Annex 18 - Comparative tables of main pollutants for three countries

This section contains *unadjusted* data for the main pollutants with data matched for Round 1 - 3 and Round 2 - 4 to reflect seasonal changes. The distribution of these pollutants across the thirty households was skewed, moderately so for PM, but much more for the carbon monoxide measures. For purposes of comparison and ease of interpretation, both means (and 95% confidence intervals) and medians (and inter-quartile ranges) are reported. Means have been compared with paired t-tests, and distributions with Wilcoxon paired signed rank sum test) . It can be seen that very substantial reductions in particulates were recorded for Sudan, whilst in Kenya and Nepal, the reduction were more modest. The differences between Nepal rounds 2 and 4 were disappointing, and the reasons for this are discussed in Chapter 8.

Table 7.1.1   24 hour PM$_{resp}$ data
This table refers to the mean and median weights (in µg/m^3) of particulates measured over 24 hours and recorded for thirty households for each of four rounds.

Kenya: PM$_{resp}$ 24 hour data				
Round 1		Round 3		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
605.54	462-750	303	223-384	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
545.62	328-794	237	126-480	<0.0005
Round 2		Round 4		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
454.25	327-580	283	204-361	0.009
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
419.13	193-635	233	166-356	0.009
Nepal: PM$_{resp}$ 24 hour data				
Round 1		Round 3		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
1264.11	387-2140	385.99	302-469	0.046
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
771.63	323-978	314.09	216-518	<0.0005
Round 2		Round 4		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
569.53	428-710	590.19	442-737	0.832
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
481.61	348-690	510.69	351-747	0.784
Sudan PM$_{resp}$ 24 hour data				
Round 1		Round 3		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
1149.10	704-1593	228.19	176-279	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
651.09	279-2133	189.81	131-264	<0.0005
Round 2		Round 4		Sig.
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
633.98	433-834	313	242-294	0.002
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**[+]
455.57	192-986	265	199-346	0.006

$^@$Inter-quartile range
*Paired t-test (parametric)
[+]Wilcoxon Paired Signed Rank Sum Test (non-parametric)

Room levels

Table 7.1.2   24 hour mean and median CO for room
The CO-monitor recorded 1440 minute-interval readings to make up 24 hours. For each household the mean was calculated in parts per million (ppm). Table 2 shows the mean and median of all thirty household means. Around half the carbon monoxide has been removed in the Kenyan households whereas in Nepal, the reduction is much greater between the first and third round than between the second and fourth round. One possible reason for this is that a road is being put through close to the village and substantial quantities of beer were being brewed during the round 4 monitoring. This confounding variable was further investigated, and is reported later. The reductions in Sudan are sizeable.

Kenya: 24hr mean & median CO – room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
8.91	4.18-13.64	3.75	2.81-4.69	0.038
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
5.84	4.24-7.65	2.70	2.21-6.43	0.001
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
7.82	5.82-9.83	3.55	2.22-4.89	0.001
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
6.26	4.46-9.54	2.68	1.70-4.55	<0.0005
Nepal 24hr 24hr mean & median CO – room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
10.50	5.31-15.69	4.41	2.94-5.88	0.007
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
6.30	4.20-11.77	3.54	2.00-5.14	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
9.75	7.00-12.51	6.89	5.31-8.47	0.068
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
7.06	4.55-13.26	6.06	3.56-9.66	0.232
Sudan: 24hr mean & median CO – room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
13.15	9.10-17.20	3.38	1.28-5.49	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
10.99	5.10-19.44	1.42	0.83-2.54	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
9.62	6.08-13.16	1.96	1.13-2.79	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
7.08	2.94-12.27	1.39	0.52-2.46	<0.0005

[@]Inter-quartile range
*Paired t-test (parametric)
[+]Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.3   24 hour 90th centile CO – room

It is useful to know the physical process involved in smoke reduction in a room. Looking at how the distribution of pollutant changes can provide good information. Table 3 shows the 90th percentile for kitchen CO that is the level in ppm which is exceeded in 10% of the readings over the 24 hours, equivalent to just under 2.5 hours. For example, it can be seen that although the median levels of kitchen CO in Kenya dropped by around one half, the impact on the 90th percentiles (the higher levels) were greater, being reduced by about two-thirds.   Further analysis of the 98th percentile (the level exceeded by 2% of readings, about 30 minutes) and the 99th percentile (exceeded for about 15 minutes) indicated that the very highest peak levels of kitchen CO during the day were also markedly reduced . Note that the levels in Sudan were markedly reduced, whilst those in Nepal, though appreciable, were much less marked.

