Supplementary Material (for EHP MS #9479)

INDOOR POLLUTANT CONCENTRATIONS

Systematic and probability-weighted sampling of household indoor pollution levels from solid fuel combustion has not been done in China. However, we have found some 120 studies, published in either English- or Chinese-language journals, in which indoor concentrations of one or more PICs and other pollutants were measured in one or more locations within a household. Most of these studies were summarized in Sinton et al. (1995), a database prepared for the World Health Organization.[1] These studies have impressively covered rural and/or urban households of 29 provinces plus municipalities of Beijing, Shanghai, Tianjin, and Chongqing. Most of these studies concerned coal combustion. In Figure S1, we summarize indoor concentrations of 6 commonly measured pollutants by rural vs. urban, by fuel type, and by indoor locations (kitchen, bedroom, living room, and unspecified indoor location). A significant fraction of the urban households measured in the published studies used both coal and gas fuels (LPG, coal gas, or natural gas). In this case, we designate fuel type as Coal&Mixed. In addition to the median, percentiles, and outliers that a standard box plot presents, number of data points, mean, and standard deviation are also presented in the figure. It is important to note that no standardized protocol was used in the studies summarized here. For example, air sampling methods used in different studies were not standardized; sampling duration ranged from minutes in some studies using grab sampling methods to 24 hours in a few studies of daily exposure; most of the studies did not provide information on when and how long the air samples were taken. It is, therefore, difficult for us to define peak concentrations and time-averaged concentrations using the dataset gathered from the ~120 studies. The concentrations shown in Figure S1 are simply the data available in the publications with some ambiguous ones excluded (e.g., predicted concentration data not supported with any measurements). Although these data are not derived from population-based studies using systematic approaches and, hence, are not necessarily representative, the information summarized in Figure S1 may be useful in assessing inter-household variability that can aid designing intervention studies of proper statistical power. Indoor concentration ranges shown in the figure should give what concentrations can be expected for typical Chinese households using biomass or coal stoves.

Figure S1 (a, c, e, g, i, k) shows that biomass fuels were only used in the rural households and that fewer measurements were made in the biomass fuel households, making comparisons between biomass and coal households difficult. Indoor TSP concentrations were > 200 $\mu g/m^3$, and indoor PM_{10} concentrations were >100 $\mu g/m^3$ in any indoor locations of more than 50% of all the measured rural households. This is consistent with the findings, from recent rural monitoring studies in several Chinese provinces, that coal and biomass stoves produced PM_{10} levels well in excess of the new Chinese IAQ standard of 150 $\mu g/m^3$ (Sinton et al. 2004, He et al. 2005). Based on the non-systematic data, we do not see higher concentrations in kitchen than in other indoor locations in rural households. Consistently across the measured urban households, however, PM_{10} (TSP sometimes) and SO_2 had highest concentrations in kitchen (see Figure S1 b, d, j). This "kitchen effect" was, however, less profound and consistent for NO_x, CO, and B[a]P, perhaps due to the confounding from coal heating stoves and tobacco smoking. Presumably, coal combustion for heating occurs at more steady burning conditions than coal combustion for cooking. It is known that highest emissions of particles occur during unsteady combustion stages such as the beginning and end of the fire. Results from individual studies comparing

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[1] Available in pdf and spreadsheet versions at http://ehs.sph.berkeley.edu/hem/page.asp?id=32

concentrations in various indoor locations, however, often show highest peak concentrations in kitchens (Qin et al. 1991, He et al. 2005).

The published concentrations data indicate that indoor CO levels were up to 560 mg/m^3 and were >10 mg/m^3 (IAQ standard for CO) in 35% of the measured households. High indoor SO_2 concentrations, up to 23,000 $\mu g/m^3$, were measured in coal and Coal&Mixed households, of which ~50% had indoor SO_2 concentrations > 500 $\mu g/m^3$ (IAQ standard for SO_2). Household biomass combustion generates lower NO_x and NO_2 emissions than fossil fuel combustion (Zhang et al. 2000); and, thus, higher NO_2 concentrations were measured in coal and gas households than biomass households. The published data on NO_2 measurements (excluding NOx measurements) show that about 30% of the coal and gas households had NO_2 levels exceeding the NO_2 IAQ standard (240$\mu g/m^3$). A study comparing households using coal stoves and those using LPG stoves found 24-h NO_2 indoor concentrations significantly higher in the coal-using households (Zhang et al. 1996). This is not surprising because typically coal burning takes much longer than LPG or other gas burning for cooking. China has also established IAQ standard for B[a]P at 1.0 ng/m^3, which was exceeded in nearly all the coal and biomass using households.

