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A STUDY OF INDIAN KITCHEN FROM ERGONOMIC CONSIDERATION

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ABSTRACT

Indian women working in the kitchen are subjected to greater stress due to demands of home activities. Because of faulty kitchen designs, they are also exposed to many occupational health problems like musculoskeletal disorders. The present study was conceptualized to devise some aid for helping the women who work in the kitchen to avoid the discomfort and health issues. The users, the Indian women, are not aware of the benefits of ergonomics and Kitchen work triangle. Proper arrangements for the number of storage areas and the counter space for all the essential things required for day to day kitchen activities would enable less time and energy being wasted. This study was carried out by interviewing the Indian women and also using the questionnaire. Dimensions of the kitchen work triangle are recorded by using measuring tape. The data collected were tabulated and suitable QC tools like frequency distribution, Pareto chart, Pie charts, Bar charts, and Cause and Effect diagram were used for analysis of data. In order to understand the utility of the kitchen work triangle and problems faced by women in the kitchen in this study, we surveyed 11 kitchens in Warangal and Nagpur cities in 2017. The major outcome of the study is the homemakers using modular kitchen enjoyed more kitchen usage compared to non-modular and semi-modular kitchen users. This study will help to minimize the physical and energy cost of homemakers to improve work efficiency.

KEYWORDS: *Kitchen work triangle, musculoskeletal disorders, Ergonomics.*

1. INTRODUCTION

Indian women spend a lot of time in the kitchen almost 5-6 hours in a day, which may amount to approximately one-fourth of her lifespan (Kiran Shete 2015) [1]. Right from the childhood to old age, the kitchen activities are performed. Due to this, they are exposed to many occupational health hazards. One of the most important health hazards for women working in the kitchen is the lower and upper back region problem of the body.

Due to the improper lifting of the utensils while bending down, reaching for higher cabinet's, bending while arranging the utensils, holding the head down to cook food, lifting pots and pans while moving these are commonly done while working in a kitchen (Kiran Shete 2015) [1]. The major role is played by the posture and its maintenance in reducing the muscle stress.

The Ergonomics plays an important role and takes into account the user's capabilities and finds methods that make tasks easier utilizing equipment and the surrounding environment. (Abhishek Shukla 2017) [5]The Ergonomics can be applied to various industries, small manufacturing enterprises, in various departments like welding department workers will also suffer from musculoskeletal disorders due to bending, reaching, lifting heavy weights. (Uday V Aswalekar 2017) [12] Mainly the kitchen work area should be properly arranged and adequately designed to reduce the psychological, physical and temporal cost of homemaker.

2. LITERATURE REVIEW:

· According to Karwowski W & Rodrick D, the ergonomics are classified into three main domains like ergonomics related to cognitive, physical and organizational. The cognitive ergonomics deals with reasoning, thinking, attitude, attention, consciousness, argument to have communication among personnel and other components. Physical ergonomics deals with physiological, anthropometric characteristics, development of socio-technical systems, policies and procedures are dealt with by macro ergonomics or organizational ergonomics (Karwowski W& Rodrick D (2001)) [2].

· Health and safety problems should be considered because a large percentage of the workforce in the organizations gets affected. (Helali F (2009)[3].

· The application/implementation of ergonomics in work structure design can accomplish equity between task demands and workers (Das B & Shikdar AA (1999))[4].

· Abhishek Shukla provides the information about Human Factor Ergonomics deals with various factors related to industrial ergonomics, fundamental approach, design-driven approach (Abhishek Shukla 2017) [5].

· There are different phases like application, design, redesign, and uninterrupted improvement of the structure these all come under the Human Factor Ergonomics (Japan Ergonomics Society 2006).

· Musculoskeletal disorders can occur due to bending, reaching, wrong posture, and forceful exertion. These impacts significantly on musculoskeletal disorders (Punnett L& Wagman D (2004) Lei Let al. (2005))[6].

· Kitchen worktops, shelving, and sink heights are the areas that ergonomics can be applied to. (Peace et al., 2007)[7].

· Energy will be more depleted while doing grinding activity in sitting posture rather than standing posture because tendons will compress and the lady feels more fatigue (Bhargava 1997)[8].

· Mostly the ergonomists use questioners and visual observation to understand the problems of women and the workers because these are very flexible and easy to use (Barriera-Viruet et al. (2006)[9].

3. MAJOR WORKS CARRIED OUT IN KITCHEN:

The major works carried out by Indian women in the kitchen are as follows:

Chopping vegetables, cooking vegetables, kneading dough, other activities.

Main activities in Kitchen centers

The kitchen can be divided into three centers. Mixing and preparation center, Clean up the center, Cooking and serving center. There are the three main activity centers where the Indian women work, daily, in the kitchen shown in Table-1

Table-1: The types of kitchen centers and kitchen activities

S. no	Main kitchen center's	Kitchen Activities
1.	**Mixing and preparation center**	· Near fridge, near the sink (may have its own sink separate from the main cleanup sink)' · Near trash and compost containers · Needs counter space · knife storage, cutting boards, measuring and mixing utensils, small appliances such as food processor or ble nder, casseroles and baking dishes, flavorings, cookbook storage, graters
2.	**Clean up center**	· Main sink · Dishwasher, garbage disposal, trash · Storage for cleaning materials. · Dishtowels, paper towels, garbage bags. · The materials, food storage containers, everyday dishes.
3.	**Cooking and serving center**	· The main item in this area is the stove. · Gas should not be placed near the draughts. · Cupboards and drawers in this area should contain equipment relation to cooking and serving.

