

Supplementary Materials for

Fragile skin microbiomes in megacities are assembled by a predominantly niche-based process

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The PDF file includes:

- fig. S1. Information of the geographical location and characteristics of each city.
- fig. S2. Relative mean abundances of four predominant phyla.
- fig. S3. Mean relative abundance of bacterial genera in the skin microbiome among the five cities in China.
- fig. S4. Principal coordinate analysis with weighted UniFrac distances.
- fig. S5. Distance decay analysis.
- fig. S6. The β -diversity comparisons of the skin microbiome of the five cities.
- fig. S7. Distribution of PD.
- fig. S8. Analysis of MSE by random forest modeling.
- fig. S9. Comparison of predicted functional metagenomic profiling using PICRUSt between the megacity and non-megacity groups.
- fig. S10. The richness (observed OTUs) of the genus *Staphylococcus* in five cities.
- table S1. Sample metadata, number of sequences, and α diversity across samples based on rarefaction of 4860 reads per sample.
- table S2. Relative average abundances of the 15 most abundant genera.
- table S3. Environmental factors and city indices of five cities.
- table S4. Environmental factors and city indices of five cities.
- table S5. The observed species pool of five cities.
- Legend for data file S1

Other Supplementary Material for this manuscript includes the following:
(available at advances.sciencemag.org/cgi/content/full/4/3/e1701581/DC1)

- data file S1 (Microsoft Excel format). The information of OTUs in Fig. 3A.

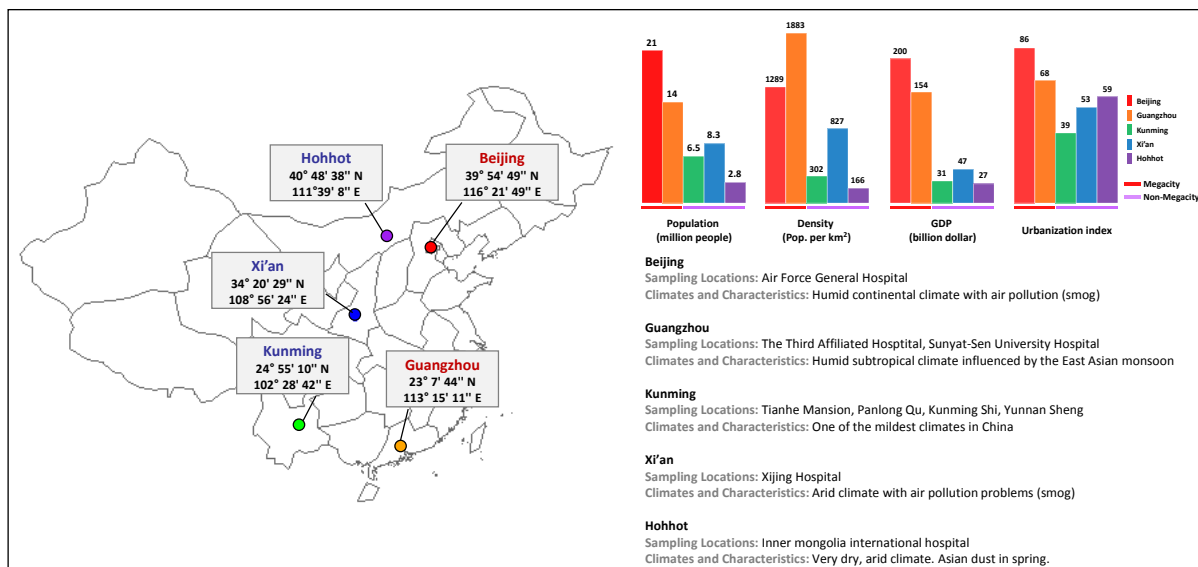


fig. S1. Information of the geographical location and characteristics of each city. Sampling was performed at selected hospitals and at licensed offices. The five large cities are located at least 409 km apart from each other, vary in their climatic conditions, and differ in their city indices such as population size, population density, GDP, and urbanization.

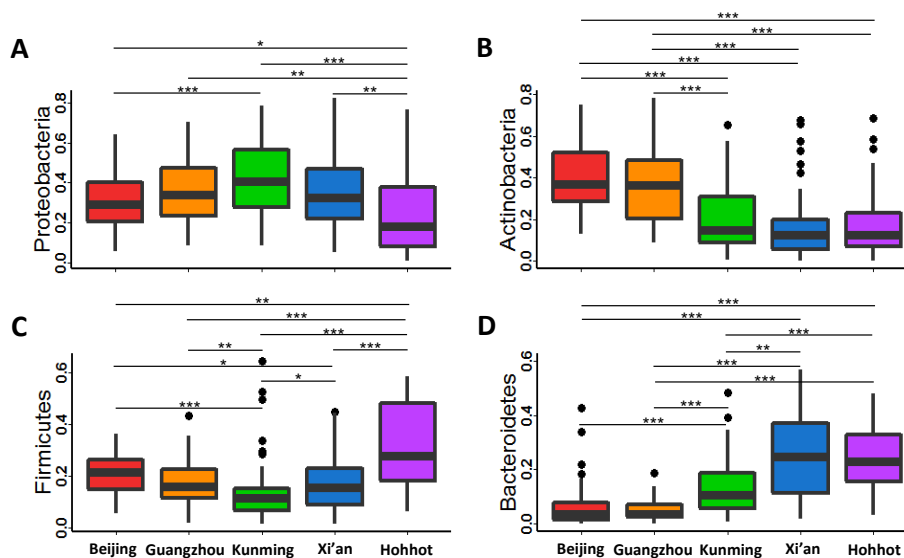


fig. S2. Relative mean abundances of four predominant phyla. On each graph, an asterisk indicates a significant difference in relative abundances (** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, Wilcoxon rank sum test [Kruskal–Wallis test]).

