

# **Contributions of indoor household activities to inhalation health risks induced by gaseous air pollutants in Hong Kong home**

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### Text S1. Layout of the apartment and setting of the experiment

According to the layout of the apartment shown in Figure S1, all windows were closed and at least one air conditioner was on during the sampling to maintain a suitable temperature range and stable relative humidity for instruments' operation and living comfort. Cooking took place in the kitchen, with the door opened and the ventilator on. Bathing and laundry were conducted in the bathroom, and the door of the bathroom was closed for bathing and open for laundry. Besides, incense burning, candle burning, smoking and coffee/tea brewing were all performed in the living room. Air freshener spraying and cleaning were carried out in all rooms. All activities were undertaken independently to avoid the influence of concentrations of air pollutants between different activities.

**Table S1.** VOC species in standard gas used for PTR-Q-MS calibration.

Compound	m/z	Volume mixing ratio (ppm)	Uncertainty (%)
Formaldehyde	31	1.119	±5
Acetaldehyde	45	1.100	±5
Acrolein	57	0.933	±5
Propanal	59	0.986	±5
Crotonaldehyde	71	1.022	±6
Butanal	73	1.023	±5
Pentanal	87	0.968	±5
Hexanal	101	0.923	±6
Heptanal	115	0.952	±5
Octanal	129	0.965	±5
Nonanal	143	0.613	±8
Decanal	157	0.497	±7

**Table S2.** 30 major HAPs identified in this study, their RfC and IUR values, and their impacts on health endpoints.

Compounds	RfC <sup>a</sup> (mg m <sup>-3</sup> )	IUR <sup>a</sup> (µg <sup>-1</sup> m <sup>3</sup> )	Health endpoint	Ref.
Formaldehyde	0.1	1.3×10 <sup>-5</sup>	Respiratory system	1,2,3
Acetaldehyde	0.14	2.7×10 <sup>-6</sup>	Respiratory system	1,3
Acrolein	3.5×10 <sup>-4</sup>		Respiratory system	1

Acetone	56.548		Neurobehavioral effects	4
Propanal	0.008		Respiratory system	3
Crotonaldehyde	0.15		Respiratory system	4
Hexanal	0.09		Respiratory system	4
Heptanal	0.09		Respiratory system	4
Octanal	0.09		Respiratory system	4
Nonanal	0.09		Respiratory system	4
Decanal	0.09		Respiratory system	4
Acetonitrile	0.06		Whole body	3
Propylene	3		Respiratory system	1
Benzene	0.03	$2.9 \times 10^{-5}$	Hematologic system; immune system	1,3
Cyclohexane	6		Developmental/reproductive	3
Toluene	5		Developmental/reproductive; nervous system; respiratory system	1,3,5
Styrene	1		Nervous system	1,3,5
Xylenes	0.1		Nervous system; respiratory system; eyes	1,3,5
Ethylbenzene	1	$2.5 \times 10^{-6}$	Alimentary system (liver); kidney; developmental/reproductive	1,3,5
Trimethylbenzenes	0.06		Nervous system	3
1,4-Dichlorobenzene	0.06	$1.1 \times 10^{-5}$	Alimentary system (liver); kidney; nervous system; respiratory system	1,3,5
Benzo[a]pyrene	$2 \times 10^{-6}$	0.087	Developmental/reproductive	2,3
Chrysene		$1.1 \times 10^{-5}$		1
Benz[a]anthracene		$1.1 \times 10^{-4}$		1
Benzo[b]fluoranthene/ Benzo[k]fluoranthene		$1.1 \times 10^{-4}$		1
Indeno[1,2,3-cd]pyrene		$1.1 \times 10^{-4}$		1
NO <sub>2</sub>	0.04		Respiratory system	2,4
SO <sub>2</sub>	0.05		Increase in daily mortality; respiratory system	4
CO			Acute health risk in cardiovascular system	6
O <sub>3</sub>	0.1		Increase in daily mortality	4