3.1 Major occupational health problems faced by the women and possible causes:

Types of work-related musculoskeletal disorders:

According to (Isabel L. Nunes 2011) [10], the frequency of work-related musculoskeletal injuries has led to classification and definition of these conditions in the medical and occupational environments. The scientific community understands how to treat the conditions, it also provides the information about design processes and equipment to mitigate the risk factors that engineers can utilize it. Work-related musculoskeletal disorders can affect all areas of the body. The major musculoskeletal disorders faced by Indian women are given in Table-2

Table 2.The major health problems of women and results related to it.

S. no	Health problems of women in the kitchen	Results	References
1.	**Back Injuries**	· Back injuries take place because of the overexertion of pressure when lifting a heavy object or improper bending and postures. · The most frequently affected part of the body is back. · Back is nothing but the spinal cord. The discs are different in size and are filled with a fluid called spinal fluid which acts as shock absorbers. · Lifting an object, ben ding for a long period results in an increase of pressure on discs. This leads to the bulging out of the discs, which exerts pressure on the spinal nerve. · Therefore, it leads to back pain.	(Isabel L. Nunes 2011) [10]

2.	**Carpal Tunnel Syndrome**	· Carpal tunnel syndrome is a condition where the median nerve is compressed when passing through the waist. · Symptoms of this syndrome include numbness, burning sensation in fingers. If it is more severe then, it includes pain, wasting of the muscles at the base of the thumb, dry · Many of the symptoms firstly occur at night. This syndrome may be only confined to a specific part of the hand, other than the whole. · If untreated, it may spread from the wrist to the shoulder. · It can be caused by kneading the dough, making roti, cleaning utensils in the kitchen.	(Isabel L. Nunes 2011) [10]
3.	**Tendonitis**	It is characterized by tenderness at the point of inflammation and followed by severe pain upon themovement of the affected joint. Tendonitis is an inflammation of the tendon sheaths around the joint. Excess use of a joint can result in tendonitis. This can be commonly caused in the wrist, elbow and shoulder joints. In the kitchen, this may be due to kneading dough.	(Isabel L. Nunes 2011) [10]
4.	**Tenosynovitis**	· Tenosynovitis is an injury which is caused by the repetition and movement. · The Synovial sheath of the joints is affected. · Wrist, The base of the thumb is severely affected in tenosynovitis. · High intensified and forceful movements of the wrist may be the cause. · Its symptoms are swelling, paining, losing the grip, tenderness and hearable cracking on movement. · In the kitchen, t his may be due to making *roti*, kneading the dough, cleaning utensils.	(Isabel L. Nunes 2011) [10]
5.	**Ischemia**	· The condition for where the blood supply is insufficient is called ischemia. · It is commonly caused by the pressure in the palm of the hand which stops the supply further to the other part resulting in fatigue and numbness. · The blood vessels are supposed due to excessive pressure thus causing ischemia. · In the kitchen, it may be due to the kneading dough.	(Isabel L. Nunes 2011) [10]
6.	**Frozen Shoulder**	· Frozen shoulder starts off with stiffness and slowly develops into a shoulder pain. · As a result, the patients are not able to move their shoulder. · Dystrophy of the shoulder jointtissue takes place due to which a severe pain is observed. · Frozen shoulder occurs when kind of works are done. · Generally, in the kitchen, if the platform is too high above the elbow frozen shoulder can be sighted.	(Isabel L. Nunes 2011) [10]

7.	**Cervical spondylosis**	· Cervical spondylosis affects the neck and spine. · Due to degeneration of the intervertebral joints, cervical spondylosis is developed. · It causes pain in the neck and shoulders. · Causes generally due to the lifting of heavyweights on the shoulder. · Uncomfortable and improper working position in the kitchen can cause cervical spondylosis.	(Isabel L. Nunes 2011) [10]
8.	**Thoracic Outlet Syndrome**	· When the blood vessels between the neckand the shoulder are supported by some external pressure, thoracic outlet syndrome is seen. · The symptoms include numbness, shoulder pain, pain in the arms etc. · Prolonged usage of arms and shoulder in an uncomfortable raised position or carrying on the heavy object are the causes. · In the kitchen lifting the heavy objects may result in thoracic outlet syndrome.	(Isabel L. Nunes 2011) [10]
9.	**De Quervain's Syndrome**	· The prolonged usage of thumb may result in this syndrome. · Frequent moments with so much of force in the wrist and thumb are the consequences to De Quervain's Syndrome. · Its symptoms are the pain, swelling, numbness irritating, in the moment of thumb. · In the kitchen, this may be due to making the roti, cleaning utensils etc.	(Isabel L. Nunes 2011) [10]
10	**Trigger finger**	· Trigger finger is an injury which is the result of the excessive usage of fingers in gripping the heavy objects. · Its symptoms include pain, swelling. · In the kitchen, it may be cutting vegetables, cleaning utensils etc.	(Isabel L. Nunes 2011) [10]

***3.2* Task-Related risk factors:**

Repetition, force, posture, vibration, temperature extremes, and static posture (Isabel L. Nunes2011) [10].These are most widely accepted task-related risk factors. The risk factors for each region of the body are described in this review as follows Table-3.

Table 3: The task-related factors and risks.

S. no	Task-related risk factors	Risks
1.	**Neck and shoulder risk factor**	· Either repeating moments of the neck or repeating moments of the shoulder. · Overstrain on the neck causes an increase in pressure. · Prolonged down head posture of neck/shoulder.
2.	**Shoulder risk factors**	· Over moments of shoulder joints including injuries. · When the arm is stretched far long by a greater angle between the upper hand and torso results in shoulder risk factors.
3.	**Elbow risk factors**	· Frequent rotation of the lower hand, stretching of the wrist. · When the upper limb is stretched continuously, an amount of pressure is generated. · Frequent rotation, frequent moment, motion consisting of abduction seizures.