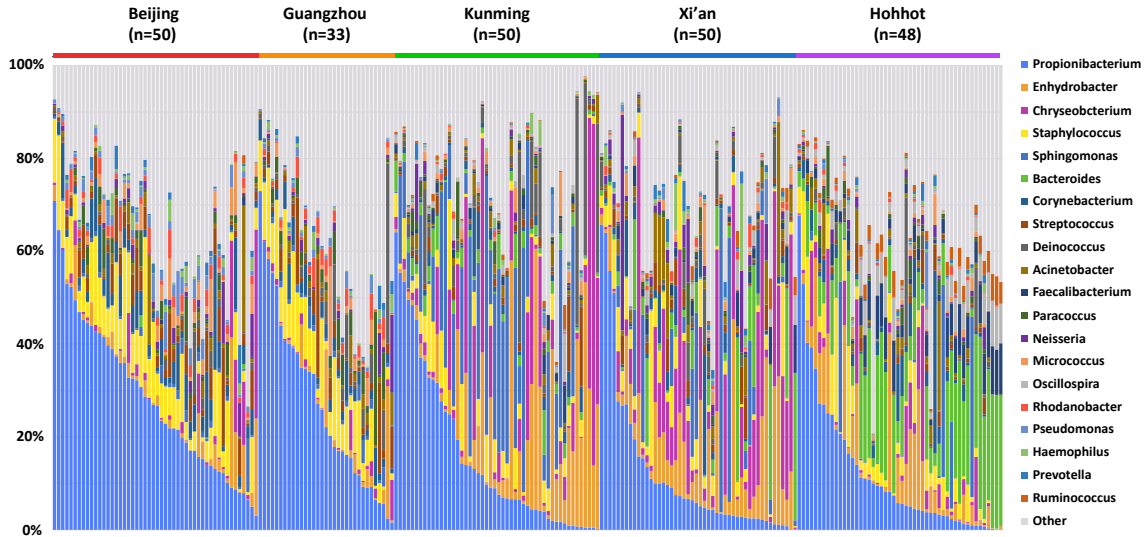


fig. S3. Mean relative abundance of bacterial genera in the skin microbiome among the five cities in China. The mean relative abundances of the top 20 genera show differences between the compositions of megacity and non-megacity skin microbiomes. Especially, *Propionibacterium* and *Staphylococcus* were more abundant in megacities than non-megacities, and *Bacteroides* was the most abundant genus in Hohhot (see table S2).

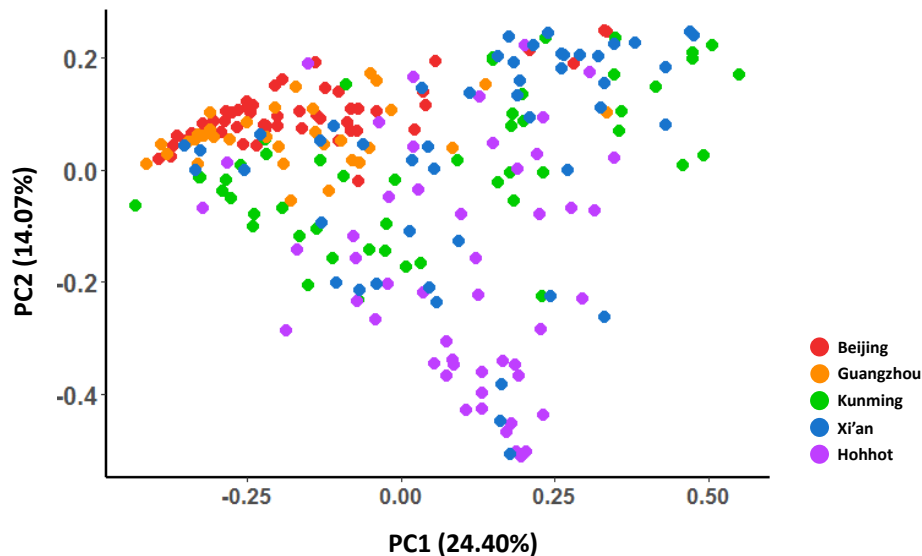


fig. S4. Principal coordinate analysis with weighted UniFrac distances. Principal coordinate analysis derived from the weighted UniFrac distance metrics based on the 97%-similar OTUs of the bacterial community compositions across five cities ($R^2 = 0.26$, $P < 0.001$, analysis of similarity).

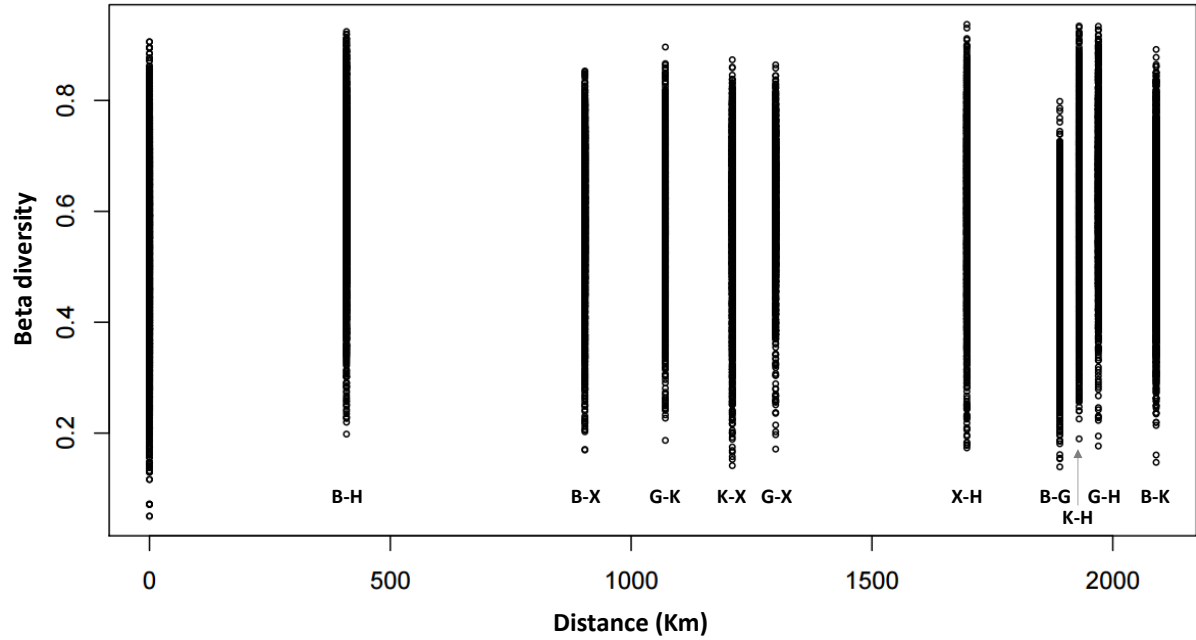


fig. S5. Distance decay analysis. The distance between cities is at least 409 km (Beijing to Hohhot) and the maximum is 2090 km (Beijing to Kunming), and there was no distance decay relationship among all five cities. The β -diversities among the samples belonging to each city were calculated as weighted UniFrac distance metrics. Capital letters in the graph indicate each city (B: Beijing, G: Guangzhou, K: Kunming, X: Xi'an, and H: Hohhot).

