SUPPORTING EPPENDIX FOR

Direct energy consumption associated emissions by rural-to-urban migrants in Beijing

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Survey on Residential Energy Consumption for migrants in Beijing

Does your Hukou (registration place) locates in Beijing?
A. Yes
B. No

Address of Homeplace
Province: _____
City: _____
Country: _____
Town or village: _____

Gender
A. male
B. female

Housing status?
A. self-owned
B. rented

Monthly rent (if applicable)
_____ yuan

Current address in Beijing
_____

How many roommates or family members are you living together with?
_____

Your housing type
A. bungalow
B. multistoried apartment without elevator
C. multistoried apartment with elevator
D. basement
E. houses built privately on farmers' land
F. temporary shed

How long has it been since you reside in Beijing?
_____Years and _____months

Average monthly income
_____ yuan

Your way of daily commuting
A. public transportation
B. bicycle
C. private car
daily gasoline spending: _____ yuan
D. electric bicycle

What home appliances do you have (choose all you have)?
A. electric heater
B. television
C. air conditioner
D. deductive stove
E. washing machine
F. electric rice cooker
G. refrigerator
H. computer
I. electric water heater
J. electric fan
K. microwave oven
L. electric bicycle
M. water kettle

Monthly spending on household electricity
A. 0 - 50 yuan
B. 50 - 70 yuan
C. 70 - 90 yuan
D. 90 - 100 yuan
E. 100 - 150 yuan
F. 150 - 200 yuan
G. > 200 yuan

Do you use gas powered water heater on household?
Household total use per day: _____ minutes

What cooking energy do you use (you can choice more than one)
A. pipeline natural gas
B. liquid propane gas
C. honeycomb coal briquette
D. chunk coal
E. firewood
F. electricity
E. others, please specify: _____

Monthly spending on cooking per person
A. 0 - 10 yuan
B. 10 - 20 yuan
C. 20 - 30 yuan
D. 30 - 40 yuan
E. > 40 yuan

What do you use for heating in winter (choose all that applies)?
A. no heating
B. centralized heating system
C. build-in electricity heater
D. electric heater
E. honeycomb coal briquette stove
E. chunk coal stove
E. firewood
E. others, please specify: _____

Yearly spending on heating per person:
A. 0 - 200 yuan
B. 200 - 400 yuan
C. 400 - 600 yuan
D. 600 - 800 yuan
E. 800 - 1000 yuan
F. 1000 - 1500 yuan
G. 1500 - 2000 yuan
G. > 2000 yuan

Monthly spending on water per person:
A. 0 - 10 yuan
B. 10 - 20 yuan
C. 20 - 30 yuan
D. 30 - 40 yuan
E. 40 - 50 yuan
F. 50 - 80 yuan

(All currency used in this questionnaire are in RMB)

----- This is the end of the survey. Thank you!