4.	**Upper limb – wrist risk factors**	· Repetitive moments of either finger or wrist. · Stretching of the wrist, seizures. · The amount of pressure exerted when forceful moments are done. · Generally, in the cold environment the exposed parts hands, foot, enter the state of numbness which when exerting pressure is harmful.
5.	**Lower back region risk factors**	· The Lifting of heavy objects require a far greater strength and also pressure. · An uncomfortable, irritable loading position for a long period or sometimes just a fraction of seconds. · When sat, a sudden moment of a jerk, for example in driving, this produces vibration.

3.3 Factors which affect kitchen working:

There are many factors which affect the kitchen activities. These create a disturbance while the lady performing tasks (like cooking, cutting vegetables) (University of Illinois 1949) [11]. Some of these are shown below Table-4.

Table 4. The major typical problems in the kitchen and risks

S. no	Typical problems in the kitchen	Risks
1.	**Problems related to storage space, storage utensils &Equipment, poorly planned storage.**	There are many problems related to storage space, some of them are given below: · There is no space for keeping pans and it is quite difficult to remove the pan which is below. · There is no proper storage for *polpat* and *belan*, tray and chopper. · Proper storage is not there for keeping potatoes, onions, garlic, and ginger. · The major problem in the kitchen is lack of storage place utensils can't be placed properly.
2.	**Inadequate window area and ventilation**	· Due to inadequate windows and doors in the kitchen. The women working in the kitchen will get suffer from a headache, shortness of breath. · There will be a lot of suffocation in the kitchen and unnecessary heat due to improper ventilation.
3.	**Poor lighting**	· The main problems of almost 70% of kitchens are in poor lighting. · Mainly in some of the kitchens having poor lightning like in some specific tasks preparing food, cutting vegetables. · Poor lighting can affect the quality of work and it is the health hazard.
4.	**Poor workflow**	· If the cooking range, refrigerator, and sink are placed very close to each other, then the kitchen triangle will be very small, it creates a lot of mess or disturbance in the workflow. · If properly balanced kitchen triangle is not maintained in the kitchen then it brings poor workflow.

5.	**Problems related to Reaching, Bending, and Posture**	· There is a problem with kitchen platform height, if the kitchen platform is not according to the height of the women then it will one of the major problem related to posture. · It is very difficult to reach the cupboard shelves which are in the top. · The heavy utensils and pans cannot carry by women by bending down.
6.	**Problems of Strength and Dexterity**	· Most of the women working in kitchen reported in closing taps, kneading the dough, opening the jars, lifting heavy utensils and water vessels.
7.	**Pan Storage Problem**	· There is a lot of mess with pan storage that proper storage is not available. · If the storage space is available also the handles get stuck into the wire mesh and it is a very difficult task to remove. · And there is no storage available for an easy accessory of pans.
8.	**Roti making**	· If the cooking range in front of the person then it is very difficult to place *polpat* and *belan* due to insufficient place available.

4. RESEARCH METHODOLOGY:

In order to find out the various types of the kitchen in India and the problems faced by the women while working in the kitchen, we surveyed 11 kitchens in Nagpur and Warangal and used the concept of the kitchen work triangle. The study was carried out using a questionnaire, actually observing the work and also interacting with the ladies working in the kitchen.

Kitchen work triangle:

Kitchen work triangle was formalized by the School of Architecture of the (University of Illinois 1949) [11] with the three main functions in a kitchen as ***storage, preparation,*** and ***cooking***.

The main functions are carried out between the stove, refrigerator, and sink. The experts make up these three points and the imaginary line between them and are referred to as the kitchen triangle. The kitchen triangle is shown below Figure: (1).

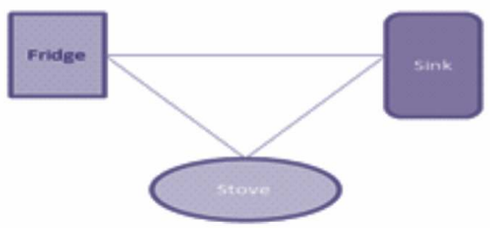

Figure-1. Kitchen work triangle (Illinois in 1944)

Table 5. The different types of kitchens and description:

S. no	Types of kitchens	Description
1.	Modular kitchen	· Modular kitchen is a new type of kitchen in this we can disassemble the kitchen and can fix it to a new place by assembling the parts. · The kitchen consisting of kitchen cabinets, platforms, chimneys, Designed storage space for all the kitchen items (like pans, cooking spoons, cylinder, mixer grinder, basins etc). · It is a closed kitchen.
2.	Semi-modular kitchen	· The semi-modular kitchen consists of a platform which is made out of marble stone it is permanently fixed to the wall it cannot be easily moved to another place. · We can add shutters, trolleys, and cabinets, shelves below the countertop. · It is semi closed kitchen.
3.	Non-modular kitchen	· In the non-modular kitchen, the countertop is already made out of stone and shelves will present we should dump and arrange our utensils openly. · It is not closed kitchen; all the utensils will appear outside.

Kitchen work triangle guidelines:

According to University of Illunois [11]the guidelines to be followed in the kitchen work triangle are as follows:

- The leg of the triangle should be in between 4 feet (1.2m) to 9 feet (2.7 m).
- All the three sides of the triangle should be between 13 feet (4.0 m) and 26 feet (7.9m).
- By more than 12 inches (30 cm) cabinets or other obstacles should not intersect any leg of the triangle.
- There should be no major traffic flow between the legs, if possible.
- A tall cabinet or a full-height obstacle should not come between any two points of the triangle.