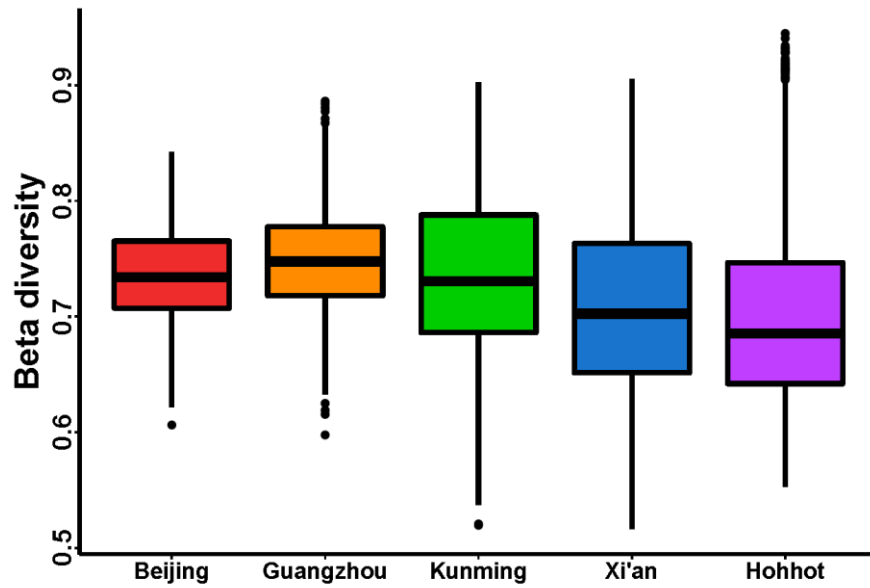


fig. S6. The β -diversity comparisons of the skin microbiome of the five cities. Beta diversity between the samples belonging to each city was calculated as unweighted UniFrac distance metrics. The black line and whiskers in the boxplot represent the mean and range of minimum and maximum alpha diversity values. The beta-diversity of each city was significantly different ($P = 0.001$, $R^2 = 0.47$, ANOSIM).

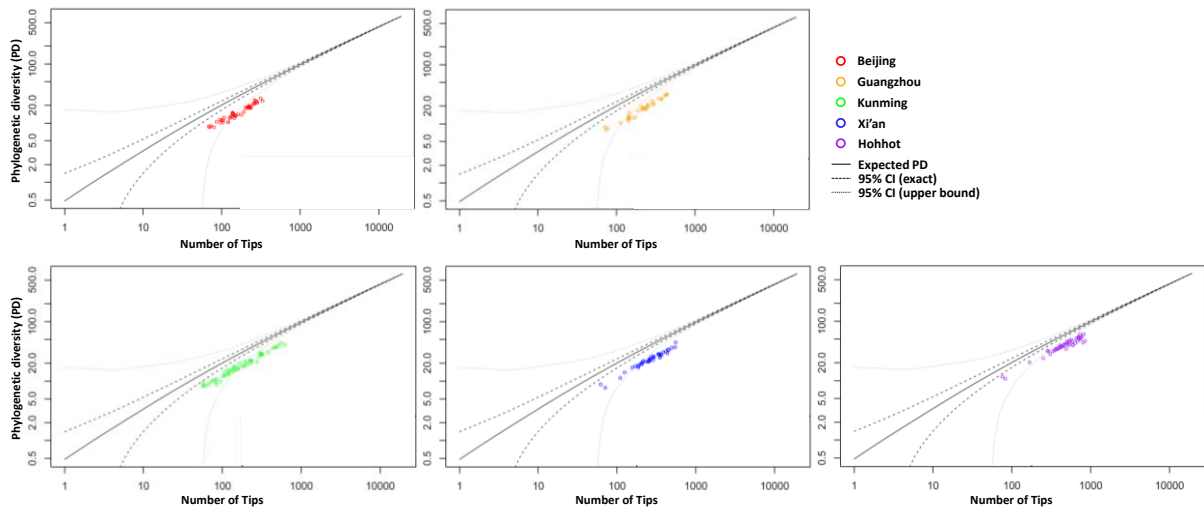


fig. S7. Distribution of PD. The distribution of the actual phylogenetic diversity (PD) values in five cities compared to the expected PD values shows the community assembly characteristics of the skin microbiota in each region. Solid lines represent the expected PD, the first dashed lines represent the lower bound of the 95% confidence interval, and the second dashed lines represent the upper bound of the 95% confidence interval computed using the variance of the sampled PDs.

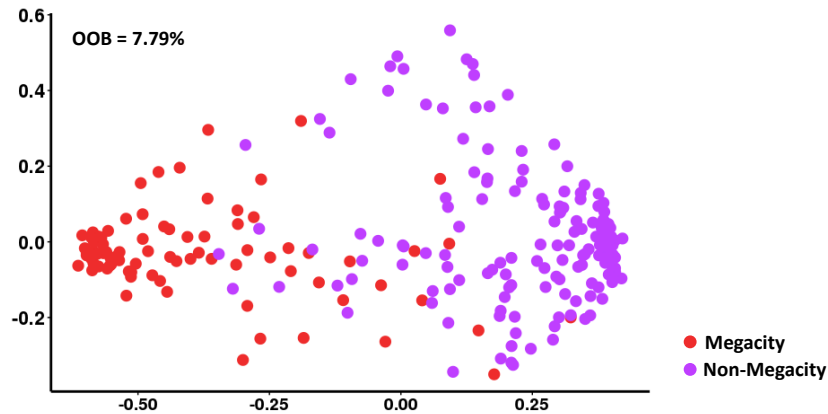


fig. S9. Comparison of predicted functional metagenomic profiling using PICRUST between the megacity and non-megacity groups. The Nearest Sequenced Taxon Index (NSTI) was calculated for assessing the accuracy of PICRUST, and the NSTI score of our data was 0.056 ± 0.016 . An NSTI value below 0.06 generally means that the closely related reference genomes were applicable to the dataset. A multidimensional plot of the proximity matrix was calculated using random forest analysis of the PICRUST results (out-of-box error rate = 7.79%, ntree = 100), showing a significant difference between the two groups.

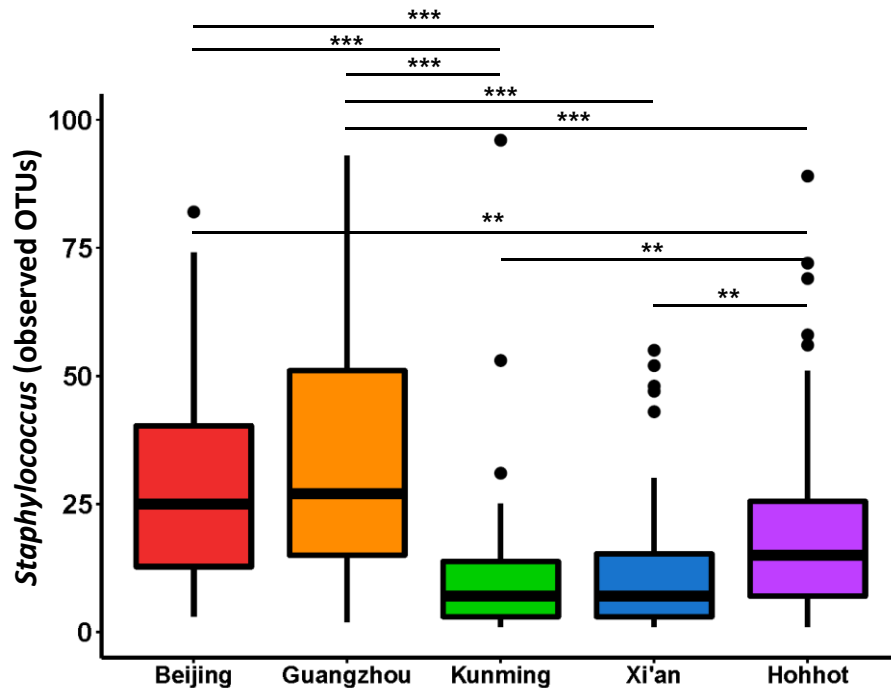


fig. S10. The richness (observed OTUs) of the genus *Staphylococcus* in five cities. On each graph, an asterisk indicates a significant difference (** $P < 0.01$, * $P < 0.05$, Wilcoxon rank sum test).

table S1. Sample metadata, number of sequences, and α diversity across samples based on rarefaction of 4860 reads per sample.

