Total	**91**	**119**	**153**	**363**

4.2. Result of Postural Analysis

Figure 1 showed the overall summary of results of the CMDQ from the 120 respondents of the study and ranked from highest to lowest percentage of risk.

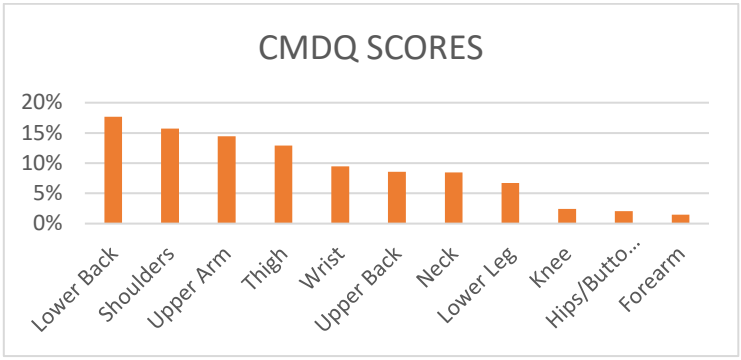


Figure 1. Result of CMDQ Scores

Based on the results, the most affected body parts of workers in terms of discomfort and MSD when performing their task are the following: lower back, shoulders, upper arm and thigh.

In order to validate the cause of discomfort and MSD of workers, the researchers conducted rapid entire body assessment (REBA) based on the work posture of kitchen workers as shown in Figure 2.

Figure 2. Work Posture of Waiter

Table 2. Summary of REBA Scores

Tasks	Score A	Score B	Score C	Activity Score	**REBA Score**
Cook	4	6	6	3	**9**
Waiter	5	4	5	3	**8**
Dishwasher	7	3	7	3	**10**

The result of REBA score as shown on Table 2 indicates that the current work posture of workers pose high risk of developing a range of disorders primariliy to upper limb and lower back associated with the occupational task and must be investigated and changed immediately.

The researchers also assessed the lifting posture of kitchen workers using NIOSH Lifting Equation as shown on Figure 3. The job resulted in poor lifting conditions for both tasks such as lifting of plates from the dining table and lifting of cook wares since the recommended load is greater than the actual load. This means that there is a high risk for workers in developing MSD which caused for concern as the location of the hands of the workers when lifting is outside the preferred lifting zone of 75 cm to 110 cm vertical height and horizontal reach of 40 cm based from 5th percentile male

reach distance with elbow at side of body (www.ergo-plus.com). This proved why majority of the workers experienced pain and MSDs on their parts of the body as reflected in the CMDQ scores of the respondents. The result of NIOSH lifting equation is shown in Table 3.

Figure 3. Lifting Posture of Waiters

Table 3. Summary of NIOSH Scores

		HM	VM	DM	AM	FM	CM	RWL	Load	LI
Lifting of plates	Origin	1	0.78	0.86	0.71	0.65	0.95	15.13	63.25	**4.18**
	Destination	0.5	0.93	0.86	1	0.65	1	13.26	63.25	**4.77**
Lifting of cook wares	Origin	0.82	0.81	0.78	1	0.79	1	20.87	42.5	**2.04**
	Destination	0.78	0.79	0.76	1	0.74	1	17.67	42.5	**2.40**

4.3 Assessment of Environmental Factor

The researchers also assessed the physical work condition of restaurant kitchen area in terms of temperature level, illumination level and noise level. The result of physical assessment is shown on Table 4.

