CHAPTER 3

RESULTS

A cross-sectional study of two hundred and forty-nine females (never smoked) was carried out. Out of them one hundred and forty-seven women were using biomass fuels for domestic cooking and they were labeled as exposed and one hundred and two not using the biomass fuel were labeled as controls. Control subjects were using clean fuel e.g. Liquefied Petroleum Gas (LPG) or electricity for domestic cooking.

3.1 Physical Characteristics: The mean age ± standard deviation of the exposed subjects was 31.64 yr ± 14.36 yr while the mean ± standard deviation age of control subjects was 31.09 yr ± 11.40 yr. The mean height ± standard deviation and range of exposed and controls were 151.00 cm ± 5.72 cm (range 138 cm to 170 cm) and 150.99 cm ± 6.44 cm (range 125 cm to 166 cm) respectively. The mean weight with standard deviation and range of exposed and control subjects were 43.95 kg. ± 9.26 kg (range 26 kg to 87.2 kg) and 45.96 kg ± 9.31 kg (range 26.4 to 78 kg) respectively (Table 3.1).

The mean and range of body mass index (BMI) of the exposed and the control subjects were 19.26 kg/m² ± 3.82 kg/m² (range 12.54 kg/m² to 39.00 kg/ m²) and 20.29 kg/m² ± 3.71 kg/m² (range:12.8 kg/m² to 33.8 kg/m²) respectively. The average body fat (BF%) of exposed and control subjects was 27.27% ± 6.75% and 27.70% ± 6.72% respectively. The average VFA (%) of exposed and control subjects were 2.74±3.48 and 3.29 ± 2.89 respectively. The average
basal metabolic rate (BMR) of exposed and control was 1073.26 ± 128.29 and 1091.11±107.55.

BMI study show that 45.6% subjects among exposed and 56.4% among controls having normal BMI (18.5kg/m²-24.9 kg/m²). BMI < 18.5 kg/m² (under weight) was 47.6% among exposed subjects and 34.7% among controls subjects. Over weight was observed among 4.1% exposed and 6.9% controls (BMI 25-29.9 kg/m²). The prevalence of obesity (BMI >30 kg/m²) was approximately equal in both the groups (2.7% exposed vs 1.98% control) (Table 3.3).

Analysis of body fat reveals that 54.6% among exposed subjects and 43.4% among control subjects having normal body fat (Normal 20-30%). Prevalence of low body fat percent was observed more among control (14.1%) as compare to exposed (12.3%). Similar pattern was observed in high body fat. High body fat prevalence was more among control (42.4%) as compared to exposed (33.1%). Normal (1%-9%) significant prevalence (p<0.05) of visceral fat per cent was observed among the exposed (96.9%) subjects as compared to controls (89.9%). A reverse pattern was observed in high visceral fat prevalence (> 9.1%) among control group (5.1%) as compared to exposed (3.1%) (Table 3.3).

3.2 Life Style and Socio-economic: Fifty nine (40.1%) exposed and 37 (36.3%) control subjects belong to joint family while 59.9% exposed and 63.7% controls were from nuclear family. The marital status shows that 67.4% exposed and 81.4% control subjects were married. Literacy rate of exposed and controls were nearly equal. 41.5% exposed and 42.2% control subjects
were literate. Among them maximum (31.3% exposed and 20.6% control) subjects had passed high school (10th standard). Only 0.7% subject among exposed and 4.9% among controls were graduate. Illiteracy was also equal among both the groups (exp 58.5%; con 57.8%) (Table 3.1).

The socio-economic status of the studied exposed subjects showed that 91.2% had social class 4 followed by 8.2% subjects with social class 3. Among controls 98.0% subjects belong to social class-4 and only 2.0% belong to social class-3 (Table 3.1).

The housing pattern was not uniform. Houses were constructed in an unplanned way. Generally houses were thatched one, some houses were made of flattered drums or discarded metallic boards and some houses were cemented. Basically, there are 3 types of houses, the Kachcha houses (mud wall thatched houses), pucca houses (cemented houses) and mixed (wall cemented and thatched roof). Exposed subjects have kachcha, pucca and mixed houses in equal proportion i.e 33.33 % each while in controls 90.2% houses were pucca followed by kachha houses (6.9%) and mixed houses (2.9%). Among the exposed the percentage of subjects having kitchen inside the houses was 71.4% while in controls it was 87.2% (Table 3.1).