Sample	Location	Age	Married childbirth	Moisture (A.U)	Oil (A.U)	pH	TEWL (g/m ² h)	Horny Substance	Skin Type	Occupation	Number of sequences	Number of OTUs	Chao1	PD whole tree
Bei.01	Beijing	35	Married with children	54.80	9	5.95	22.67	15.2	nomal	Working	25524	184	445.1	21.9
Bei.02	Beijing	34	Married without children	43.97	2	5.43	34.53	16.6	NA	Working	29200	327	703.0	35.6
Bei.03	Beijing	34	Married with children	69.97	7	5.66	20.27	13.8	dry	Working	30137	274	594.8	30.4
Bei.04	Beijing	35	Married with children	44.27	19	5.89	29.73	15.6	dry	Working	29995	119	518.0	17.7
Bei.05	Beijing	35	Married with children	63.17	11	5.64	22.13	15.2	nomal	Housewife	33924	235	497.6	27.0
Bei.06	Beijing	34	Married without children	58.20	19	5.43	29.43	15.5	nomal	Working	30572	124	352.8	16.3
Bei.07	Beijing	32	Married without children	54.80	15	5.12	20.13	14.9	nomal	Working	26984	301	815.1	32.2
Bei.08	Beijing	35	Married with children	54.17	5	5.96	17.8	17.2	dry	Working	37907	279	1035.1	34.7
Bei.09	Beijing	35	Married with children	47.53	1	5.85	23.23	15.2	dry	Working	33725	239	632.9	26.5
Bei.10	Beijing	25	Unmarried	66.20	13	5.92	27.1	20.5	nomal	Working	33265	159	436.5	19.9
Bei.11	Beijing	34	Married with children	56.20	11	5.63	15.97	20.8	dry	Working	36735	309	1104.0	32.5
Bei.12	Beijing	26	Unmarried	60.93	19	5.66	22.67	16	combination	Working	33649	134	279.5	18.4
Bei.13	Beijing	28	Unmarried	53.07	22	6.37	18.53	18.1	combination	Working	30526	205	488.6	24.2
Bei.14	Beijing	28	Married with children	39.73	0	6.07	27.23	19.4	nomal	Working	42935	340	1226.2	37.2
Bei.15	Beijing	33	Married with children	66.93	21	7.03	21.7	18.7	nomal	Working	40901	336	877.8	32.4
Bei.16	Beijing	35	Married with children	78.53	21	6.90	27.73	15.3	nomal	Housewife	24596	223	521.5	27.1
Bei.17	Beijing	26	Married without children	63.73	3	6.86	18.93	14.7	nomal	Working	31406	71	211.3	11.1
Bei.18	Beijing	25	Unmarried	42.50	11	6.59	25.23	17.6	dry	Working	32636	137	230.9	16.8
Bei.19	Beijing	25	Unmarried	54.00	29	6.88	22.57	16.5	dry	Working	21564	68	134.4	11.5
Bei.20	Beijing	25	Unmarried	64.27	20	7.04	23.73	22.3	dry	Working	23654	110	218.1	13.0
Bei.21	Beijing	25	Unmarried	62.97	17	6.75	29.2	16.3	dry	Working	22766	290	678.3	33.2
Bei.22	Beijing	31	Married with children	50.80	11	6.94	22.9	14.8	nomal	Working	31123	159	807.0	21.3
Bei.23	Beijing	35	Married with children	44.37	4	7.04	25.8	18.3	dry	Working	36963	235	593.0	25.2
Bei.24	Beijing	30	Married without children	56.97	8	6.67	25.5	18.2	oily	Working	35400	184	500.9	17.3
Bei.25	Beijing	35	Married with children	33.67	21	6.86	20.1	17.6	dry	Working	47779	320	833.0	33.1
Bei.26	Beijing	25	Unmarried	49.73	10	6.91	14.4	21.3	nomal	Working	23496	123	336.3	13.7
Bei.27	Beijing	25	Unmarried	39.50	12	6.87	19.33	26.3	nomal	Working	28078	160	520.0	20.5
Bei.28	Beijing	35	Married with children	52.27	21	6.90	21.03	17.4	dry	Working	12944	227	548.0	25.9
Bei.29	Beijing	34	Married with children	54.03	14	6.77	20.7	19.4	dry	Working	28958	157	476.5	20.3
Bei.30	Beijing	25	Unmarried	67.47	13	6.95	17.1	16.6	nomal	Working	32794	88	211.0	11.6
Bei.31	Beijing	26	Unmarried	45.77	23	6.77	18.63	19.9	nomal	Working	33077	94	206.9	15.1
Bei.32	Beijing	33	Married without children	49.67	31	6.82	28.67	16	oily	Working	31565	229	956.2	25.9
Bei.33	Beijing	26	Unmarried	49.93	39	6.72	36.3	15.4	oily	Working	42672	240	616.9	26.5
Bei.34	Beijing	32	Married without children	68.50	15	6.44	25.33	21.2	dry	Working	38999	188	1076.0	18.8
Bei.35	Beijing	27	Unmarried	35.63	12	6.75	26.4	15.6	dry	Working	33544	81	471.0	13.5
Bei.36	Beijing	25	Unmarried	29.80	5	6.78	24.5	16.7	nomal	Working	33089	135	231.3	18.6
Bei.37	Beijing	31	Married without children	76.87	9	6.53	14.97	19.5	nomal	Working	41716	242	605.1	27.8
Bei.38	Beijing	27	Unmarried	52.23	5	6.78	15.93	18	nomal	Working	22586	204	477.2	23.7
Bei.39	Beijing	27	Married without children	62.30	28	6.75	27.13	15.1	nomal	Working	33381	106	272.5	17.5
Bei.40	Beijing	35	Married without children	40.07	8	6.91	16.4	21	oily	Working	23692	147	391.4	20.1
Bei.41	Beijing	35	Married without children	42.57	1	7.05	25.3	16.6	dry	Working	24439	211	1565.7	20.9
Bei.42	Beijing	34	Married with children	59.30	21	6.83	22.23	16.9	dry	Working	35693	148	435.3	21.1
Bei.43	Beijing	34	Married without children	60.93	4	5.25	21.5	15	dry	Working	22815	150	369.0	18.2
Bei.44	Beijing	34	Married without children	44.83	35	5.78	38.1	21.1	oily	Working	16864	120	390.1	17.4
Bei.45	Beijing	35	Married with children	45.13	20	5.69	16.87	17.1	dry	Working	37619	280	739.0	34.6
Bei.46	Beijing	25	Unmarried	56.13	11	6.47	24.7	21.1	dry	Working	32540	90	206.3	15.2
Bei.47	Beijing	33	Married without children	54.97	30	6.21	32.27	14.1	dry	Working	39109	215	565.2	26.0
Bei.48	Beijing	25	Unmarried	39.73	18	5.80	19.03	17.5	dry	Working	36759	152	371.0	16.5
Bei.49	Beijing	33	Unmarried	51.97	21	6.32	48.87	16.6	dry	Working	18666	105	321.2	15.7
Bei.50	Beijing	26	Unmarried	67.13	26	6.11	14.3	16.7	nomal	Working	9483	151	308.9	19.2