4.1 Types of kitchen layouts:

The kitchen layouts differ from house to house according to the space available for kitchen according to University of illunois. There are 5 different types of kitchen layouts as shown in Table-6.

Table-6. The types of kitchen layouts, description of the layout and advantage, disadvantages

S. no	Kitchen layouts	Description	Advantages	Disadvantages
1.	Single wall/ corridor layout	Here work triangle is a single line and it is suitable for small homes and apartments.	It is very cheap in cost and suitable for small families and it has limited space.	Kitchen triangle is not formed and has to travel longer distances for preparing food and washing utensils.
2.	**U shaped**	Here two adjoining walls are connected to each other to form L shape. The sink is centrally located and both sides stove and fridge is located.	There is no traffic in the workflow. It is suitable for small and medium kitchens. And can adjust to any length.	The corner spaces will be wasted; it is not efficient for large kitchens and multiple cooks.
3.	**L shaped**	This uses three sides of walls of kitchen one side covers stove and another side it consists of a sink, it is in U shape.	There is a lot of cupboard space in it , no traffic flow disruption in the workflow. Suitable for small, medium and larger kitchens.	This is not suitable for larger kitchens without an island in middle. Not suitable for narrow kitchens also.
4.	**Parallel wall**	Parallel wall kitchen consists of two walls opposite to each other.	There is a lot of space available for storage, workspace and cabinets mostly it is effective for apartments with less space.	It needs more lightning and can be difficult for through traffic.
5.	**Island kitchen**	It consists of an island in between either it is L shape or U shape.	It is very useful for cutting vegetables, storage space will be more below the platform, it cans also double the storage space.	An island kitchen disrupts the workflow.

4.2 User Research Survey:

Objective:

The objective of the study is to understand the user Perception about kitchen and storage methods as well as needs requirements in the kitchen space.

1. The Number of persons in the family :

Out of 11 families surveyed-

· 9 families have 4 persons each which belong to Conjugal Family.

· 1 family has 5 persons and is of Conjugal Family.

· 1 family has 14 persons and is of joint Family. These details are shown below (Fig: 2)

2. A Number of the user doing job and service:

Out of 11, only 4 kitchen users were doing outside job or service. Also, their working time in kitchen varied as compared to others, (Fig: 3)

Figure-2: (Number of persons in the family)

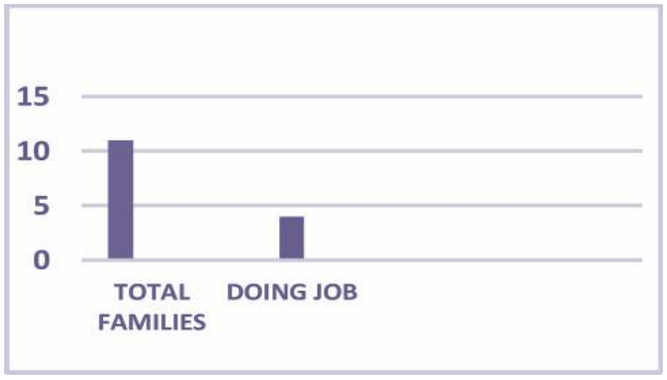

Figure: 3 (Comparison of total families and doing the job)

3. Average daily time working in the kitchen:

Out of 11 families, the highest number of users working in a kitchen is 4 and average daily time is 6 hours, this is shown in below Table-7 and (Fig: 4)

Number of users	Working hours
1	4hours
5	5hours
4	6hours
1	7hours

Table7. (No of users and working hours)

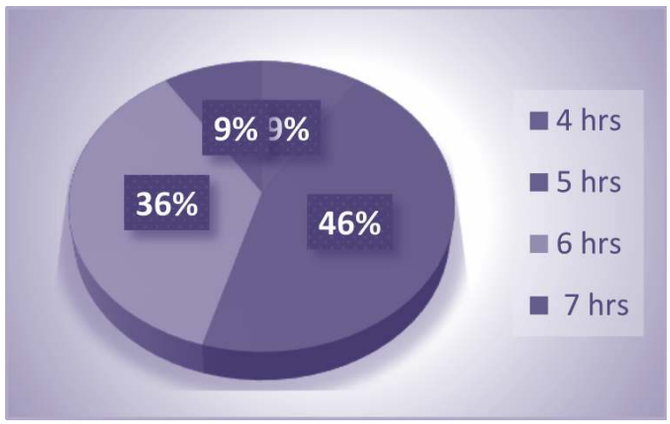

Figure: 4 (Highest number of users and working hours)

4. Type of Kitchen Used:

Out of 11 kitchens, no family is using the modular kitchen and 7 families are using the non-modular kitchen, this is shown in Table-8 and (Fig: 5)

Number of users	Kitchen type
0	Modular kitchen
4	Semi Modular Kitchen
7	Non Modular Kitchen

Table8. (Number of users and kitchen type)

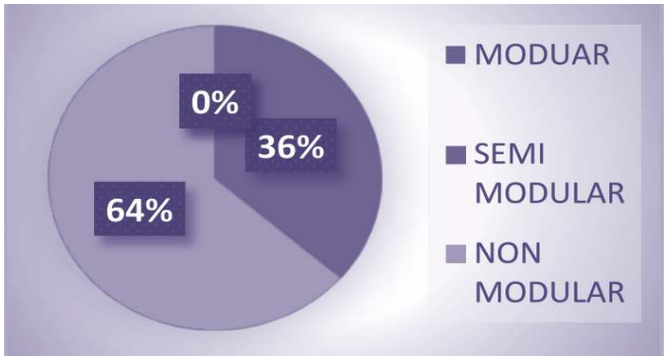

Figure-5: (Type of kitchen used)