Among exposed 53.7% and 46.1% control were house wives. Thirty two percent exposed and 12.7% controls were students. Rest 14.3% exposed and 41.2% females were working. Among exposed maximum females (8.1%) were labour while in controls 23.5% were kitchen workers. (Table 3.2).

3.3 Blood pressure and pulse: The mean systolic blood pressure of exposed subjects was 115.76±14.22 mm Hg. The range of systolic blood pressure was
90-156 mm Hg. In controls the mean systolic blood pressure was 117.22±11.22 mm Hg with the range 96-142 mmHg. Among exposed 3.4% subject had high systolic blood pressure (>140 mm Hg) where as among controls only 2.0% subjects had high systolic blood pressure (Table 3.1).

The mean diastolic pressure was 75.73 ± 8.32mm Hg. The range of diastolic blood pressure was 60-106mm Hg. Among them 4.1% subjects had high diastolic pressure (>90 mm Hg). In controls the mean diastolic blood pressure was 77.08 ± 6.78 mm Hg with the range of 60-92 mm Hg. Only 2.0% of control subjects had high diastolic blood pressure (Table 3.1).

The mean pulse rate [beats per minute (bpm)] among exposed was 74.79 bpm ± 3.74 bpm (range 66 bpm-84 bpm). In controls the mean pulse rate was 77.37 bpm ± 4.55 bpm (range 70 bpm-88 bpm) (Table 3.1).

3.4 Exposure Index wise analysis: Exposure index (hr-yrs) wise analysis shows that average hour exposure to biomass fuel smoke per day among exposed subjects was 1.83 hr ± 0.75 hr (range 0.5hr to 4 hr) while in controls it was 1.21 hr ± 0.43 hr (range 0.5hr to 2.5 hr). The average year of exposure to biomass fuel smoke of exposed subjects was 16.27 yr ± 12.39 yr (range-0.5 yr to 50 yrs) while in controls it was 11.35 yr ± 9.12 yr (range-0.33 yr to 40 yrs). Average exposure index of exposed subject was 34.97 hr-yrs ± 30.77 hr-yrs (range 0.25 hr-yrs to 135 hr-yrs) while in controls the exposure index was 13.94 hr-yrs±12.38 hr-yrs. (range 0.3 hr-yrs to 52 hr-yrs). Here it was observed that exposure index of exposed subjects was more than controls. It was because that exposed subjects using biomass fuel require more time for cooking as compared to control subjects using clean fuel (Table 3.4).
The exposure wise exposed and control were divided in groups of ten based on their exposure index i.e. EI (hr-yrs) 0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90. These EI were grouped into three groups for analysis purpose. These three groups were up to 20 hr-yrs or 0-20 hr-yrs [Exp. (n) = 63, Control (n) = 78]; >21–50 hr-yrs [Exp. (n) = 45; control (n) = 24] and > 51 hr-yrs [Exp. (n) = 39; control (n) = 0].

3.5 System wise morbidity: System wise morbidity was observed in respiratory, gastro intestinal tract, musculoskeletal, dermal, ocular, dental, genitourinary systems etc. (Table 3.5). Prevalence of respiratory morbidity was observed among exposed subjects (18.4%) was significantly higher (p<0.05) as compared to controls (8.8%). Prevalence of gastro intestinal tract (GIT), musculoskeletal problems (MSP) and Genito urinary tract (GUT) morbidities among the exposed were 19.1% and 24.5% and 12.9% respectively while among controls the morbidities were 25.5% and 26.5% and 23.5% respectively. Differences in the morbidities were not found to be statistically significant as compared to controls.