table S1. - continued.

Sample	Location	Age	Married childbirth	Moisture (A.U)	Oil (A.U)	pH	TEWL (g/m ² h)	Horny Substance	Skin Type	Occupation	Number of sequences	Number of OTUs	Chao1	PD whole tree
Guang.01	Guangzhou	31	Married without children	38.67	0	5.84	20.67	20.7	normal	Working	42480	236	549.8	27.4
Guang.02	Guangzhou	32	Married without children	49.13	4	5.79	18.67	19.8	normal	Working	12403	130	275.5	18.5
Guang.03	Guangzhou	31	Unmarried	61.07	33	5.30	15.03	18.5	oily	Working	54957	386	849.8	41.0
Guang.04	Guangzhou	26	Unmarried	34.90	11	5.63	29.17	17.9	dry	Working	23817	180	626.3	18.8
Guang.05	Guangzhou	28	Unmarried	53.60	21	5.72	23.73	21.5	combination	Working	17125	143	269.4	20.5
Guang.06	Guangzhou	35	Married with children	36.73	23	5.80	47.13	15.8	dry	Working	8023	80	150.1	12.4
Guang.07	Guangzhou	35	Married with children	61.77	5	5.85	13.67	16	normal	Working	42314	277	694.3	35.5
Guang.08	Guangzhou	32	Married without children	49.53	7	5.98	15.43	14.3	normal	Working	42908	278	602.3	31.0
Guang.09	Guangzhou	29	Married with children	42.53	8	6.15	19.33	18.5	combination	Working	51439	459	1075.9	47.9
Guang.10	Guangzhou	34	Married with children	73.13	32	5.70	14.43	19.8	normal	Working	40223	278	600.3	28.4
Guang.11	Guangzhou	34	Married with children	52.53	33	5.98	20.1	20.8	combination	Working	50922	392	952.3	40.8
Guang.12	Guangzhou	28	Unmarried	52.43	4	5.74	12.07	21.6	normal	Working	20668	160	791.3	16.5
Guang.13	Guangzhou	29	Married without children	55.80	19	5.62	20.67	18.4	dry	Working	42051	153	348.5	19.3
Guang.14	Guangzhou	34	Married with children	35.90	3	6.72	27.47	22.5	dry	Working	23169	180	1445.6	19.6
Guang.15	Guangzhou	35	Married with children	62.63	0	5.66	21.23	18.5	dry	Housewife	29987	312	721.9	32.6
Guang.16	Guangzhou	32	Married without children	44.80	4	5.36	17.17	19.9	normal	Working	40980	445	1199.7	43.7
Guang.17	Guangzhou	31	Married with children	40.80	4	6.23	21.63	24.3	dry	Working	28854	237	640.3	30.1
Guang.18	Guangzhou	28	Unmarried	64.70	1	5.98	14.43	18.7	normal	Working	22855	254	641.5	29.1
Guang.19	Guangzhou	32	Married with children	61.87	33	5.43	15.5	22.1	normal	Working	34431	159	313.1	20.2
Guang.20	Guangzhou	33	Married without children	49.10	23	5.51	28.9	16.4	normal	Working	42886	307	734.7	33.9
Guang.21	Guangzhou	35	Married with children	31.27	17	5.36	17.53	21.2	normal	Working	32956	310	557.6	33.3
Guang.22	Guangzhou	29	Married without children	17.43	10	5.76	22.27	22.3	normal	Working	54649	183	310.5	25.5
Guang.23	Guangzhou	33	Married with children	40.27	13	4.24	14.67	22.4	normal	Working	31566	231	546.5	29.1
Guang.24	Guangzhou	27	Unmarried	26.87	2	5.96	25.33	18.7	normal	Working	22739	274	648.2	31.9
Guang.25	Guangzhou	29	Unmarried	53.67	3	5.52	14.57	19	normal	Working	28141	157	476.5	23.5
Guang.26	Guangzhou	27	Married without children	52.07	4	5.83	22.4	17.5	normal	Working	2560	n/a	n/a	n/a
Guang.27	Guangzhou	31	Married without children	58.47	2	5.44	19.7	19.8	dry	Working	43698	389	924.9	41.6
Guang.28	Guangzhou	29	Married without children	68.83	26	5.42	21.3	18.5	dry	Working	32832	230	557.2	27.2
Guang.29	Guangzhou	30	Unmarried	62.27	9	6.21	28.33	18.5	dry	Working	22568	79	266.0	11.8
Guang.30	Guangzhou	34	Married with children	69.37	14	5.58	15	14.4	normal	Working	18383	152	407.6	21.8
Guang.31	Guangzhou	27	Unmarried	30.33	2	6.27	13.33	22.3	normal	Working	39629	442	874.7	43.6
Guang.32	Guangzhou	32	Married with children	51.30	10	6.18	26.9	16.1	normal	Working	28276	80	290.0	11.9
Guang.33	Guangzhou	25	Married without children	61.43	11	5.96	19.2	17.6	normal	Working	32096	241	537.0	28.4

table S1. - continued.