Figure S1 Design of the questionnaire

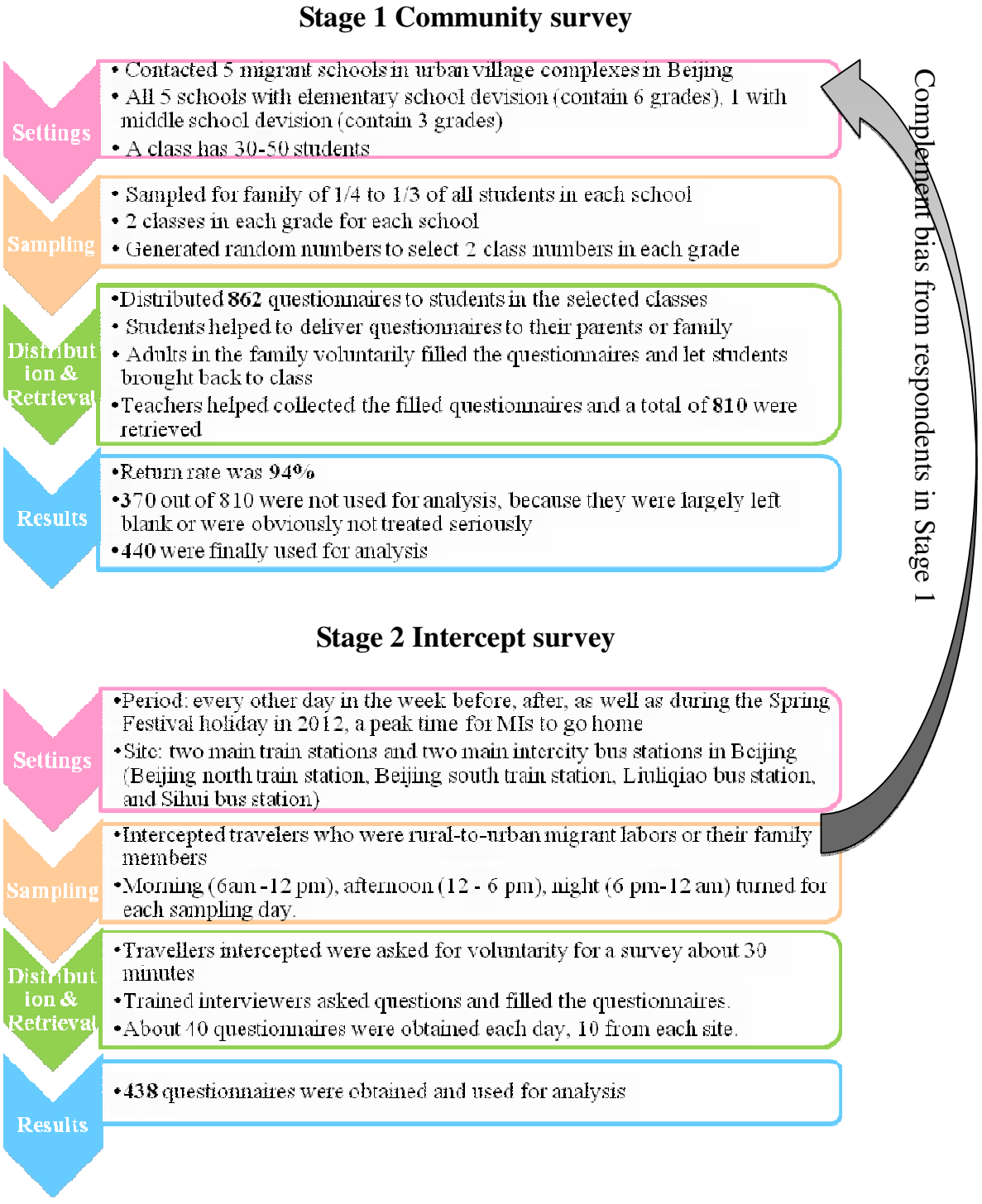

Figure S2 Flow chart of the 2-stage survey methods.

In the community stage, 440 of the retrieved questionnaires were finally used for data analysis. The left 370 were either not well filled or appeared not to be treated seriously. The reason might lie in the fact that school children were the intersection between us and the true respondents- parents or other family members who were migrant labors. Children might have failed to deliver the questionnaires to their parents .

Table S1a Calculating price-to-energy factors for converting residential fuel prices to mass/volume, and to megajoules

Energy	Type	Prices[1]		Standardized coefficients for mass/volume units [2]		Converting mass/volume to energy consumed [3]		Price-to -energy conversion factors[4] yuan/MJ
Thermal	central heating	20	yuan/m2	0.0251	tce/m2	29271	MJ/tce	0.027
PNG		2.28	yuan/m3			38.93	MJ/m^3	0.059
LPG	market price	105	yuan/canister	15	kg/canister	50.179	MJ/kg	0.140
Coal	honeycomb	1.2	yuan/piece	1.25	kg/piece	17.563	MJ/kg	0.055
	lump coal/chunk coal	0.75	yuan/kg			20.908	MJ/kg	0.036
Crop residues	rural	free	NA			14.50	MJ/kg	0.000
Wood	rural	free	NA			16.726	MJ/kg	0.000
	urban area of Beijing	6	yuan/kg			16.726	MJ/kg	0.359