The ocular problem was nearly equal in both the groups (exp. 24.5%, con=27.5%). Significant higher prevalence (P <0.05) of dermal problems was observed among exposed subjects (10.9%) as compare to controls (3.9%). Dental problem was also significantly (P <0.05) higher in exposed (46.9%) as compare to control (34.3%). A mixed pattern was observed among others. 'Other' includes many health problems of lesser magnitude. ‘Others’ includes headache, fever, hair problems, allergy, discoloration of skin, fatigue, numbness, swelling on body, palpitation etc. Headache (exp 11.6%; con 6.8%), fever (exp 8.2%; con 4.9%) are more marked among exposed as
compare to controls. Significant higher prevalence (P < 0.05) of allergic problems was also observed among exposed subjects (6.1%) as compare to controls (1%) (Table 3.5). Detailed morbidity of various systems are described below:

3.5.1 **Respiratory morbidity:** The overall prevalence of respiratory problems was significantly (p <0.05) higher in exposed subjects. The prevalence of breathlessness, recurrent cough and cold, productive cough, pain in throat and pulmonary tuberculosis were 6.1%, 7.5%, 1.4%, 2%, 1.4% respectively while in controls only breathlessness (3.9%), recurrent cough and cold (3.9%) and productive cough (1%) were prevalent (Table 3.6).

3.5.2 **Musculoskeletal morbidity:** The overall prevalence of MSP was 24.49%. Among exposed the backache (4.08%), body ache (4.08%), pain in joints (4.08%) and pain in limbs (11.56%) were prevalent among exposed while in control subjects the prevalence was 6.86%, 4.90%, 7.84%, 5.88% respectively (Table 3.7).

3.5.3 **Gastro intestinal morbidity:** Non significant prevalence of GIT problems was 19.05% in exposed while in control it was 25.5%. Among them the common complaints were pain in abdomen (exp 8.84%; con 15.69%), excess gas formation (exp 2.04%; con 3.92%), constipation (exp 0.68%; 1.96%), reduce appetite (exp 2.04%; con 0%), distention in abdomen (exp 0.68%; con 0%), and loose motion (exp 2.72%; con 0.98), hemorrhoids (exp 1.36%; con 0%) and giddiness (exp 0.68%; con 2.95%) (Table 3.8).

3.5.4 **Menstrual impairments** (other than GUT morbidity): A highly significant overall menstrual impairment (OR=11.06; 95% CI: 5.8-21.29; p<0.001) was observed among exposed (74.15%) as compare to controls (20.6%). The impairment in menarche age (up to 11 years and 16 and above)
among exposed subjects was 26.53% while in controls it was 13.72%. This impairment in menarche age of menstrual cycle was significantly (p<0.05) higher than controls. There is significant difference in variables of menstrual cycle among exposed [length of cycle (p<0.05), bleeding duration (p<0.05)] when compared to controls. The prevalence of early menopause (up to 37 years) among the exposed and the control were 8.16% and 1.96% respectively and this difference was significant (p<0.05) (Table 3.9).

3.5.5 Adverse pregnancy outcomes, neonatal and infant mortality:
Adverse pregnancy outcomes include miscarriage, stillbirth, low birth weight, and early infant mortality.

Among exposed, 99 (67.35%) women and among controls, 83 (81.37%) women were married. The total number of pregnancies among 99 exposed and 83 controls were 401 and 279 respectively. The results of various adverse pregnancy output and mortalities are as follows:

3.5.5.1 Intrauterine mortality: A non significant prevalence of still birth was observed. It was 5.74% among exposed as compared to controls 3.23%. But the odds ratio [1.83 (0.79-4.33)] indicates the increasing trends of effects of bio mass fuel on prevalence of still birth. The prevalence of miscarriage was almost equal in both the groups (exp 12.47%; con 12.9%) (Table 3.10).

3.5.5.2 Neonatal mortality: A significant (p<0.05) neonatal mortality (death within 28 days after birth) was observed in the houses of exposed subjects (2.24%) while in controls the mortality was 0.36% (Table 3.10).
3.5.5.3 **Infant mortality:** Similarly, a highly significant (p<0.001) infants mortality (death of baby between 28th days and one year) was also observed in the houses of exposed subjects (6.73%) as compared to controls (0.72%) (Table 3.10).

3.5.5.4 A non significant pattern was observed in the prevalence of deaths of toddlers [OR 1.16 (0.24-6.17)] but their health may impair due to bio mass fuel smoke (Table 3.10).