Few of the measured urban households used solely coal and thus they were excluded from the current analysis. The lack of more detailed information (e.g., frequency of coal use vs. gas use) prohibits us from constructing more accurate category than a simple “Coal&Mixed”. Even so, indoor concentrations of TSP, PM_{10}, CO, and SO_2 were higher in the vast majority of the urban Coal&Mixed households than in the urban gas households.

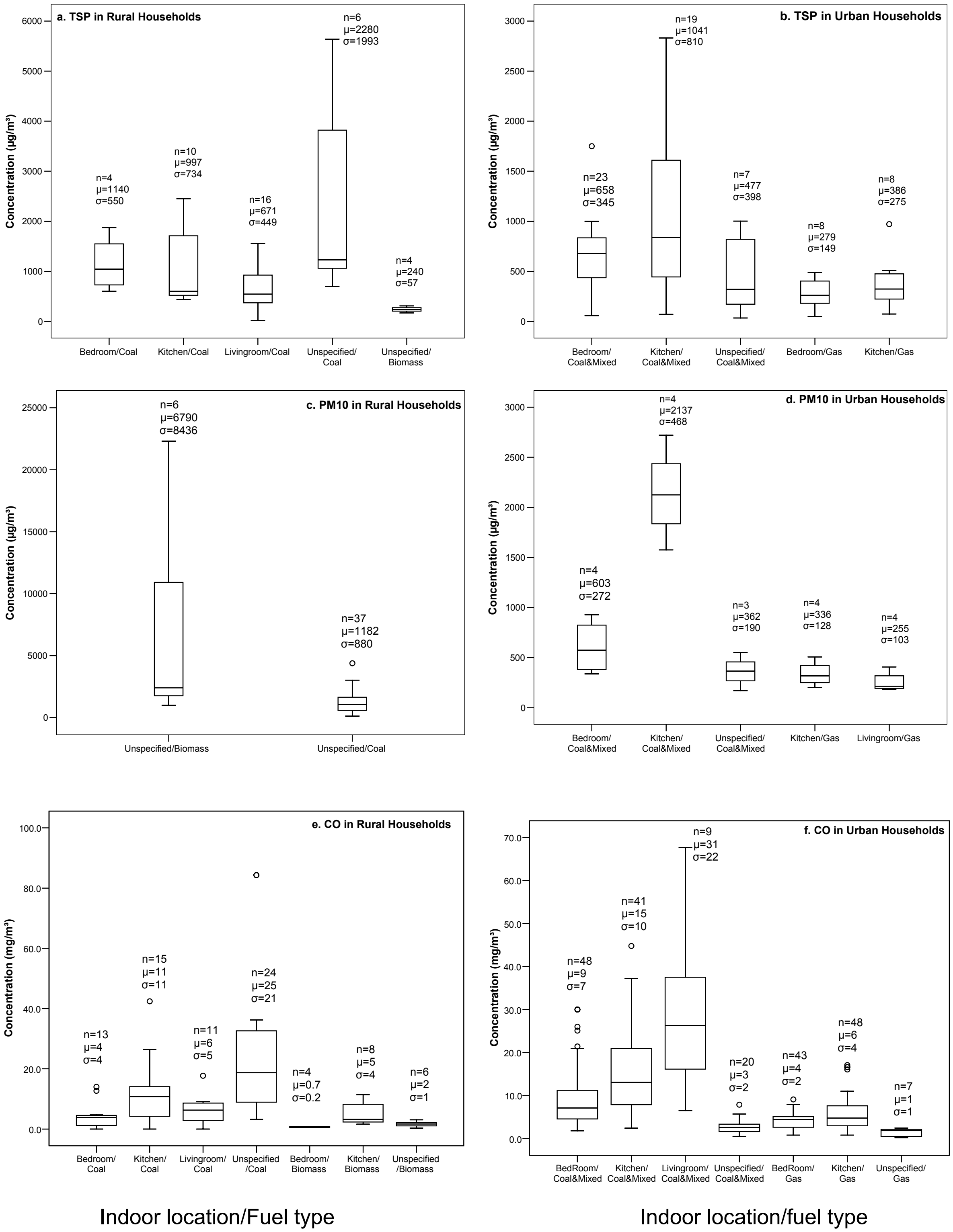

Figure S1. *Concentrations of pollutants measured in solid-fuel-use households, extremely high values may not be shown so that the plot scales are more appropriate for the vast majority of the data points.*