**Table S3.** Type and number of daily activities in the sampling campaign period.

Date	Activities									
	Candle burning	Incense burning	Tobacco smoking	Cooking	brewing	Coffee & tea	Cleaning	Laundry	Bathing	Air freshener spray
24/10/2019							✓			
25/10/2019									✓✓	
28/10/2019								✓	✓	
30/10/2019									✓	
31/10/2019							✓			
01/11/2019									✓✓	
02/11/2019										✓
04/11/2019		✓							✓	
06/11/2019									✓	
07/11/2019							✓		✓	
08/11/2019									✓	
09/11/2019				✓			✓	✓	✓	
10/11/2019										✓
11/11/2019		✓							✓✓	
13/11/2019				✓					✓	
15/11/2019				✓						
16/11/2019				✓						
17/11/2019				✓						
18/11/2019									✓	
19/11/2019				✓✓						
20/11/2019				✓✓✓		✓				
21/11/2019				✓✓✓					✓	
22/11/2019	✓			✓✓				✓		✓
23/11/2019			✓	✓✓		✓		✓	✓	
24/11/2019			✓	✓					✓	
25/11/2019	✓			✓✓		✓			✓	✓
27/11/2019	✓		✓✓	✓✓						✓
28/11/2019	✓			✓✓						✓
29/11/2019				✓✓✓					✓	
30/11/2019						✓✓				
01/12/2019									✓	
02/12/2019			✓							
04/12/2019	✓			✓✓						
05/12/2019	✓			✓		✓		✓		
06/12/2019						✓				
07/12/2019				✓		✓	✓	✓		
08/12/2019				✓		✓	✓	✓		
09/12/2019						✓		✓		
10/12/2019	✓	✓		✓✓			✓		✓	
11/12/2019				✓✓		✓		✓		

Note: each tick represents one activity.

**Table S4.** Recommended values of time spent indoors for different age groups.

	<i>Age group</i>	<i>Duration (min day<sup>-1</sup>)</i>
<i>Birth~&lt;18 years</i> <sup>7</sup>	0~<3 months	1390
	3~<6 months	1350
	6~<9 months	1321
	9~< 1 year	1303
	1~<2 years	1285
	2~<3 years	1279
	3~< 4 years	1275
	4~<5 years	1284
	5~<6 years	1286
	6~< 9 years	1297
	9~<12 years	1298
	12~<15 years	1300
	15~<18 years	1302
	<i>Adults</i> <sup>8</sup>	18~44 years
45~59 years		1157
60~79 years		1178
≥80 years		1228

**Table S5.** Occurrence frequency of typical household activities in ordinary Hong Kong homes.

Activities	Frequency	
	Weekdays	Weekends and public holidays
Candle burning	1 time day <sup>-1</sup>	1 time day <sup>-1</sup>
Incense burning	1 time day <sup>-1</sup>	1 time day <sup>-1</sup>
Smoking	2 time day <sup>-1</sup>	3 time day <sup>-1</sup>
Laundry doing	2 time week <sup>-1</sup>	
Coffee & tea brewing	1 time day <sup>-1</sup>	2 time day <sup>-1</sup>
Cleaning	3 time week <sup>-1</sup>	
Bathing	1 time day <sup>-1</sup> × 3 persons	
Cooking	2 time day <sup>-1</sup>	3 time day <sup>-1</sup>
Air freshener spraying	3 time week <sup>-1</sup>	

**Table S6.** Age sensitivity factor of people in different ages to cancer risk of carcinogenic HAPs <sup>9</sup>.

Age group	Age sensitivity factor (unitless)
0~2 years of age	10
2~16 years of age	3
≥16 years of age	1

**Table S7.** Two-tail t-test for different assumptions under the confidence level of 0.01.

Pollutant	Assumptions <sup>a</sup>										
	I>O	O>I	Candle burning >I	Incense burning >I	Tobacco smoking >I	Laundry >I	Coffee & tea brewing >I	Cooking >I	Cleaning >I	Bathing >I	Air freshener spray >I
Formaldehyde	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.98	<0.001
Acetaldehyde	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.029	<0.001
Acrolein/ butylene	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Propanal/ acetone	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.43	<0.001
Crotonaldehyde	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexanal	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.045	<0.001
Heptanal	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Octanal	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.56	0.013	<0.001
Nonanal	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.94	<0.001
Decanal	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Acetonitrile	<0.001	1.00	<0.001	<0.001	<0.001	0.080	<0.001	<0.001	1.00	<0.001	<0.001

Table S7 continued.