Table S1-b Calculating weighted average of converting factors from electricity price to megajoules for coal, oil, and natural gas fired power plants

Source of energy	Electricity price	Efficiency[5]	Conversion factor [6]	Power station mix[7]	Weighted average of conversion
	yuan/kWh		MJ/kWh		MJ/kWh
Coal	0.4883	0.333	3.596	0.762	**2.830**
Oil		0.336	3.628	0.005	
Natural Gas-f		0.439	4.741	0.015	

Notes:

[1] Prices are unit prices in residential sector in 2010 in Beijing.

[2] Standardized units coefficient are the unit conversion from unit for charging prices to standardized mass or volume unit for energy calculation.

[3] Conversion factors are coefficients that transform mass or volume units to energy unit of Mega joule. All conversion factors are Lower Heating Values (LHV).

[4] Price to energy conversion is the Quotient of price and standardized units coefficient and conversion factors. Its unit is yuan/MJ, which can be used to transform expenditures directly to MJ.

[5] For electricity, efficiency is output divided by input. It shows the demand for raw fossil fuels to produce 1 kWh of electricity. Note that transmission loss is not included, as with all other fuels listed here are only considered for end use.

[6] Conversion factor is the energy needed in input fuels to provide 1 kilowatt hour of electricity. Efficiencies for different types of power plants matter as they have different capabilities to transform energy in fuels to electricity. Because the absence of direct data source, conversion factors for oil-fired and natural gas-fired power plants are calculated using coal-fired conversion factor and the efficiencies. e.g. $CF_{oilfired} = CF_{coalfired} \times \eta_{oilfired} / \eta_{coalfired}$, where CF is conversion factor, and η is efficiency.

[7] Power station mix shows the percentage of power produced by a type of power plant out of total power produced by all kinds of power plants. Note that the total is less than 100% because generation from nuclear and renewables are considered as emission free and is not included in this paper.

[8] Weighted average of the coal, gas, and oil fired power plants represents the fuel consumption in power sector, and is used for all energy calculation and emission estimation in this paper. It correspond to all end-use consumption, including all kinds of energy losses within the power station, but excluding losses in power transmission.

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Table S2 Emission factors of various air pollutants

Energy	CO_2	SO_2	PM_{10}	$PM_{2.5}$	EC	OC	CO	NO_x	Hg	PAHs	BaP
	tC/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	mg/GJ	mg/GJ	mg/GJ
Elec. coal	24300	744	98.1	49.0	0.452	0.512	57.9	237	8.11	1.63	0.091
Elec. oil	20200	221	8.76	6.64	0.319	0.553	29.5	216	0.343	15.8	0.060
Elec. gas	13800	7.19	2.99	2.99	0.005	0.037	49.1	102	1.23	0.068	0.001
Thermal	24300	397	98.1	49.0	0.452	0.512	57.9	190	8.11	1.63	0.091
Gasoline	18200	56.2	75.4	68.9	5.09	9.84	2870	337	0.078	4390	7.73
PNG	13800	7.45	2.81	2.81	0.308	0.038	20.6	54.4	0.0056	2.70	0.037
LPG	16300	1.20	10.4	10.4	1.11	1.04	192	28.1	0.173	8.67	0.070
Coal	24300	500	478	375	174	227	5010	66.0	16.5	7890	81.0
Crop residues	0	27.3	413	400	53.9	135	6340	97.0	1.04	4540	65.4
Wood	0	21.0	325	274	102	179	4760	73.3	1.21	15700	92.8

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Table S3 Fraction of non-renewable traditional woodfuels for Chinese provinces