Sample	Location	Age	Married childbirth	Moisture (A.U)	Oil (A.U)	pH	TEWL (g/m ² h)	Horny Substance	Skin Type	Occupation	Number of sequences	Number of OTUs	Chao1	PD whole tree
Kun.01	Kunming	29	Married with children	35.23	11	6.20	32.47	30.7	combination	Housewife	76954	269	444.5	31.5
Kun.02	Kunming	30	Married with children	41.93	12	5.69	22.1	26.8	combination	others	12447	241	531.1	32.2
Kun.03	Kunming	32	Married with children	23.30	3	6.45	48.33	27.3	dry	Working	12063	504	1515.1	52.8
Kun.04	Kunming	26	Unmarried	35.60	10	6.40	16.93	30.3	dry	Working	12072	582	1550.0	59.3
Kun.05	Kunming	25	Unmarried	54.17	17	6.08	27.97	27.6	nomal	Working	10753	537	1203.5	54.5
Kun.06	Kunming	26	Unmarried	39.43	9	6.03	22.43	27.4	combination	Working	12353	268	435.2	35.8
Kun.07	Kunming	29	Married without children	67.73	23	6.27	58.4	27.7	combination	Working	10748	349	623.2	39.8
Kun.08	Kunming	25	Married without children	54.17	16	5.31	17.97	25.1	combination	Working	6305	94	109.0	15.3
Kun.09	Kunming	28	Married with children	47.77	14	6.36	56.53	27.3	dry	Working	20913	248	635.6	28.0
Kun.10	Kunming	35	Married with children	53.60	5	6.43	21.53	27.2	combination	others	13952	682	1586.5	58.2
Kun.11	Kunming	28	Unmarried	64.83	11	5.45	21.23	26.7	nomal	Working	13706	305	671.2	38.2
Kun.12	Kunming	32	Married without children	66.80	8	6.05	22.57	29.2	combination	Working	25258	153	196.6	21.5
Kun.13	Kunming	25	Unmarried	37.03	4	6.46	21.23	29.8	combination	Working	10704	549	1125.6	56.4
Kun.14	Kunming	25	Unmarried	52.53	4	6.23	28.43	27.4	nomal	Working	24938	159	197.8	21.9
Kun.15	Kunming	35	Married with children	48.80	13	6.18	23.13	28.5	combination	Working	33098	82	112.6	15.4
Kun.16	Kunming	33	Married with children	54.20	19	6.19	23.03	27.6	combination	Working	8165	315	619.3	41.9
Kun.17	Kunming	28	Married with children	56.40	6	6.36	28.03	25.8	combination	Working	36919	138	169.2	21.4
Kun.18	Kunming	27	Married without children	52.07	26	6.24	29.1	26	combination	Working	12575	168	336.1	24.4
Kun.19	Kunming	25	Unmarried	27.03	5	6.24	20.33	26.4	dry	Student	3014	n/a	n/a	n/a
Kun.20	Kunming	30	Unmarried	58.30	5	6.21	24.1	29.1	combination	Working	20750	185	472.6	28.6
Kun.21	Kunming	35	Married without children	74.00	3	6.39	19.07	28.8	combination	Working	16016	427	1441.5	42.6
Kun.22	Kunming	28	Married without children	37.00	3	6.14	23.2	29.1	nomal	Working	17622	368	1059.7	43.8
Kun.23	Kunming	25	Unmarried	67.93	26	6.31	35.1	23.6	nomal	Working	14821	205	421.2	24.8
Kun.24	Kunming	33	Unmarried	50.50	7	6.24	16.47	28.4	combination	Working	13723	166	180.9	25.8
Kun.25	Kunming	25	Unmarried	63.83	11	6.18	27.13	25.4	oily	Working	31388	151	355.4	18.3
Kun.26	Kunming	33	Married with children	53.13	7	6.14	20.87	28.3	nomal	Working	4981	n/a	n/a	n/a
Kun.27	Kunming	25	Unmarried	28.43	4	6.13	19.67	26.6	combination	Working	36100	175	318.0	22.0
Kun.28	Kunming	30	Unmarried	54.73	7	6.10	24.07	24.9	combination	Working	21891	70	122.5	12.1
Kun.29	Kunming	27	Unmarried	55.00	3	6.04	25.77	25.6	dry	Working	30717	85	132.1	11.1
Kun.30	Kunming	35	Married with children	51.37	4	6.35	27.5	26.3	dry	Working	26778	90	136.4	11.5
Kun.31	Kunming	26	Unmarried	53.37	2	6.37	38.73	24.3	oily	Working	16958	68	113.3	10.4
Kun.32	Kunming	28	Married with children	50.13	11	6.53	21.97	26.5	combination	Working	59541	212	279.2	27.6
Kun.33	Kunming	35	Married with children	49.17	4	6.88	24.33	24.5	dry	Working	13391	256	464.4	31.5
Kun.34	Kunming	26	Unmarried	67.73	27	6.02	28.23	25	combination	Working	8991	527	1039.8	53.9
Kun.35	Kunming	25	Unmarried	56.73	7	6.42	20.83	24.9	combination	Unemployed	22236	179	237.2	23.5
Kun.36	Kunming	28	Married with children	63.63	3	6.11	38	25.2	combination	Working	37283	172	249.2	24.8
Kun.37	Kunming	25	Unmarried	54.70	22	6.18	25.7	23	combination	Student	9660	168	358.4	25.6
Kun.38	Kunming	28	Married with children	44.50	15	5.98	35.2	24.9	dry	Housewife	34396	73	84.0	11.3
Kun.39	Kunming	32	Married with children	49.87	29	6.10	39.53	23.1	combination	Working	31607	113	141.9	18.8
Kun.40	Kunming	25	Unmarried	53.63	15	6.34	29.23	23.2	combination	Working	3870	n/a	n/a	n/a
Kun.41	Kunming	25	Unmarried	61.83	2	5.81	30	27.2	dry	Working	3449	n/a	n/a	n/a
Kun.42	Kunming	25	Unmarried	64.93	34	6.23	34.67		oily	Working	18148	112	211.2	13.9
Kun.43	Kunming	25	Unmarried	52.23	3	6.15	27.93	27.5	extremly_dry	Working	13326	109	125.5	18.0
Kun.44	Kunming	35	Married with children	63.67	4	6.34	20.53	25.1	combination	Working	18162	93	165.5	14.7
Kun.45	Kunming	33	Married with children	49.57	11	6.10	20.57	25.4	nomal	Working	18040	309	501.6	30.0
Kun.46	Kunming	25	Unmarried	49.63	2	6.16	32.5	23.7	combination	Working	15923	105	124.3	18.0
Kun.47	Kunming	33	Unmarried	43.10	10	6.23	25.03	28.2	nomal	Working	20095	90	132.2	14.8
Kun.48	Kunming	32	Married without children	49.13	6	5.99	15.2	27	dry	Working	6940	354	729.9	41.0
Kun.49	Kunming	28	Unmarried	48.53	3	6.17	24.33	27.5	dry	Working	9752	153	196.0	20.5
Kun.50	Kunming	26	Married without children	60.17	4	6.24	43.83	27.8	combination	Working	29321	160	274.0	21.6

table S1. - continued.