Pollutant	Assumptions <sup>a</sup>										
	I>O	O>I	Candle burnin >I	Incense burning >I	Tobacco smoking >I	Laundry >I	Coffee & tea brewing >I	Cooking >I	Cleaning >I	Bathing >I	Air freshener spray >I
Propylene	0.00	1.00	1.00	<0.001	0.64	1.00	<0.001	<0.001	1.00	0.72	<0.001
Benzene	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cyclohexane	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.00	<0.001	<0.001
Toluene	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.00	0.012	<0.001
Styrene	0.00	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.52	1.00	<0.001
Xylenes/ ethylbenzene	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Trimethylbenzenes/ acetophenone	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Dichlorobenzenes	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.99	<0.001	<0.001
Chrysene	1.00	<0.001	<0.001	-	0.056	0.51	0.83	0.76	0.78	1.00	-
Benzo[b,k]fluoranthene	1.00	<0.001	0.085	-	0.0078	0.84	0.91	0.91	0.69	0.98	-
Indeno[1,2,3-cd]pyrene	1.00	0.0023	1.00	-	0.033	0.32	0.97	0.058	1.00	0.94	-



**Table S7** continued.

Pollutant	Assumptions <sup>a</sup>										
	I>O	O>I	Candle burnin >I	Incense burning >I	Tobacco smoking >I	Laundry >I	Coffee & tea brewing >I	Cooking >I	Cleaning >I	Bathing >I	Air freshener spray >I
Benzo[a]anthracene	1.00	<0.001	0.0017	-	0.0076	0.93	0.99	0.95	0.80	1.00	-
Benzo[a]pyrene	0.99	0.012	-	-	0.58	0.95	1.00	1.00	0.96	1.00	-
O <sub>3</sub>	1.00	0.00	1.00	<0.001	1.00	1.00	1.00	1.00	1.00	<0.001	1.00
NO <sub>2</sub>	1.00	<0.001	<0.001	<0.001	1.00	<0.001	<0.001	<0.001	<0.001	1.00	1.00
CO	1.00	<0.001	<0.001	<0.001	<0.001	1.00	<0.001	<0.001	1.00	1.00	<0.001
SO <sub>2</sub>	1.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.60	<0.001

<sup>a</sup> As examples, the assumption of I>O means that indoor background concentration was higher than that outdoors, while candle burning>I means that the concentration during candle burning is higher than that in indoor background air. The assumptions are similar for all the other items.