Province	Expected fraction of non-renewable biomass (%)
Anhui	26.3
Beijing	44.7
Chongqing	22.6
Fujian	4.9
Gansu	13.1
Guangdong	0.0
Guangxi	22.8
Guizhou	23.1
Hainan	8.8
Hebei	18.4
Heilongjiang	9.3
Henan	22.2
Hubei	29.0
Hunan	35.4
Jiangsu	12.8
Jiangxi	24.9
Jilin	9.0
Liaoning	9.0
Inner Mongolia	10.1
Ningxia	9.0
Qinghai	10.0
Shaanxi	34.8
Shandong	11.9
Shanghai	8.8
Shanxi	31.1
Sichuan	23.9
Taiwan	9.3
Tianjin	19.6
Xinjiang	10.0
Xizang	14.2
Yunnan	14.5
Zhejiang	21.1

Notes:

In the cited paper, we chose the scenario under low plantation productivity. And the data are the expected values of non-renewable biomass with consideration for biomass available from deforestation and afforestation.

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Table S4 Standard deviations of emission factors for Monte Carlo simulation

Energy	CO_2	SO_2	PM_{10}	$PM_{2.5}$	EC	OC	CO	CO	Hg	PAHs	BaP
	tC/GJ	lg(g/GJ)	lg(g/GJ)	lg(g/GJ)	lg(g/GJ)	lg(g/GJ)	lg(g/GJ)	lg(g/GJ)	lg(mg/GJ)	lg(mg/GJ)	lg(mg/GJ)
Elec. coal	890	0.78	0.15	0.15	0.55	0.46	0.38	0.21	0.24	0.52	0.84
Elec. oil	750	0.39	0.38	0.38	0.31	1.12	0.50	0.20	0.24	0.92	0.90
Elec. gas	60	0.63	0.16	0.16	0.50	0.50	0.24	0.16	0.50	3.36	3.30
Thermal	890	0.78	0.15	0.15	0.55	0.46	0.38	0.13	0.24	0.52	0.84
Gasoline	910	0.52	0.79	0.79	0.21	0.58	0.58	0.26	0.06	0.13	0.10
PNG	60	0.63	0.16	0.16	0.50	0.50	0.23	0.35	0.28	3.36	3.30
LPG	180	0.69	0.55	0.55	0.50	0.15	0.61	0.82	0.25	0.34	0.30
Coal	890	0.79	0.45	0.45	0.35	0.70	0.20	0.49	0.35	0.47	0.42
Crop residues	900	0.67	0.27	0.27	0.18	0.27	0.23	0.29	0.14	0.18	0.18
wood	900	0.78	0.40	0.40	0.40	0.41	0.40	0.23	0.12	0.30	0.19

Notes:

For emission activities, coefficients of variance were assumed to be 5% for power and thermal stations, 10% for gasoline, PNG, LPG, and coal, and 20% for biomass fuels.

The standard deviations listed in the table are log-transformed except for CO_2.

Table S5 Per person residential energy consumptions (GJ) for the RRs, MIs, and URs

Usage	Energy	URs	MIs	RRs
Household	Electricity	3.15	2.79	0.76
	Thermal	2.62	1.13	0.00
	PNG	3.54	0.67	0.02
	LPG	0.68	1.27	0.34
	Coal	1.39	5.84	1.99
	Crop residuals	0.00	0.00	10.77
	Wood	0.00	0.12	4.60
	Total	**11.39**	**11.82**	**18.48**

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Figure S4 Origins of the rural-to-urban migrants investigated in this study in comparison with distribution of rural-to-urban migrants in China. The two distributions are similar with top five[0] provinces of Henan, Hebei, Anhui, Shandong, and Sichuan.