Kenya 24hr 90th centile - room				
Round 1		Round 3		Sig.
Mean	95% CI	Mean	95% CI	p-value*
25.51	10.95-40.07	9.56	6.82-12.29	0.039
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
16.00	12.00-22.00	6.00	4.00-15.00	<0.0005
Round 2		Round 4		Sig.
Mean	95% CI	Mean	95% CI	p-value*
23.03	16.05-30.00	8.77	5.35-12.19	0.001
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
16.50	13.00-29.18	6.00	4.75-10.00	<0.0005
Nepal 24hr 90th centile – room				
Round 1		Round 3		Sig.
Mean	95% CI	Mean	95% CI	p-value*
31.23	14.55-47.91	13.10	8.59-17.61	0.011
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
17.90	13.00-37.00	10.00	6.00-15.25	<0.0005
Round 2		Round 4		Sig.
Mean	95% CI	Mean	95% CI	p-value*
25.83	18.13-33.54	20.31	15.11-25.51	0.233
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
17.00	12.00-33.00	15.00	10.90-29.00	0.462
Sudan 24hr 90th centile - room				
Round 1		Round 3		Sig.
Mean	95% CI	Mean	95% CI	p-value*
41.43	26.64-56.23	8.34	2.33-14.36	<0.0005
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
33.00	12.00-61.00	3.00	2.00-4.50	<0.0005
Round 2		Round 4		Sig.
Mean	95% CI	Mean	95% CI	p-value*
29.91	18.26-41.56	4.50	2.71-6.29	<0.0005
Median	IQR$^{@}$	Median	IQR$^{@}$	p-value^{+}
20.50	9.25-40.50	3.45	2.00-5.75	<0.0005

$^{@}$Inter-quartile range
*Paired t-test (parametric)
$^{+}$Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.4   Number of minutes CO > 3 - room

This project was interested in removing the kitchen smoke, but it only affects the woman when she is in the room. This measure was taken to get an indicator of the number of minutes during which the fire was emitting sufficient carbon monoxide to generate a reading of 3ppm or more on the CO monitor. In all cases, the time during which the room was polluted with carbon monoxide reduced after the intervention. Note particularly that Nepal showed a considerable reduction in this measure.

Kenya: No of minutes CO > 3 - room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
720	616-823	494	399-587	0.003
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
728	484-886	440	327-693	0.005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
702	607-797	495	390-601	0.002
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
697	502-858	427	292-681	0.003
Nepal: No of minutes CO > 3 - room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
645	552-739	427	347-507	<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
674	514-827	427	284-594	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
729	616-842	551	474-629	0.022
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
718	527-881	553	407-696	0.018
Sudan: No of minutes CO > 3 - room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
633	543-723	214	92-535	<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
670	445-789	109	23-229	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
483	393-574	181	91-271	<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
507	284-648	136	24-233	<0.0005

@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.5   Number of minutes CO > 9 – room

This further cut-off was examined to assess the amount of time that levels of CO in the kitchen were potentially health-damaging. Comparisons with air quality guidelines however is complicated by the fact that kitchen levels are not continuously high over long periods. Nevertheless, it was thought useful to consider CO > 9ppm, as this is the 8-hour limit set by the USEPA.   It can be seen from the interquartile ranges (IQRs) that many homes exceed 9 ppm for 8 hours, albeit not continuously - many of the households are exposed for much longer. During this time, the mean and median values of carbon monoxide over 24 hours are around three times the CO>9 level. The effect on health of this chronic exposure to CO is not yet well characterised by it is believed to be damaging particularly for pregnant women, and people with other health problems. Note the very marked reduction, especially in Sudan and Kenya.

Kenya: No of minutes CO > 9 – room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
322	256-387	116	61-171	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
285	214-362	36	1-248	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
301	252-350	97	48-146	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
291	231-341	47	5-155	<0.0005
Nepal: No of minutes CO > 9 - room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
359	276-442	187	129-245	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
316	226-512	148	53-270	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
376	278-475	302	241-363	0.186
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
324	188-577	259	172-411	0.304
Sudan: No of minutes CO > 9 - room				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
386	299-474	107	25-189	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
410	185-541	26	0.5-76.5	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value**[*]
290	218-363	67	31-103	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
281	141-397	31	0.5-104.5	<0.0005

[@]Inter-quartile range
[*]Paired t-test (parametric)
[+]Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.6   24 hour mean and median CO – woman
The project sought to find ways to alleviate smoke in the room, but also to encourage women to consider their health and to address ways of reducing their exposure. Conversely, there is always the chance that women would find the rooms more pleasant for work when less smoke was polluting the room. This measure looked at how the intervention affected her personal exposure. It can be seen that in all cases but Nepal, the levels of exposure were reduced – some significantly. This is particularly notable in Sudan, but also in the median values for both Kenya and Nepal rounds 2 to 4.