Table 4. Summary of Environmental Factor Assessment

ENVIRONMENTAL FACTOR							
KITCHEN	LIGHTING (in lux)	NOISE LEVEL (in dbA)	TEMP (°C)	WORKING SPACE (in sqm)	PRODUCTION RATE (meals/day)	LAYOUT	FLOORING MATERIAL
Kitchen Area 1	130	83.5	42.1	67.29	140	L-shaped style	ceramic
Kitchen Area 2	90	78.3	52.3	55.23	120	zone style	porcelain
Kitchen Area 3	70	88.2	61.2	49.9	115	zone style	ceramic
Kitchen Area 4	80	78.3	48.5	45.22	110	L-shaped style	ceramic
Kitchen Area 5	60	92.1	55.7	41.63	115	zone style	ceramic
Kitchen Area 6	70	93.2	41.8	42.96	120	L-shaped style	porcelain
Kitchen Area 7	70	71.5	51.3	35.23	95	L-shaped style	porcelain
Kitchen Area 8	80	81.5	38.9	32.67	95	zone style	porcelain
Kitchen Area 9	90	88.7	37.8	37.25	90	zone style	ceramic
Average	**80.2**	**83.9**	**47.7**	**45.3**	**111.1**		

The result of physical environment assessment proved the following: for the lighting level, the average illumination for kitchen areas of restaurant was measured 80.2 lux which is below the recommended illumination level for kitchen areas of 160-500 lux (www.osha.com). For noise level, average noise is 83.9 dBA which is within the recommended noise level for 8-hour exposure of 90 dBA. Average temperature level is 47.7 C which is beyond the ideal comfort zone of workers of 19 C to 26 C. For the working space, average area is 45.3 sqm. Average production rate of workers is 111 meals a day. For the layout, there are 2 types of kitchen layout commonly used in restaurant kitchens such as L-shaped style and zone style. L-shape style layout uses work surfaces, cabinets and appliances in an L shape to maximize space. L shaped kitchen design features two walls that form a perpendicular angle. While zone style layout arranges primary equipment along the walls into "zones", according to purpose. This layout keeps kitchen workers contained within their zones and out of each other's way – an invaluable attribute in tight spaces where kitchen collisions can be both dangerous and wasteful. And for the flooring material, there are two types of material commonly used in kitchen restaurant such as ceramic and porcelain.

4.4. Result of Statistical Analysis

All the data gathered from the initial assessment were used by the researchers to analyze the indicators for task related factors and environmental factors that will be considered in the study to determine the strength of relationship and predict the severity of MSD and injuries experienced by kitchen workers. Correlation and regression analysis were employed as shown in Table 5.

Table 5. Result of Correlation Analysis

Correlation Results for Days Lost				**Correlation Results for CMDQ Score**		
Factors	**Pearson correlation**	**p-value**		**Factors**	**Pearson correlation**	**p-value**
Illumination level	**-0.907**	**0.000**		Illumination level	-0.579	0.002
Temperature level	**0.905**	**0.000**		Temperature level	0.599	0.001
Working space	**0.88**	**0.000**		Working space	0.756	0.000
Production Rate	0.654	0.001		Production Rate	**0.876**	**0.000**
Layout	**0.89**	**0.000**		Layout	0.321	0.112
Flooring material	**-0.863**	**0.000**		Flooring material	-0.621	0.001
Working posture	**0.987**	**0.000**		Working posture	**0.898**	**0.000**
Lifting posture	**0.785**	**0.000**		Lifting posture	**0.945**	**0.000**
Type of shift	0.243	0.287		Type of shift	0.231	0.195
Job type	0.167	0.322		Job type	0.032	0.865
Length of stay	0.387	0.675		Length of stay	0.453	0.093

The results of correlation analysis proved that for injury score, the factors that have strong positive relationship to the days lost are temperature level, working space, floor layout, working posture and lifting posture, this means that as the values of this factors increase, the days lost per type of injury also increase, while factors that have strong negative relationship to days lost is illumination level and flooring type. This means that as the illumination level decreases the days lost per type of injury increases, same with flooring material, as the flooring material becomes more wet, the days lost per injury increases. For the correlation result of MSD score, the data shows that factors that have strong positive relationship to the CMDQ scores of respondents are production rate, working posture and lifting posture. This means that as the values of these factors increase, the severity of MSD of the respondents also increase.

The data were further analyzed and treated using regression analysis. This was used to verify true predictors for discomfort and MSD experienced by workers in the kitchen restaurant. The result of the regression equation is shown below.