5. The Shape of The Platform:

Out of 11 kitchens, 5 users are using the single corridor, 4 are using L shape and 2 are using U shape kitchens are shown in Fig: 6 and Table-9

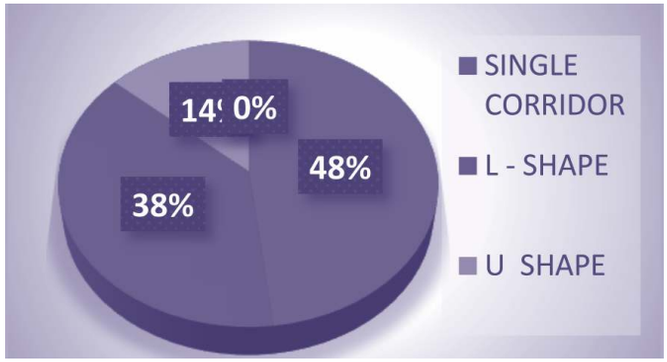

Figure 6. (Shape of kitchen platform)

Number of users	The Shape of Kitchen Platform
5	Single Corridor
4	L Shape
2	U Shape

Table: 9 (Number of users and shape of the kitchen Platform)

6. A Number of Kitchen Users Using The Refrigerator In The Kitchen:

Out of 11 kitchens,

- Only 3 Users found who are using the refrigerator in Kitchen and remaining 8 Users are using in the drawing room or any other place, Due to the Unavailability of space in the kitchen for keeping the refrigerator.
- Some Users Kept in drawing room, For them to put the items and take out items from refrigerator have to travel More Distance and which also consume time Especially this is not suitable for those who are doing Job/ service Because for them Morning is of rush hours Performs many activities simultaneously Requires more energy to accomplishing every task For working women as well as non working women who have to make Tiffin's and breakfast, they have to finish all the activities in a less time.
- However, As per Work Triangle, Refrigerator should be inside the kitchen for smooth workflow. So for designing the Kitchen Work triangle concept and guideline should be kept in mind. This is shown in (Fig: 7)

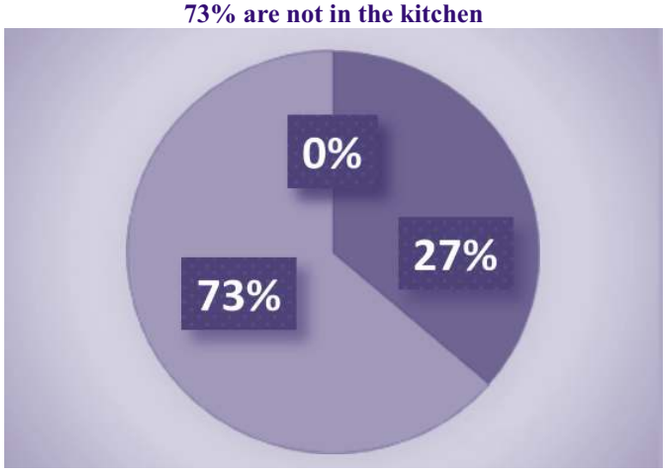

Figure: 7 (Number of kitchen users using the refrigerator in the kitchen)

7. Standing Aid In The Kitchen:

Out of 11 kitchens,

- A number of users need standing aid in the kitchen are 6.
- This is due to the uncomfortable kitchen platform height, sink height, so for easy working, reaching they use a small stool of wood. This is a more common problem in Non Modular kitchen.
- Most of the times it is relatively hard to reach up to the cupboard shelves to access larger items such as pans, plates, and bowls so users are using a stool to reach up. This is shown in (Fig: 8)

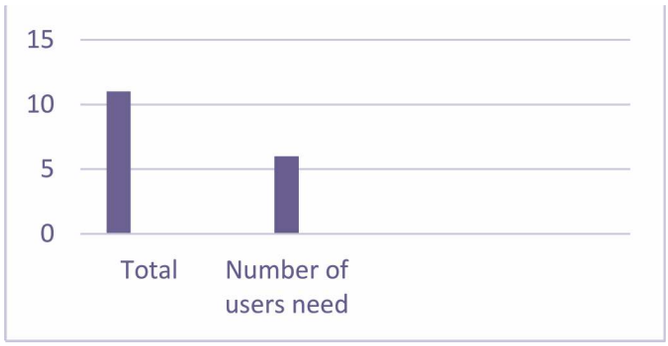

Figure: 8 (Total number of users and users needs to stand in the kitchen)

8. Activities Did Sitting On The Floor:

Out of 11 kitchens,

- Nine users found who do Activities like chopping vegetables, Kneading dough, serving food sitting on the floor due to the Unavailability of space on the kitchen platform or some users are comfortable with this because of Daily routine habit, they don't want to perform this activity on kitchen platform because of Longstanding. (Fig: 9)

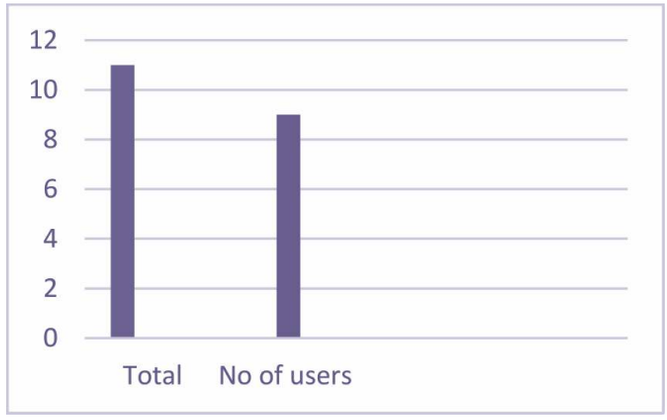

Figure: 9 (Comparison of total number of kitchens and activities done on sitting floor)