Kenya: 24hr mean and median CO - woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
5.03	1.90-8.17	2.98	2.41-3.55	0.191
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
3.05	2.48-4.12	2.63	1.83-3.88	0.163
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
4.18	2.78-5.57	2.57	2.16-2.99	0.023
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
3.07	2.54-4.93	2.67	1.70-3.04	0.004
Nepal: 24hr mean and median CO - woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
3.16	2.15-4.17	3.55	2.61-4.50	0.557
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
2.69	1.66-3.69	3.23	2.03-4.59	0.581
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
5.39	3.90-6.87	3.30	1.94-4.66	0.072
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
4.38	2.95-7.25	2.47	1.31-3.35	0.027
Sudan: 24hr mean and median CO - woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
6.37	4.39-8.28	1.93	1.30-2.56	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
3.85	3.32-8.45	1.56	0.86-2.42	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
6.80	4.60-8.90	1.85	1.43-2.27	<0.0005
Median	**IQR**[@]	**Median**	**IQR**[@]	**p-value**[+]
4.68	3.12-9.51	1.67	0.92-2.53	<0.0005

[@]Inter-quartile range
*Paired t-test (parametric)
[+]Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.7   24 hour mean and median CO – woman (with room CO > 3)
 This measurement uses woman's CO readings only for those minutes when the kitchen CO is greater than 3 ppm, which is taken to be when the fire is alight. It is possible that the mean CO for the woman could be affected by completely different sources of pollution. Since the woman tends to be at, or near, the stove when cooking is taking place, this measure seeks to remove any exposure to carbon monoxide caused by the woman, for instance, standing behind a polluting bus, or visiting another person's house whilst they are burning biomass. All measures show a post-intervention reduction, although in the case of Nepal, not all the changes are significant.

Kenya: 24hr mean and median CO – woman for room CO > 3				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
4.33	1.26-7.41	2.08	1.44-2.72	0.162
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.51	2.14-3.80	1.67	0.90-2.86	0.041
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
3.53	2.19-4.87	1.62	1.19-2.05	0.011
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.47	2.06-4.01	1.26	0.87-2.31	0.001
Nepal 24hr mean and median CO – woman for room CO > 3				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
2.29	1.28-3.30	1.99	1.28-2.69	0.571
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.02	1.13-2.71	1.62	0.83-2.93	0.475
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
4.29	2.80-5.77	2.36	1.11-3.61	0.081
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.96	2.13-4.95	1.33	1.04-2.23	0.024
Sudan: 24hr mean and median CO – woman for room CO > 3				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
5.39	3.47-7.30	0.98	0.41-1.54	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.99	1.82-7.43	0.37	0.05-1.16	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
3.92	2.55-5.28	0.66	0.33-0.99	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value$^+$**
2.56	1.34-5.52	0.36	0.02-0.87	<0.0005

$^@$Inter-quartile range
*Paired t-test (parametric)
$^+$Wilcoxon Signed Ranks Test (non-parametric)

Table 7.1.8.   24 hour 90th centile CO - woman

Percentiles allow one to look at how the intervention is affecting the higher levels to which the woman is exposed. Although Nepal had lower CO-pollutant levels than Kenya and Sudan before the intervention, this particular measure was disappointing in that Nepal did not show any notable improvement after the intervention. Both Sudan and Kenya showed appreciable changes.

Kenya: 24hr 90th centile CO – woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
14.92	4.99-24.85	7.29	5.82-8.77	0.137
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
9.00	6.00-12.00	6.00	4.00-10.00	0.037
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
10.53	6.90-14.16	5.54	4.47-6.61	0.010
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
8.50	6.00-12.25	5.00	4.00-7.00	0.001
Nepal: 24hr 90th centile CO - woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
9.03	5.98-12.08	9.04	6.25-11.83	0.997
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
7.00	5.00-11.00	7.50	6.00-11.00	0.976
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
10.79	8.23-13.35	8.99	4.70-13.28	0.514
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
9.00	6.00-13.00	6.00	4.00-8.00	0.077
Sudan: 24hr 90th centile CO - woman				
Round 1		**Round 3**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
15.58	11.71-19.44	4.69	3.50-5.88	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
11.90	8.50-22.00	4.00	3.00-6.50	<0.0005
Round 2		**Round 4**		**Sig.**
Mean	**95% CI**	**Mean**	**95% CI**	**p-value***
14.78	10.59-13.73	4.63	3.59-5.67	<0.0005
Median	**IQR$^@$**	**Median**	**IQR$^@$**	**p-value**$^+$
4.68	3.12-9.51	1.67	0.92-2.53	<0.0005

$^@$Inter-quartile range

*Paired t-test (parametric)

$^+$Wilcoxon Signed Ranks Test (non-parametric)