Sample	Location	Age	Married childbirth	Moisture (A.U)	Oil (A.U)	pH	TEWL (g/m ² h)	Horny Substance	Skin Type	Occupation	Number of sequences	Number of OTUs	Chao1	PD whole tree
Xi.01	Xian	35	Married with children	47.73	30	5.72	19.3	14.3	oily	Working	20169	291	693.8	34.9
Xi.02	Xian	27	Unmarried	51.17	41	6.16	20.33	16	dry	Working	21653	486	1189.3	50.9
Xi.03	Xian	27	Unmarried	42.10	0	5.97	24.33	18	combination	Working	15456	326	527.0	39.6
Xi.04	Xian	25	Unmarried	57.97	31	5.66	26.47	15.9	nomal	Working	19435	277	499.0	34.3
Xi.05	Xian	28	Married with children	56.03	0	5.55	26.53	14.8	nomal	Working	25722	171	192.1	25.1
Xi.06	Xian	35	Married with children	49.43	4	5.86	29	17.6	nomal	Working	18086	228	345.6	30.2
Xi.07	Xian	27	Married with children	59.80	8	5.74	34.17	12.6	dry	Working	2556	n/a	n/a	n/a
Xi.08	Xian	25	Unmarried	64.10	3	6.07	35.27	13.1	nomal	Working	16295	274	512.0	33.8
Xi.09	Xian	30	Married with children	47.40	36	5.88	21.63	19.8	combination	Working	18167	121	146.0	18.8
Xi.10	Xian	26	Unmarried	63.53	5	5.59	32.4	15.8	dry	Working	4177	n/a	n/a	n/a
Xi.11	Xian	30	Married with children	66.63	0	5.94	19.2	17.1	combination	Housewife	14441	408	917.5	42.3
Xi.12	Xian	32	Married without children	42.07	1	6.05	25.2	13.1	dry	Unemployed	33031	157	337.6	20.5
Xi.13	Xian	30	Married with children	48.37	4	5.78	33.87	14.1	dry	Working	19374	245	490.2	33.6
Xi.15	Xian	25	Married with children	54.17	3	6.16	23.63	16.9	combination	others	2979	n/a	n/a	n/a
Xi.16	Xian	32	Married with children	45.40	9	6.07	29.5	21.2	dry	Working	11240	455	953.2	49.6
Xi.17	Xian	34	Married with children	48.50	0	6.33	23	17.7	combination	Working	9135	398	707.8	44.9
Xi.18	Xian	31	Married with children	24.60	4	6.36	27.37	22.9	oily	Working	886	n/a	n/a	n/a
Xi.20	Xian	25	Unmarried	43.10	0	6.33	21.1	18.3	dry	Working	15257	491	842.4	47.5
Xi.21	Xian	26	Unmarried	51.03	13	6.06	27.07	19.4	oily	Working	25735	68	87.5	14.6
Xi.22	Xian	31	Married with children	38.17	0	5.76	21.33	19.1	combination	Working	20359	373	637.7	40.1
Xi.23	Xian	31	Married with children	30.33	0	6.05	33.4	17.1	combination	Working	15266	389	783.5	44.7
Xi.24	Xian	32	Married with children	49.03	5	6.12	22.8	21	combination	Working	32843	216	8092.5	11.3
Xi.25	Xian	29	Married without children	35.93	22	5.94	24.6	18.1	nomal	Working	22870	297	517.5	39.6
Xi.26	Xian	25	Unmarried	39.47	6	5.88	28.67	17.8	dry	Student	14820	368	688.3	45.4
Xi.27	Xian	25	Unmarried	41.60	5	6.35	29.2	19.1	oily	Student	11829	248	376.6	33.2
Xi.28	Xian	35	Married with children	46.90	5	6.36	37.73	17.5	dry	Working	15261	220	400.8	31.8
Xi.29	Xian	35	Married with children	42.90	2	5.99	16.93	20.6	oily	Housewife	13100	414	781.6	48.0
Xi.30	Xian	28	Married without children	50.07	6	6.10	35.27	20	nomal	Working	11181	179	302.5	25.8
Xi.31	Xian	25	Unmarried	49.07	11	6.07	17.77	17.2	oily	Working	15702	465	858.8	52.2
Xi.32	Xian	28	Unmarried	53.87	3	6.22	32.73	17.1	combination	Working	13103	221	408.0	31.4
Xi.33	Xian	25	Unmarried	35.90	2	6.13	27.33	23.2	combination	Working	2511	n/a	n/a	n/a
Xi.34	Xian	25	Unmarried	30.00	5	6.26	29.27	20.8	extremely_dry	Working	2238	n/a	n/a	n/a
Xi.35	Xian	28	Unmarried	37.63	18	6.98	23.3	20.6	combination	Working	9176	219	342.7	31.0
Xi.36	Xian	25	Unmarried	40.13	25	5.98	34.53	15.4	dry	Working	20317	192	463.6	27.2
Xi.37	Xian	31	Married with children	29.43	6	6.15	22.97	20.5	combination	Working	21330	272	556.2	35.1
Xi.38	Xian	35	Married with children	52.40	2	5.95	30.57	21.4	dry	Working	1762	n/a	n/a	n/a
Xi.39	Xian	32	Married without children	41.23	3	5.85	28	20.5	combination	Working	25512	292	404.2	37.8
Xi.40	Xian	32	Married with children	49.43	5	6.05	18.9	20	dry	Working	26725	433	1295.5	43.2
Xi.41	Xian	32	Married with children	57.60	2	5.56	18.63	20.4	nomal	Working	1587	n/a	n/a	n/a
Xi.42	Xian	27	Unmarried	65.20	2	5.74	29.43	16.2	dry	Working	15746	600	1044.4	65.5
Xi.43	Xian	31	Unmarried	41.67	5	5.97	25.83	21.7	combination	Working	11140	369	587.2	42.9
Xi.44	Xian	28	Married with children	39.53	20	6.16	25.7	18.2	combination	Working	13152	298	700.1	39.0
Xi.45	Xian	28	Unmarried	52.63	3	6.77	26.47	15.8	nomal	Working	33104	282	399.8	35.8
Xi.46	Xian	27	Married with children	25.77	17	6.00	19.97	18.7	nomal	Housewife	12841	314	682.2	34.7
Xi.47	Xian	26	Married with children	67.30	2	5.72	16.8	21.4	dry	Working	12232	511	665.8	52.3
Xi.48	Xian	25	Unmarried	50.67	0	6.12	16.5	18.3	dry	Working	22429	219	576.5	26.5
Xi.49	Xian	27	Unmarried	61.53	13	6.20	30.7	19.4	nomal	Working	22739	314	769.0	38.3
Xi.50	Xian	34	Married with children	72.00	8	6.25	20	22.1	dry	Working	18548	609	1571.5	56.6

table S1. - continued.