Severity of MSD (CMDQ Score) = 15.4 + 0.854 working space + 1.18 temperature + 0.513 work posture + 0.789 lifting posture

Severity of Injury (Days Lost) = 3.53 + 0.165 working space – 0.534 floor type – 0.192 lighting condition + 0.154 production rate + 0.788 kitchen layout

The result showed that factors that have significant effect to the severity of MSD experienced by workers are working space, temperature and lifting posture, On the other hand, factors that have significant effect to severity of injury are working space, floor type, illumination, kitchen layout and production rate. The model summary for the regression model incurred an adjusted R^2 of 89.2% with coefficient correlation (R) values of 0.972, and R^2 of 70.3% with coefficient correlation (R) values of 0.712 respectively which explained that independent variables in the equation are strong predictors for the musculoskeletal disorders and injury of restaurant workers. This served as the focus of the researchers in the development of risk mitigation plan. In addition, the researchers validated if the values used in the analysis are normally distributed even after eliminating all the outliers. Figure 3 showed that the residuals CMDQ are normally distributed and the points are randomly scattered around the line, which indicated that there was no violation in terms of normality, which is a requirement for multiple regression analysis.

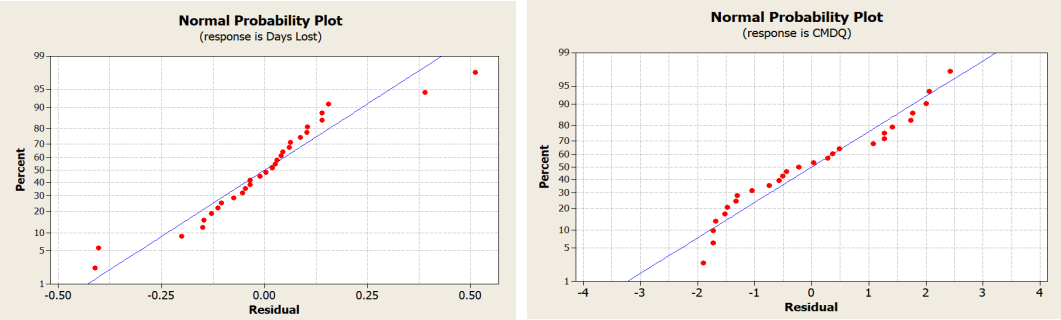


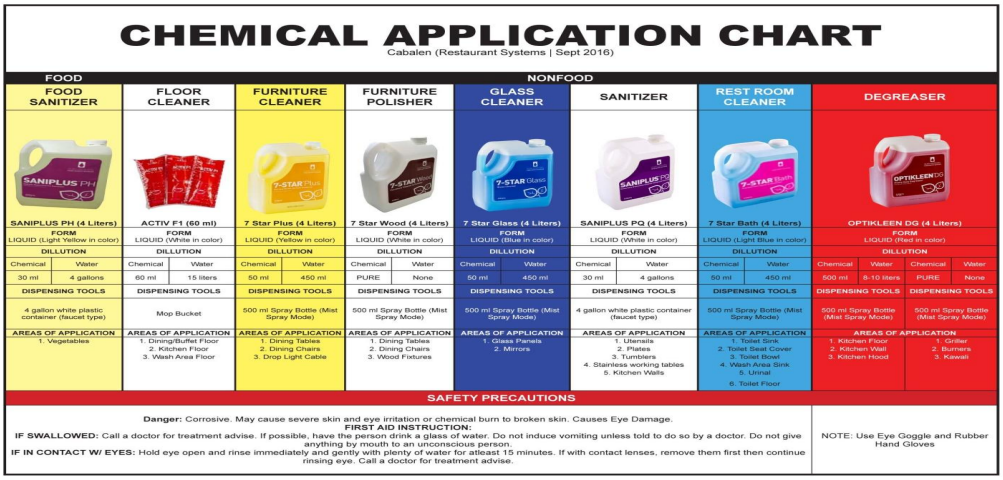
Figure 3. Results of Normality Test

4.5. Proposed Improvements

The results of the analyses have proven the need for the redesign of facilities and workstation for kitchen restaurant. Based on the result of data gathered, slipping over had the highest percentage in kitchen accidents which made It necessary to review the floor type and cleanliness inside the restaurant kitchen. There are a many reasons kitchen employees slip inside the kitchen. Some of the most usual slipping accidents happens near the sinks, mops, grease traps. Given these areas, we can say that what makes the floor slippery is the water, condensation, grease, spilled food etc. Since majority of the restaurants involved in the study are currently using dynasty gray tiles as shown in figure below, the dynasty gray tiles fall under the ceramic type which has a slip resistant surface as well. It was found that most workers in the kitchen are using splashers type of shoes. Splashers are waterproof shoes, made of rubber and used especially in the kitchen. This cost around 100-150 pesos in the market. The only problem with this is that it is not slip resistant. The researcher also found out that most kitchen restaurants use bleach (zonrox) on the tile that has a strong chemical compound that destroys the surface of the tile and remove its non-slip property.