**Table S8.** HQs of 24 HAPs in all exposure stages.

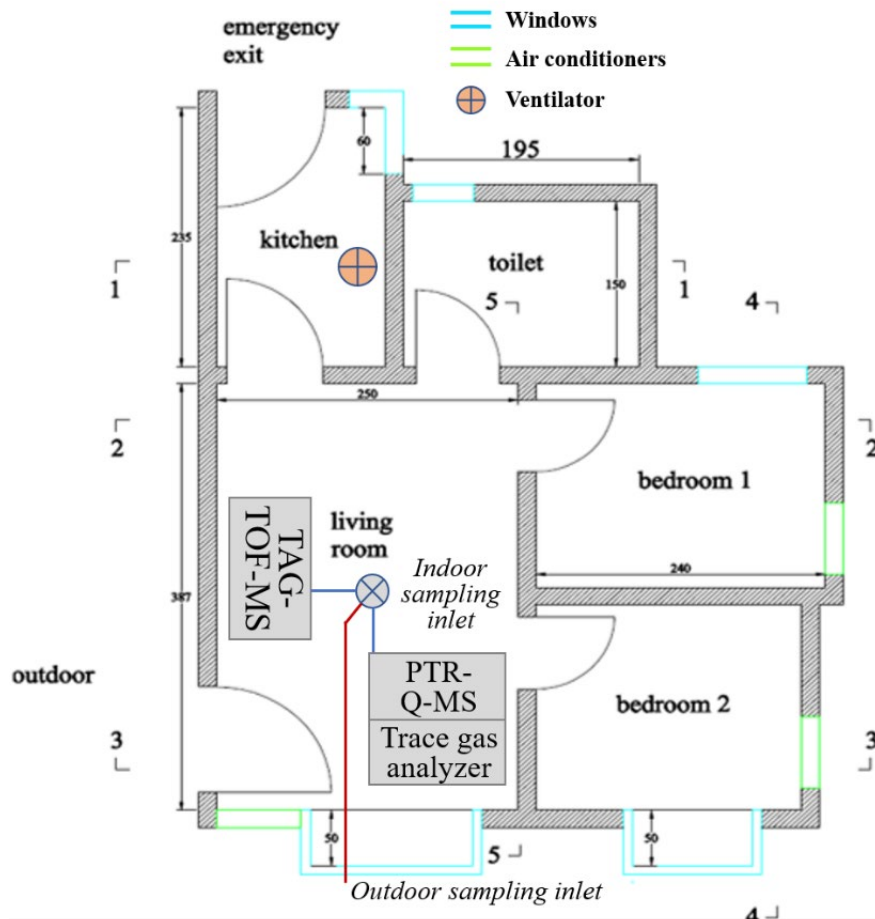
HAPs	Exposure stage (years of age)													
	0~1	1~2	2~3	3~4	4~5	5~6	6~9	9~12	12~15	15~18	18~45	45~60	60~80	80~85
Propanal	4.43	4.20	4.17	4.16	4.19	4.20	4.25	4.25	4.26	4.27	3.71	3.67	3.76	3.96
Acrolein	1.90	1.83	1.82	1.81	1.83	1.83	1.84	1.85	1.85	1.85	1.67	1.65	1.68	1.75
NO <sub>2</sub>	1.65	1.56	1.56	1.55	1.56	1.57	1.58	1.58	1.59	1.59	1.38	1.37	1.40	1.48
Hexanal	0.70	0.66	0.66	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.59	0.58	0.59	0.63
Octanal	0.58	0.55	0.55	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.49	0.48	0.49	0.52
O <sub>3</sub>	0.49	0.46	0.46	0.46	0.46	0.46	0.47	0.47	0.47	0.47	0.40	0.39	0.40	0.43
Formaldehyde	0.46	0.44	0.43	0.43	0.44	0.44	0.44	0.44	0.44	0.44	0.39	0.39	0.39	0.41
Heptanal	0.27	0.25	0.25	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.23	0.22	0.23	0.24
SO <sub>2</sub>	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.21	0.21	0.21	0.22
Nonanal	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.16	0.15	0.16	0.17
Decanal	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.09	0.09	0.09	0.10
Acetaldehyde	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.08
Trimethylbenzenes	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
Benzene	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.07
Xylenes	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

**Table S8** continued.

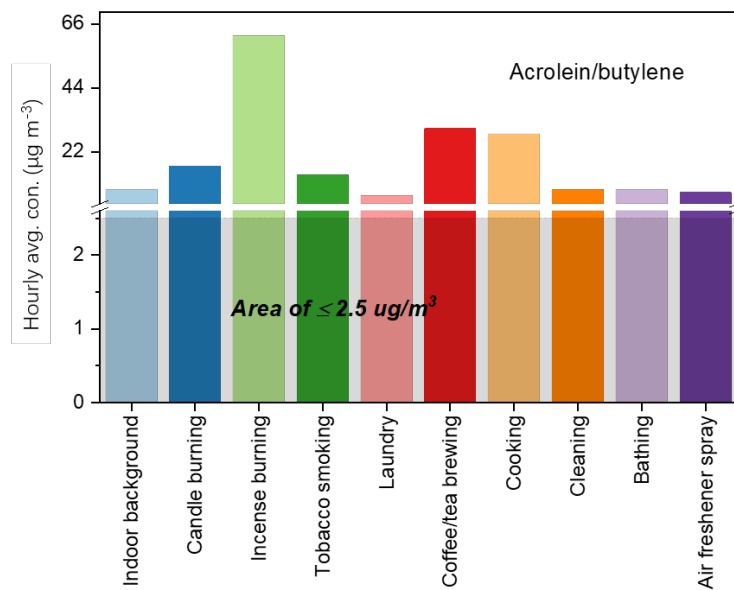
HAPs	Exposure stage (years of age)													
	0~1	1~2	2~3	3~4	4~5	5~6	6~9	9~12	12~15	15~18	18~45	45~60	60~80	80~85
Acetonitrile	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Dichlorobenzenes	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Crotonaldehyde	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ethylbenzene	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Propylene	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004
Styrene	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Benzo[a]pyrene	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Cyclohexane	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.002	0.002
Toluene	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001