3.6 **Exposure index wise morbidity:** Life-time cumulative exposure to biomass fuel was assessed with cumulative exposure index (CEI). Exposure index wise morbidity, is as follows:

3.6.1 **Respiratory morbidity:** Exposure index wise no significant association was found in respiratory morbidity. In EI 0-20 hr-yrs., 21-50 hr-yrs and > 51 hr-yrs, the respiratory morbidity was 12.70%, 24.44% and 20.51% respectively (Table 3.11).

3.6.2 **Muscle skeletal problems:** The prevalence of muscle skeletal problems among exposed subject in EI 0-20 hr-yrs, 21-50 hr-yrs and > 51 hr-yrs was 4.76%, 31.11% and 48.72% respectively which was significant higher in higher EI groups (EI-21-50, EI >51) compared to EI 0-20 (p< 0.001) (Table 3.11).

3.6.3 **Gastrointestinal tract (GIT) problems:** A significant (p<0.001) increasing trend in prevalence of GIT problems with increasing EI (EI 0-20 hr-yrs, 21-50 hr-yrs and > 51 hr-yrs) among the exposed subject was observed. The prevalence was 4.76%, 20% and 41.03% respectively (Table 3.11).
3.6.4 Ophthalmic (ocular) problems: The prevalence of ocular problems among exposed subject in EI 0-20 hr-yrs, 21-50 hr-yrs and > 51 hr-yrs was 6.35%, 31.11% and 46.15% respectively which also show increasing trend with increasing EI (p < 0.001) (Table 3.11).

3.6.5 Genitourinary tract problems: Significant higher prevalence (p < 0.001) of genitourinary tract problems was also observed in subject in EI 21-50 hr-yrs (31.11%) compared to rest of the two groups, 0-20 hr-yrs (3.17%) and > 51 hr-yrs (7.69%) (Table 3.11).

3.6.6 Allergic problems: Exposure Index wise prevalence of allergy was 2.38%, 8.89% and 5.13% among exposed subjects of EI 0-20 hr-yrs, 21-50 hr. yr and > 51 hr-yrs. while in controls it was 1%, 0% and zero percent respectively. But the overall prevalence of allergic problem was significant (P<0.05). (Table 3.5).

3.6.7 Headache: Exposure index wise prevalence of headache was 14.28% among exposed subjects in EI 0-20 hr-yrs as compared to control (7.7%) subjects. The difference was not significant but the trend showed that exposure to BMF might precipitate the problem of headache [OR 2 (0.6-6.8)]. In EI 21-50 hr-yrs and > 51 hr-yrs the prevalence of headache was 11.11% and 7.8% while in controls it was 4.16% and `not applicable’ because no exposure index (>51 hr-yrs) among controls respectively.

3.6.8 Menstrual impairments: Exposure index wise the problem was in the impairment in length of cycle. The prevalence of impairment in length of cycle in subjects exposed for more than 51 hr-yrs (33.33%) was found to significant higher (p<0.05) as when compared to exposed subjects 0-20 hr-yrs (15.87%) and 21-50 hr-yrs (11.11%). No significant changes in prevalence were observed between 0-20 hr-yrs and 21-50 hr-yrs. A similar trend was
observed in the variation in the menstrual flow. The prevalence of impairment in menstrual flow in subjects exposed for more than 51 hr-yrs was 74.3% which was found to significant higher \( p < 0.001 \) when compared to exposed subjects 0-20 hr-yrs (36.51%) and 21-50 hr-yrs (71.1%). No significant change in prevalence was observed between EI 0-20 hr-yrs and 21-50 hr-yrs. The next reproductive impairment was alteration in the menopausal age. The prevalence of early menopause among the subjects exposed for 21-50 hr-yrs (13.33%) was found significant \( p < 0.05 \) when compared to the exposed subjects 0-20 hr-yrs (1.59%) and >50 hr-yrs (12.82%). The next variation was found in the bleeding duration. In EI 0-20 hr-yrs, 21-50 hr-yrs and >51 hr-yrs the non significant trend of complaints of bleeding duration was observed (Table 3.12).