Figure 4. Current Flooring Layout in Kitchen

The researchers therefore recommend the proper use of cleaning compounds and follow the appropriate application as shown in Figure 4.



CHEMICAL APPLICATION CHART

Cabalen (Restaurant Systems | Sept 2016)

FOOD	NONFOOD						
FOOD SANITIZER	FLOOR CLEANER	FURNITURE CLEANER	FURNITURE POLISHER	GLASS CLEANER	SANITIZER	REST ROOM CLEANER	DEGREASER
SANIPLUS PH (4 Liters)	ACTIV F1 (60 ml)	7 Star Plus (4 Liters)	7 Star Wood (4 Liters)	7 Star Glass (4 Liters)	SANIPLUS PQ (4 Liters)	7 Star Bath (4 Liters)	OPTIKLEEN DG (4 Liters)
FORM: LIQUID (Light Yellow in color)	FORM: LIQUID (White in color)	FORM: LIQUID (Yellow in color)	FORM: LIQUID (White in color)	FORM: LIQUID (Blue in color)	FORM: LIQUID (White in color)	FORM: LIQUID (Light Blue in color)	FORM: LIQUID (Red in color)
DILLUTION: Chemical: 30 ml; Water: 4 gallons	DILLUTION: Chemical: 60 ml; Water: 15 liters	DILLUTION: Chemical: 50 ml; Water: 450 ml	DILLUTION: Chemical: PURE; Water: None	DILLUTION: Chemical: 50 ml; Water: 450 ml	DILLUTION: Chemical: 30 ml; Water: 4 gallons	DILLUTION: Chemical: 50 ml; Water: 450 ml	DILLUTION: Chemical: 500 ml; Water: 8-10 liters / Chemical: PURE; Water: None
DISPENSING TOOLS: 4 gallon white plastic container (faucet type)	DISPENSING TOOLS: Mop Bucket	DISPENSING TOOLS: 500 ml Spray Bottle (Mist Spray Mode)	DISPENSING TOOLS: 500 ml Spray Bottle (Mist Spray Mode)	DISPENSING TOOLS: 500 ml Spray Bottle (Mist Spray Mode)	DISPENSING TOOLS: 4 gallon white plastic container (faucet type)	DISPENSING TOOLS: 500 ml Spray Bottle (Mist Spray Mode)	DISPENSING TOOLS: 500 ml Spray Bottle (Mist Spray Mode) / 500 ml Spray Bottle (Mist Spray Mode)
AREAS OF APPLICATION: 1. Vegetables	AREAS OF APPLICATION: 1. Dining/Buffet Floor; 2. Kitchen Floor; 3. Wash Area Floor	AREAS OF APPLICATION: 1. Dining Tables; 2. Dining Chairs; 3. Drop Light Cable	AREAS OF APPLICATION: 1. Dining Tables; 2. Dining Chairs; 3. Wood Fixtures	AREAS OF APPLICATION: 1. Glass Panels; 2. Mirrors	AREAS OF APPLICATION: 1. Utensils; 2. Plates; 3. Tumblers; 4. Stainless working tables; 5. Kitchen Walls	AREAS OF APPLICATION: 1. Toilet Sink; 2. Toilet Seat Cover; 3. Toilet Bowl; 4. Wash Area Sink; 5. Urinal; 6. Toilet Floor	AREAS OF APPLICATION: 1. Kitchen Floor; 2. Kitchen Wall; 3. Kitchen Hood / 1. Griller; 2. Burners; 3. Kawali