9. A Number Of Users Who Can Clean Utensils In Washroom And Sink:

Out of 11 kitchens,

- Four users are using washroom for cleaning the Utensils, because of space constraint in the kitchen near the sink, but for small utensils like a spoon, breakfast plate etc. they use Sink. Six users are using sink only to clean the Utensils. One user has no sink inside the kitchen so they use the washroom. (fig: 10)

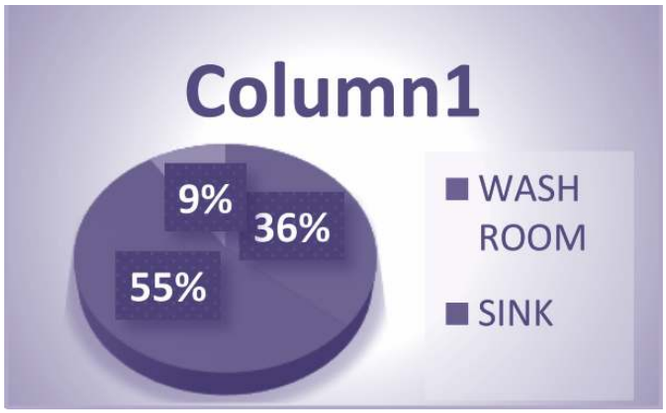

Figure: 10 (Number of users who can clean utensils in washroom and sink)

4.3 Research Analysis:

User's reality about kitchen spaces:

- Install Kitchen units only once for a lifetime.
- Unaware of the importance of ergonomics in kitchen space.
- Unaware of the importance of the work triangle according to activities and workflows to minimize the working time during rush hours.

Why Most of the users goes for Non-Modular and Semi-Modular Not for the Modular kitchen?

- For Non Modular kitchen users, the cost is the constraint, and they are comfortable with the Non-Modular Kitchen.
- For Semi-Modular Kitchen Users also Cost is the constraint and they are also comfortable with the Semi-Modular Kitchen because they know as such there is no such difference between Semi-Modular and Modular except in modular kitchen allows disassemble the whole kitchen and it to a new space and fix it all over again.

5. CAUSE AND EFFECT DIAGRAM:

Here we have identified the possible causes of the problems of women working in the kitchen Fig (11).

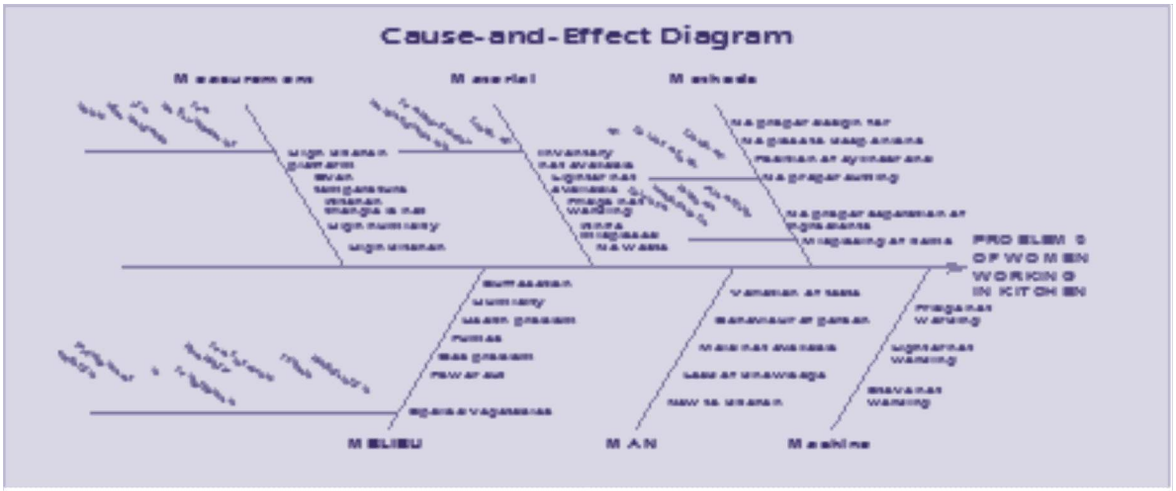

Figure-11: (The effects for problems of women working in the kitchen).

The cases occurring in 11 kitchens and the frequencies are listed in the below table-10.
Table10. The causes and the frequencies are listed in the following table

SR.NO	CAUSES	K 1	K 2	K 3	K 4	K 5	K 6	K 7	K 8	K 9	K 10	K 11	Total
1	New to kitchen				✓								1
2	Maid not available					✓				✓		✓	3
3	Stove not working properly	✓						✓		✓	✓		4
4	Fridge not working properly	✓	✓				✓	✓					4
5	Lighter not working	✓	✓				✓				✓	✓	5

6	No maintenance of inventory	✓	✓	✓	✓		✓	✓		✓	✓	✓	9
7	kitchen platform problem	✓	✓				✓						3
8	High humidity	✓					✓	✓			✓		4
9	Kitchen triangle is not formed	✓	✓	✓			✓	✓		✓	✓	✓	8
10	No mixer grinder		✓				✓						2
11	No proper design for storage of pans	✓					✓			✓			3
12	The position of cylinder and stove not proper									✓			1
13	No proper cutting methods	✓								✓	✓	✓	4
14	Inadequate window area and ventilation	✓				✓			✓		✓		4
15	Poor lightening	✓					✓		✓				3
16	Problems related to Reaching, Bending and posture.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11
17	Dough and roti making problems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11
18	Kitchen space is less	✓	✓	✓							✓	✓	5

6. PARETO ANALYSIS:

From the above table-10 considering the frequencies and causes the Pareto chart is drawn that is showed below Fig: 12 From the Pareto, we can identify the major causes which are the creating problem for the women working in the kitchen.