**Table S9.** HIs for different health endpoints in all exposure stages.

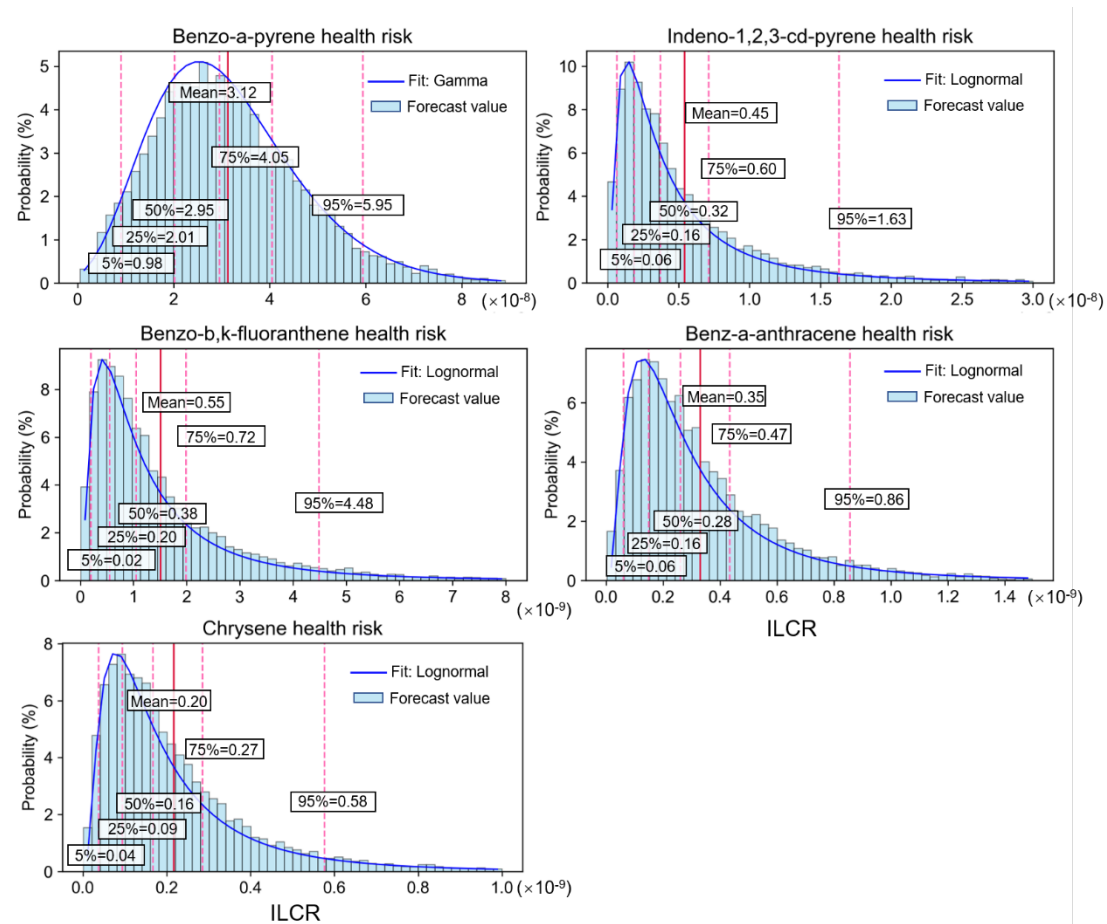
Endpoints	Exposure stage (years of age)													
	0~1	1~2	2~3	3~4	4~5	5~6	6~9	9~12	12~15	15~18	18~45	45~60	60~80	80~85
Respiratory system	4.46	4.25	4.23	4.22	4.25	4.26	4.30	4.30	4.31	4.31	3.82	3.79	3.86	4.04
Increase in daily mortality	0.75	0.70	0.70	0.69	0.70	0.70	0.71	0.71	0.71	0.71	0.61	0.60	0.62	0.66
Nervous system	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.16	0.16	0.16	0.17
Immune system	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.07
Alimentary system (liver)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
Whole body	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Eyes	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Kidney	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
Hematologic system	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.07
Reproductive/development	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01