SAFETY PRECAUTIONS

Danger: Corrosive. May cause severe skin and eye irritation or chemical burn to broken skin. Causes Eye Damage.
FIRST AID INSTRUCTION:
IF SWALLOWED: Call a doctor for treatment advise. If possible, have the person drink a glass of water. Do not induce vomiting unless told to do so by a doctor. Do not give anything by mouth to an unconscious person.
IF IN CONTACT W/ EYES: Hold eye open and rinse immediately and gently with plenty of water for atleast 15 minutes. If with contact lenses, remove them first then continue rinsing eye. Call a doctor for treatment advise.

NOTE: Use Eye Goggle and Rubber Hand Gloves

Figure 4. Recommended Chemical Application Chart

It was also found that improper working posture and lifting posture are the main causes of injury and MSD experience by workers in restaurant kitchen. It was observed that the maximum load that the workers lift in bussing tables is 63.5 lbs. and according to NIOSH, the acceptable weight limit of lifting at normal condition is only 51 lbs. Therefore, to minimize the risk of MSD and injury, it is advisable to use trolley as shown in Figure 5 for serving dishes and cleaning the tables in the dining area.

Figure 5. Recommended Trolley for Bussing Dishes

The researchers also found that the current physical environment design of restaurant kitchen affects the severity of MSD and injury of workers such as poor illumination, poor temperature level and poor working space. To address these issues, the researchers recommend to redesign the illumination level and ventilation level of kitchen by installing additional lighting fixtures and exhaust fans in the area. It was observed that the average illumination level in the kitchen is only 80.2 lux which is below the recommended illumination level for kitchen areas of 160-500 based on OSHA. It was also observed that the current temperature level in the kitchen areas is 47.7 °C which is beyond the ideal comfort zone of workers of 19 C to 26 C.

5. Conclusion

The findings of the study have proven that workers in restaurant kitchens are exposed to risks of musculoskeletal disorders and injuries. Based on the result of CMDQ, majority of the respondent experience pain in their lower back, shoulders, upper arm and neck. The risk was evident on the scores generated by REBA and NIOSH computed from their body postures while performing tasks. Several risk factors were considered in the study based on review of related literature, direct observation and interview from the people involved in the tasks. The result revealed that factors that affect the severity of injuries and MSD of workers are due to due to awkward working posture, poor lifting posture, poor flooring material, poor illumination level and ventilation level. Given these conditions, the authors suggest to use trolley in bussing the dishes in the kitchen and dining area, use of non-slip shoes for the workers, use of appropriate cleaning agents and compounds for kitchen materials, and installation of additional lighting fixtures and exhaust system in the area.

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Biographies

Ma. Janice J. Gumasing is a Professor of School of Industrial Engineering and Engineering Management at Mapua University, Philippines. She has earned her B.S. degree in Industrial Engineering and Masters of Engineering degree from Mapua University. She is a Professional Industrial Engineer (PIE) with over 15 years of experience. She is also a professional consultant of Kaizen Management Systems, Inc. She has taught courses in Ergonomics and Human Factors, Cognitive Engineering, Methods Engineering, Occupational Safety and Health and Lean Manufacturing. She has numerous international research publications in Human Factors and Ergonomics.

Kim D. Lustañas graduated from Mapua University with B.S. degree in Industrial Engineering. He is a member of Philippine Institute of Industrial Engineers (PIIE) Mapua Chapter and also an active member in Operation Research Society of the Philippines (ORSP) Mapua Chapter. His research interest includes Risk Management, Ergonomics and Human Factors.