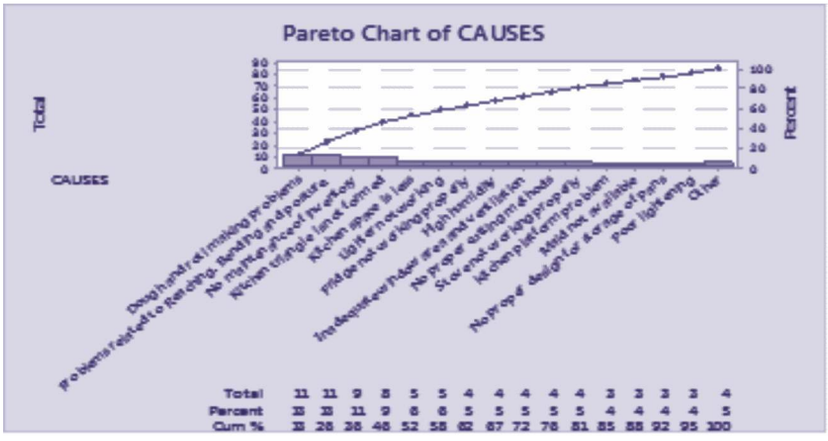

Figure-12: (The main causes are shown in above Pareto chart)

7. PUGH MATRIX:

The major causes are considered from the Pareto chart, the rating is given to the problems to select the major cause in the kitchen that is listed down below in table- 11.

S.no	Problems	Important to homemaker	Design parameter	Total rating
1.	Problems related to Reaching, Bending and posture.	8	9	17
2.	Dough and roti making problems	7	6	13
3.	No maintenance of inventory	7	7	14
4.	Kitchen triangle is not formed	9	10	19

We have visited 11 numbers of kitchens:
The kitchen dimensions are shown in the below Table- 12

Table 12. (The 11 kitchen triangle dimensions are shown in the following table).

S.NO	A1 (ft^2)	A2(ft^2)	An (ft^2)
Kitchen 1	78.75	18.95	59.79
Kitchen2	88.3	18.39	69.907
Kitchen 3	76.737	32.68	44.05
Kitchen4	194.362	41.543	149.45
Kitchen 5	146.604	30.503	112.74
Kitchen 6	75.619	11.914	29.75
Kitchen 7	102.35	52.797	49.552
Kitchen 8	90.213	42.075	45.076
Kitchen 9	123.341	33.932	89.408
Kitchen 10	90.213	65.045	25.168
Kitchen 11	75	28.728	46.2711

A 1= Area of the kitchen room, A 2 = Floor area occupied by kitchen platform,
A = Available floor area in kitchen

KITCHEN1: NON-MODULAR

Figure-13 (Non-modular kitchen)

KITCHEN2: NON-MODULAR

Figure-14: (Non-modular kitchen)

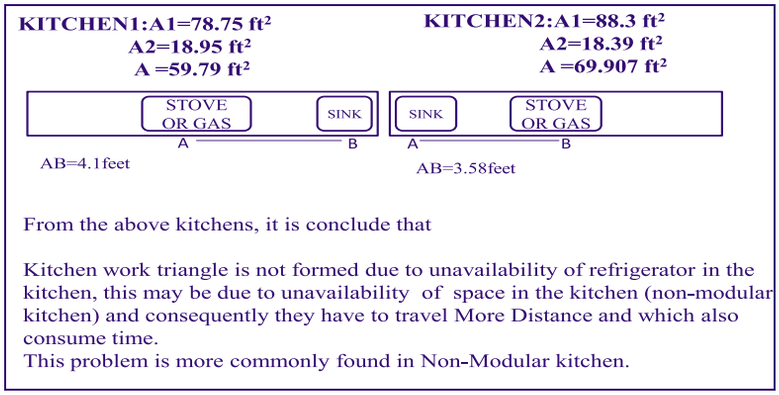

Figure-15 (It represents K1 & K2 Kitchen Triangle)

KITCHEN4: SEMI-MODULAR:

Figure-16: (Semi-modular kitchen)

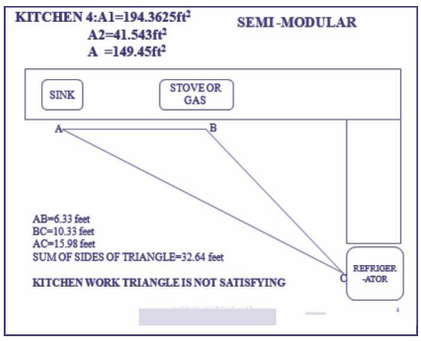

Figure-17: (It represents k4 triangle dimensions)

From the semi-modular Kitchen 4, it is concluded that,

- It is the very spacious kitchen, the area of the kitchen room is very large and the available floor Space area is more and unnecessary space is empty.
- Due to the above problem, kitchen work triangle dimensions are large and not satisfying the kitchen work triangle rule consequently, Use has to travel more distance while working in the kitchen between stove to the refrigerator and sink to the refrigerator and unnecessary time is also wasted.
- The advantage of this kitchen is that there is a smooth workflow in the kitchen due to the availability of large space.