3.6.9 Infant mortality, neonatal mortality and congenital problems: Out of 401 pregnancies among 99 exposed women, 285 (71.1%) children were alive. EI wise these married women were divide in three groups. EI 0-20 hr-yrs having 15; EI 21-50 hr-yrs having 45 and EI >51 hr-yrs having 39 married women. Similarly the total number of alive children (285) was also divided in three groups. EI 0-20 hr-yrs having 20; EI 21-50 hr-yrs having 124 and EI >51 hr-yrs having 141 alive children. There is no congenital problem, no neonatal and infant mortality in EI 0-20 hr-yrs. In EI 21-50 hr-yrs the congenital problem in new borne was 1.61%, neonatal mortality was 4.84% and infant mortality was 20.97% while in >51 hr-yrs the congenital problem in the newborn was 1.42%, neonatal mortality was 2.13% and infant mortality was 0.71%. The congenital problem in the newborn and neonatal mortality was not significant but the findings denote the chances of congenital problem [OR 1.41 (0.11-11.50)] and neonatal mortality [OR 2.34 (0.51-12.09)] may increase due to exposure to biomass fuel smoke. The infant mortality was
highly significant (p<0.001) in EI 21-50 hr-yrs (20.97%) as compared to EI >51 hr-yrs (0.71) (Table 3.13).

3.7 Lung function studies: A significant decline in the air flow limitation of PEFR (p<0.05) and reduced FEV\(_1\) among women using biomass fuels for cooking was noted, as compared to women using cleaner fuels. Decline in mean PEFR (3.69 L/s) and FEV\(_1\) (1.34 L/s) was observed in biomass fuels-exposed women compared to women using cleaner fuel (Fig 3.1). Decline in PEFR and FEV\(_1\) denotes the airway obstruction in upper and lower airway status among women exposed to biomass fuel smoke. This shows the obstructive type of respiratory problem prevalent among them.

3.8 Hematological studies: The mean hemoglobin (Hb) concentration was 11.64 gm% ± 1.09 gm% among exposed subjects (range 10-14.3gm%) while in controls the Hb was 11.33 gm%±1.41 gm% (range 10.5-14.0gm%). The total leucocytes count (per cu mm) was 7251.72±1626.25 (range 4250-10120) among exposed while in controls it was 7457.78±2011 (range 5000-10600). The differential leucocytes count (%) show polymorphs (P) 61.75±7 (range 49-77), lymphocytes (L) 33.96±6.23 (range 19-44), eosinophils (E) 1.36±1.85 (range 0-7), monocytes (M) 2.54±2.2 (range 0-7) while in controls these were 57.24±6.79 (range 50-75), 34.27±5.71 (range 21-40), 3.64±0.72 (range 2-5), 4.82±1.78 (range 2-6). The polymorphs were significant (p<0.05) as compare to controls (Table 3.14).
3.9 Serum analysis: A non significant pattern was observed in serum analysis. Little low serum creatinine was observed among 35.3% of exposed subjects while in controls 100% subjects had serum creatinine with in normal limit (WNL). High SGOT was observed among exposed (8.3%) as compare to controls (20%). High SGPT was also observed among exposed (16.7%) as compare to controls (4%). Serum glucose was within the normal limit among the exposed (93.3%) as compared to controls (100%). Only 6.7% exposed show low glucose level (Table 3.15).

3.10 Urine examination: A non significant pattern was observed in urine sample. The urobilinogen was high among exposed (35.7%) as compared to controls (0%). Protein was present in traces nearly equally in both the groups (exp=14.3%, con=16.7%). Glucose and bilirubin were not detected in any sample of both exposed and controls. The pH of urine was within the normal limit in both the groups (Table 3.16).
3.11 Air monitoring: The indoor air quality was conducted in the houses near *chulha* (earthen stove) at breathing zone show following findings:

1. The mean concentration of CO was 34.732 ppm ± 17.620 ppm (range 7.5 ppm - 75.07 ppm).

2. The mean concentration of CO$_2$ was 766.951 ppm ± 55.477 ppm (range 703 ppm - 969 ppm) while

3. The mean concentrations of PM$_{2.5}$ and PM$_1$ were 1.19 mg/m$^3$±2.53 mg/m$^3$ (range 0.0 mg/m$^3$-13.419 mg/m$^3$) and 1.19 mg/m$^3$±1.95 mg/m$^3$ (range 0.0-7.649 mg/m$^3$) respectively.

4. The CO concentration near LPG stove was 1.0 ppm.