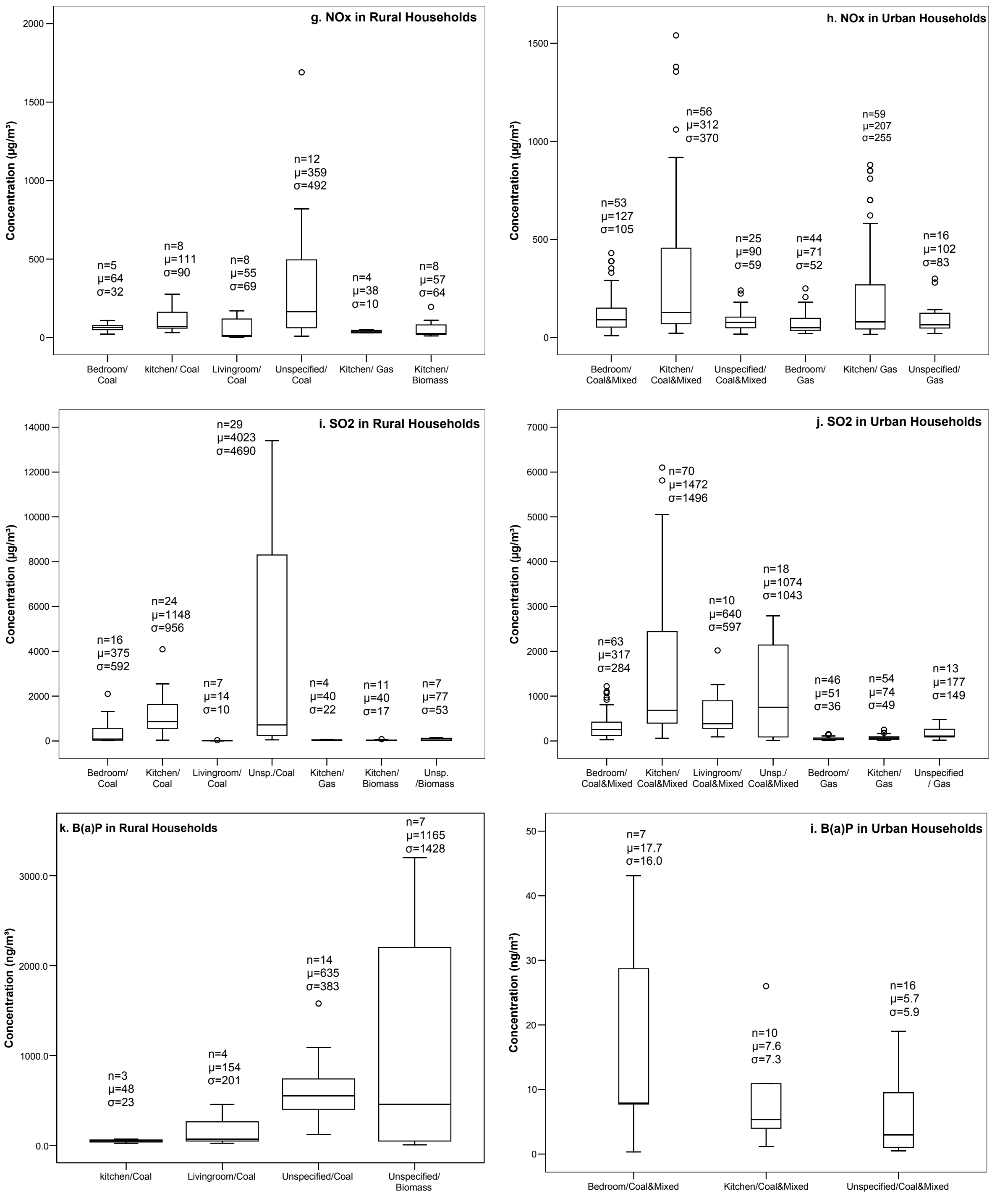

Figure S1 (Cont). *Concentrations of pollutants measured in solid-fuel-use households, extremely high values may not be shown so that the plot scales are more appropriate for the vast majority of the data points.*

References

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