KITCHEN 5: SEMI-MODULAR:

Figure-18: (Semi-modular kitchen)

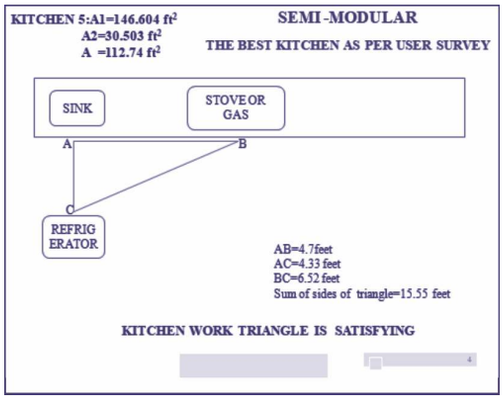

Figure-19: (It represents k5 triangle dimensions)

From the semi-modular Kitchen 5, it is concluded that,

- It is the very spacious kitchen, the area of the kitchen room is very large and the available floor Space area is more.
- Kitchen work triangle dimensions are in limit satisfying the kitchen work triangle rule consequently, User is also comfortable with the kitchen while working because everything is within the range of reach.
- There is no major traffic flow through the triangle and there is no obstacle while working there is a smooth workflow in the kitchen due to the availability of sufficient space in the kitchen and due to the kitchen work triangle rule is satisfied.
- In the kitchens with deeper drawers that support the weight of the plates, pans, bowls, cooking spoons, vessels, and larger units with open sides that we can able to pull outside and can access easily for the women working in the kitchen.

8. PRESENT CONDITION AND SUGGESTED IMPROVEMENTS:

The suggested improvements for present conditions are as follows:

8.1 Providing Easier Access and More Storage:

The proper design storage methods and easier access tothe kitchen items are:

- The kitchen storage is one of the most important problems of every Indian woman working in the kitchen.
- There is a way to create space in the kitchen by installing some extra shelves to display crockery, cookbooks etc. if the kitchen incorporated with hooks and holders so that towels, mugs, utensils can be hung to them and it is a way to save space in the kitchen.
- There are so many adjustable wall cupboards are available that these cupboards can pull downwards and forward to easily reach the items.
- If standard kitchens having at least one unit of this type installed it will be helpful for many people.
- There shall be open storages without any cupboards, so that makes items easier to access.
- Frequently used items should be available at most convenient locations.
- These are some of suggestions and improvements for storage problems in the kitchen.

8.2 Kitchen ventilation design:

The main factors that need to be taken into account when designing a kitchen ventilation system are

- Firstly we should consider the layout and shape of the kitchen.
- How many members are working in the kitchen?
- Need for easy cleaning and maintenance.
- The workload of the kitchen.
- Amount, Type and power of cooking equipment used.
- Energy efficiency.
- **Comfort:**

The general parameters considered for a comfortable kitchen:

- Temperature: 20 degree Celsius in the winter and 28 degree Celsius in the summer, with a maximum difference with the outside temperature of 6 degree Celsius.
- Relative humidity: approximately 70%.
- Air velocity: less than 0.5 m/s.

8.3 Ensuring Enough Light and Instruction Visibility:

Lightning in the kitchen is one of the important factors the suggestion for enough light and instruction visibility is as follows:

- The windows are placed above the cooking range or above the sink to ensure enough light in the workplace and also allow women to look outside while working in the kitchen.
- Mainly the natural light should be allowed to fall on the workplace where the women perform daily tasks. (Like preparation tasks etc.).

8.4 Solutions related to Reaching, Bending, and Posture:

The reaching, bending, and posture are major health factors related to people working in the kitchen the solutions are as follows:

- Related to reaching are like the shorter stature people cannot reach the items which are on the top, so they can place a stool/wooden board or they can stand on the sink to reach the items easily.
- In the kitchens with deeper drawers that support the weight of the plates, pans, bowls, cooking spoons, vessels, and larger units with open sides that we can able to pull outside without needing to reach into a cupboard.
- Crockery rack if placed in drawer helps to take out individual items as needed very easily.
- The solutions related bending are oven should at mid-level; non-tipping oven shelving; countertop dishwasher, not frequently used items should be kept on higher shelves, rotating shelving in corner units.
- The solution for the posture is the height of the platform should be lower to the short women and higher to the tallest women to avoid health problems.

8.5 Roti making:

Roti making is one of the daily preparation tasks for the Nagpur women working in the kitchen the solutions are shown below:

For this activity, space is required for keeping ***polpat***, casserole, oil and ***atta*** container

- For the roti making the space available should be more for keeping *polpat*, casserole and *atta*, so for a right-handed person the stove should be at corner of the platform and space available in front of her should be empty so that she can easily place all items and prepare the dough and can transfer the *roti* to stove easily. Vice versa for the left-handed person.

8.6 The Designed Solution For Pan Storage:

- The designed solution for pan and other utensils, in this there is a separate slot for keeping the handles so that panhandle will not get stuck into the wire mesh and between the other utensils and it is comfortable for the user to take out the pan.

9. CONCLUSIONS:

- Women were subjected to greater stress as the demands of home activities caused more discomfort in faulty kitchen designs.
- The homemakers using different kitchen areas and shape also had a direct impact on the fatigue and energy expenditure of the homemakers.
- The homemakers using modular kitchen enjoyed more reasons for their kitchen usage compared to non-modular and semi-modular kitchen users.
- The users are not aware of the benefits of ergonomics and Kitchen work triangle.
- The number of storage areas, counter space for all the essential things required for day to day kitchen activities would enable less time and energy being wasted.
- The risk of facing discomfort and musculoskeletal disorders was less in an ergonomic kitchen because of the good planning of effective reach zones in the kitchen area.
- To ensure enhanced work efficiency of homemakers kitchen design has to be developed on the basis of Ergonomic principle and Anthropometric measurements of homemaker.
- The result of the present study will be used to understand and improve work, worker, and workplace related to have health and safety of the homemakers. This will help to minimize the physical and energy cost of homemakers to improve work efficiency.

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