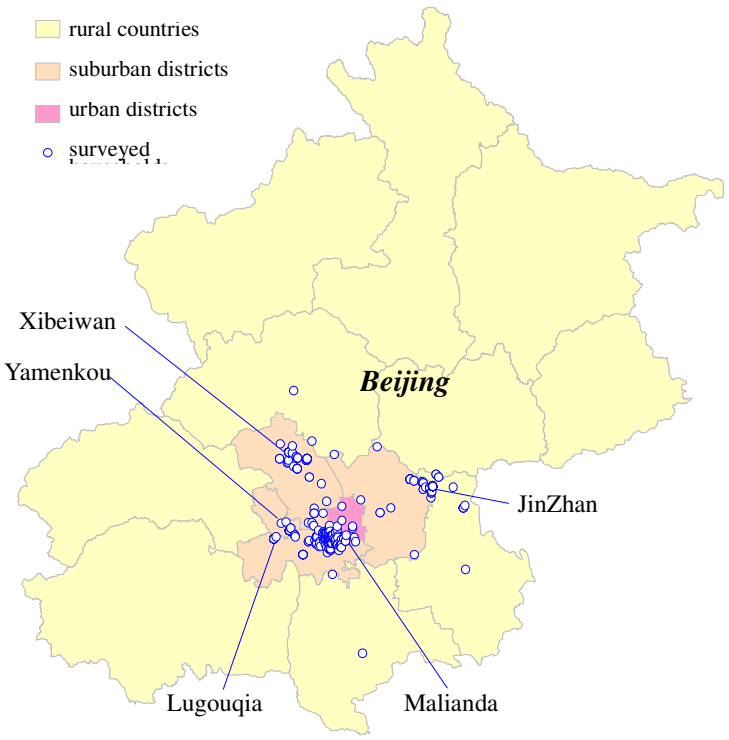
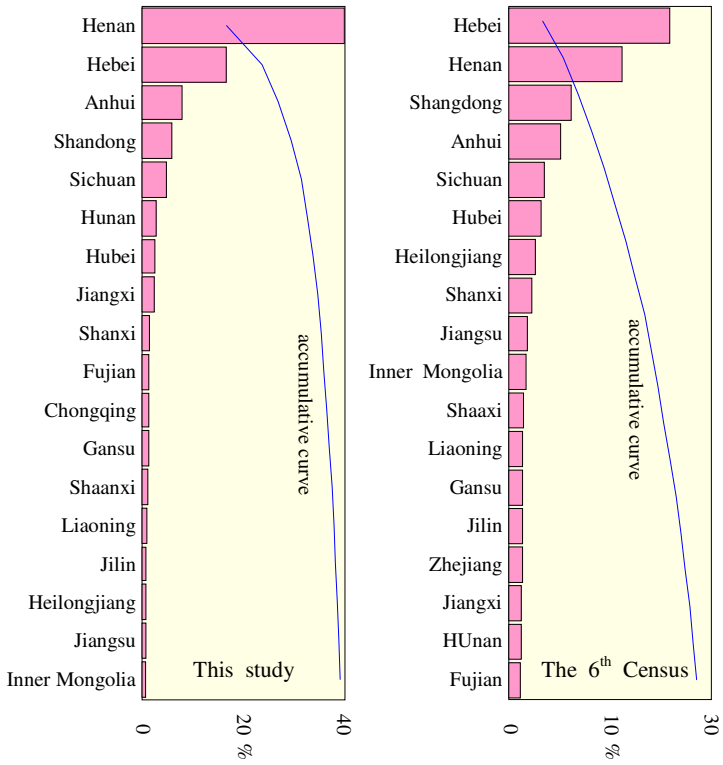


Figure S3 Current addresses of the rural-to-urban migrants investigated in this study.