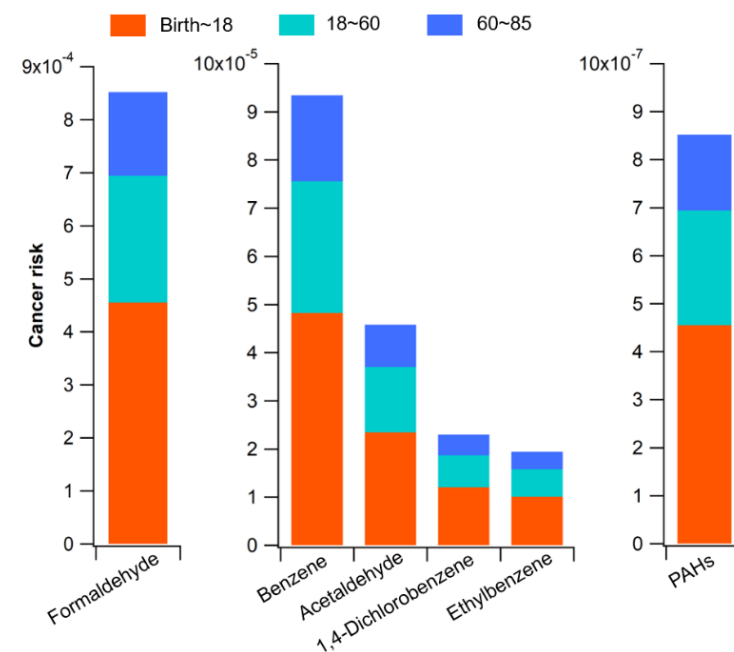
**Figure S1.** Layout of the apartment and the instrument setting.



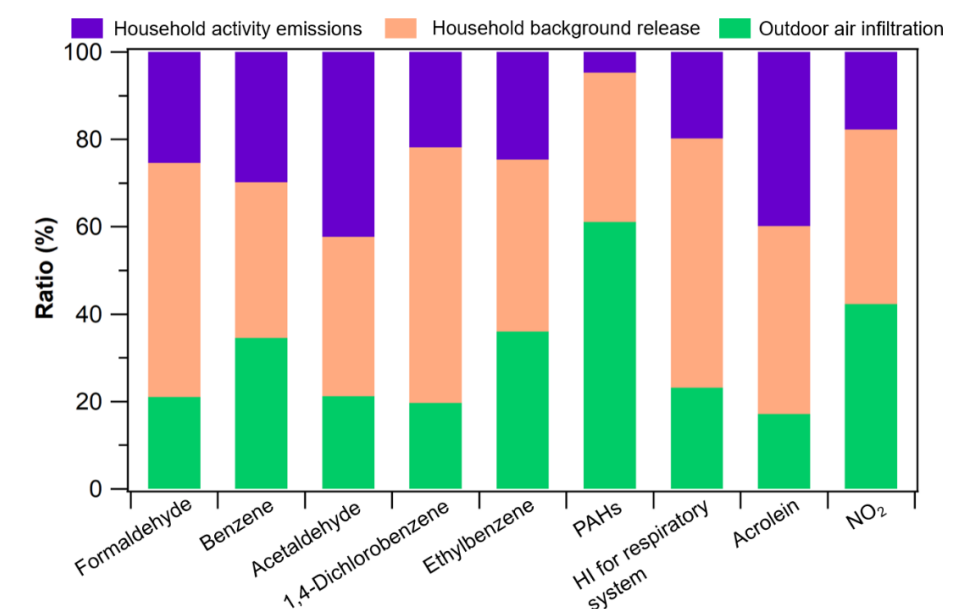
**Figure S2.** Maximum hourly average concentration of acrolein/butylene in different activities.



**Figure S3.** Incremental lifetime cancer risk for five PAHs from household activities exposure.



**Figure S4.** ILCRs of carcinogens in different exposure stages of life.



**Figure S5.** Contributions of different household sources/activities to the health risks.

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