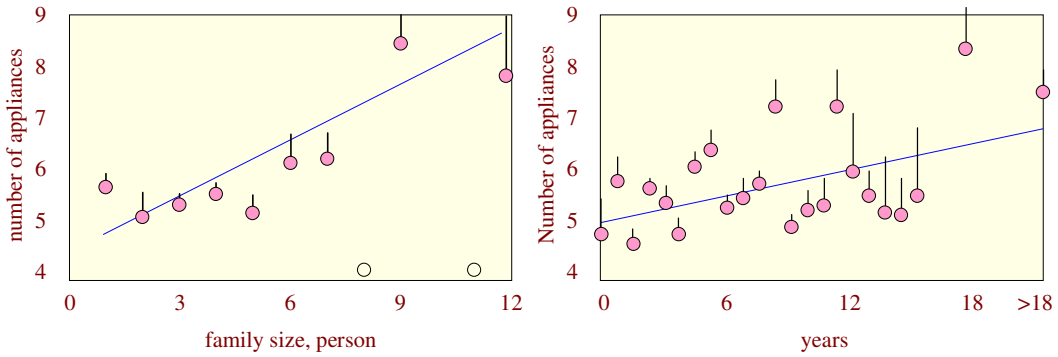


Figure S5 Relationship between number of home appliances and family size (two blank circles were outliers with relatively small sample sizes) (A) and between the number of home appliance and the length of the MIs have stayed in the city (B)

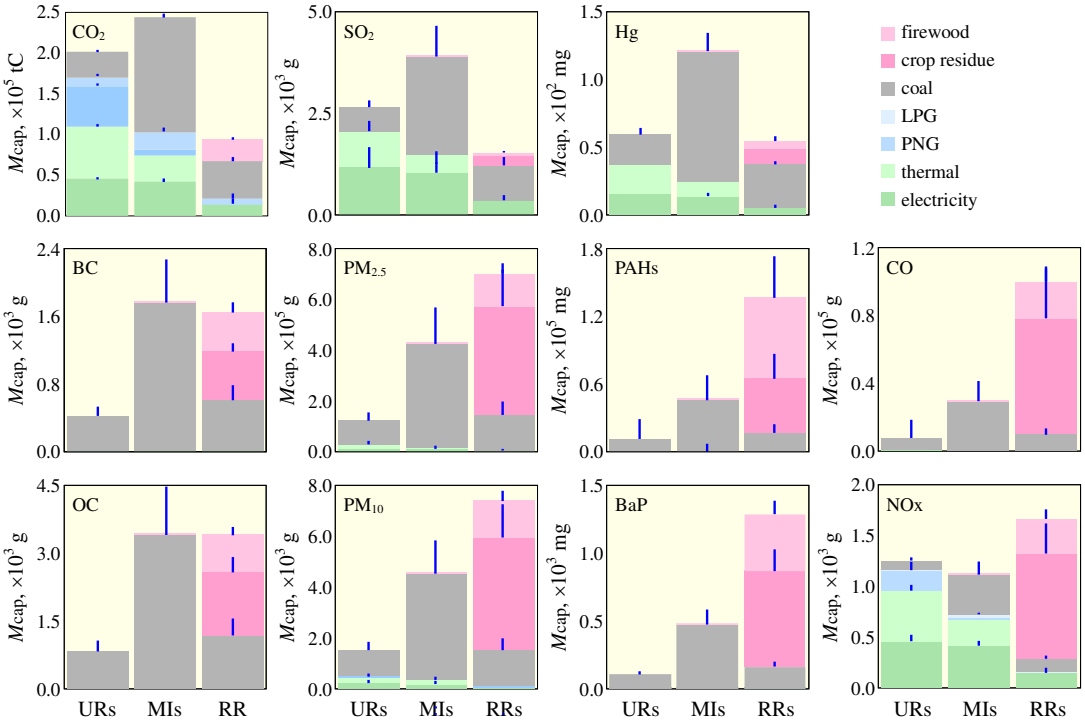


Figure S6 Per person annual emissions of CO_2, SO_2, Hg, BC, OC, $PM_{2.5}$, PM_{10}, PAHs, BaP, CO, and NOx from residential energy consumption of the URs, MIs, and RRs. Emissions from various sources are shown as stacked bars. The blue lines are standard deviations calculated from Monte Carlo simulation indicating uncertain ranges (difference between the first and the third quartiles) of individual sources.