Sample	Location	Age	Married childbirth	Moisture (A.U)	Oil (A.U)	pH	TEWL (g/m ² h)	Horny Substance	Skin Type	Occupation	Number of sequences	Number of OTUs	Chao1	PD whole tree
Ho.01	Hohhot	29	Unmarried	29.83	8	5.89	23.43	24.2	combination	Working	18887	83	128.5	16.1
Ho.02	Hohhot	35	Married with children	43.57	51	6.14	18.83	18	oily	others	15353	734	2562.1	71.6
Ho.03	Hohhot	25	Married without children	36.03	12	6.29	23.43	18.7	combination	Student	11167	744	1979.1	63.3
Ho.04	Hohhot	25	Unmarried	37.07	0	6.27	26.93	18.3	combination	Working	29250	853	3105.9	56.0
Ho.05	Hohhot	26	Unmarried	55.10	13	6.29	16.03	21.5	dry	Working	30089	362	886.3	45.1
Ho.06	Hohhot	35	Married with children	50.90	0	6.42	21.8	17.7	combination	Working	18669	725	1594.1	67.6
Ho.07	Hohhot	35	Married with children	44.07	0	5.95	14.1	18.7	dry	Working	12907	480	784.5	52.3
Ho.08	Hohhot	33	Unmarried	49.83	5	6.57	38.63	22.3	nomal	Working	11977	340	1172.5	39.7
Ho.09	Hohhot	25	Unmarried	41.87	6	6.73	23.47	22.5	combination	Unemployed	21727	745	2085.1	48.0
Ho.10	Hohhot	33	Unmarried	23.90	8	6.49	30.6	20	combination	Working	13459	433	743.1	51.6
Ho.11	Hohhot	30	Unmarried	22.97	0	6.36	30.13	23.8	dry	Working	8184	361	506.0	40.8
Ho.12	Hohhot	31	Married without children	58.90	0	6.35	18.4	18.5	dry	Working	23167	737	2092.9	64.4
Ho.13	Hohhot	35	Married with children	53.00	2	6.42	24.5	20.8	nomal	Working	18717	578	1470.8	56.9
Ho.14	Hohhot	27	Married with children	59.30	20	5.94	23.4	21.8	combination	Working	19404	612	2052.2	64.6
Ho.15	Hohhot	35	Married with children	42.47	8	6.33	15.4	24.1	dry	Working	25213	763	2018.2	76.9
Ho.16	Hohhot	35	Married with children	31.27	1	6.38	16.6	24.9	dry	Working	29830	773	2897.8	71.6
Ho.17	Hohhot	25	Unmarried	19.00	5	6.27	38.57	26.2	dry	Working	20992	539	1002.7	57.2
Ho.18	Hohhot	31	Married with children	53.27	8	6.78	15.2	19.3	nomal	Working	19496	466	1100.1	50.2
Ho.19	Hohhot	25	Unmarried	42.60	13	6.43	28.03	20.4	combination	Working	14396	431	1031.8	49.1
Ho.20	Hohhot	26	Unmarried	29.30	13	6.34	35.03	18.7	combination	Working	13496	272	740.0	39.1
Ho.21	Hohhot	26	Unmarried	48.63	0	5.71	17.5	20	combination	Working	1795	n/a	n/a	n/a
Ho.22	Hohhot	31	Married with children	55.53	0	6.50	18.9	25.3	dry	Working	10119	593	1622.9	51.1
Ho.23	Hohhot	25	Unmarried	42.03	13	6.53	20.77	30.1	oily	Working	12083	312	534.0	36.3
Ho.24	Hohhot	25	Unmarried	53.40	0	6.35	25.7	22.9	nomal	Working	16241	454	822.4	50.7
Ho.25	Hohhot	33	Married with children	29.87	0	6.83	18.2	22	combination	Housewife	12884	565	1200.7	58.9
Ho.26	Hohhot	35	Married with children	24.57	0	6.39	33.1	20.1	oily	Working	10211	385	762.4	48.1
Ho.27	Hohhot	35	Married with children	37.67	3	6.07	25.17	23.4	oily	others	16608	487	1283.1	55.8
Ho.28	Hohhot	35	Married with children	44.80	0	5.85	17.9	17.8	nomal	Unemployed	19772	757	2237.2	69.0
Ho.29	Hohhot	26	Unmarried	52.00	0	6.55	21.1	19.5	extremely_dry	Student	31249	179	265.0	25.7
Ho.30	Hohhot	26	Unmarried	54.40	3	6.44	17.3	22.1	oily	Student	16464	550	1004.3	53.8
Ho.31	Hohhot	26	Unmarried	32.60	0	6.30	20.97	22.4	nomal	Student	17316	394	771.1	44.9
Ho.32	Hohhot	35	Unmarried	42.07	1	5.97	57.3	21.8	combination	Working	6612	670	1681.9	66.3
Ho.33	Hohhot	26	Unmarried	51.33	28	6.51	26.63	19.7	nomal	Working	13530	596	1538.8	57.0
Ho.34	Hohhot	26	Married without children	55.80	21	6.48	19.87	24.3	dry	Working	20119	477	1011.7	42.4
Ho.35	Hohhot	32	Unmarried	51.53	9	6.59	31.4	20.6	combination	Working	19110	658	1773.7	54.6
Ho.36	Hohhot	25	Unmarried	28.87	9	6.46	23.33	23.9	combination	Working	15508	573	1614.1	48.9
Ho.37	Hohhot	25	Unmarried	52.60	20	6.93	37.7	20.5	oily	Working	28046	295	597.9	35.3
Ho.38	Hohhot	25	Unmarried	45.47	1	6.75	22.33	27.3	oily	Working	9620	527	1028.7	55.3
Ho.39	Hohhot	26	Unmarried	46.33	0	6.46	23.83	20.7	oily	Student	11877	387	841.3	41.3
Ho.40	Hohhot	25	Unmarried	48.43	28	6.32	17.23	22.9	combination	Working	13817	446	892.3	47.8
Ho.41	Hohhot	26	Unmarried	50.43	1	6.73	26.2	22.2	dry	Student	20295	753	2601.5	69.7
Ho.42	Hohhot	25	Unmarried	40.83	1	6.64	27.03	21.3	combination	Working	21993	92	155.0	13.0
Ho.43	Hohhot	26	Unmarried	11.03	4	6.47	36.23	26.1	combination	Working	7891	288	501.3	38.7
Ho.44	Hohhot	26	Unmarried	53.43	5	6.67	23.1	19.6	combination	Working	4293	n/a	n/a	n/a
Ho.45	Hohhot	26	Unmarried	19.57	2	6.63	32.43	19.5	oily	Working	18919	641	1673.8	65.0
Ho.46	Hohhot	25	Unmarried	42.80	3	6.55	21.57	23.7	combination	Working	16141	711	1992.6	55.1
Ho.47	Hohhot	25	Unmarried	31.13	22	6.50	29.57	27	nomal	Working	12132	445	1025.1	47.0
Ho.48	Hohhot	26	Unmarried	36.90	65	6.29	35.7	22.1	combination	Working	13886	512	1200.0	57.5
Ho.49	Hohhot	25	Unmarried	54.33	12	6.72	18.33	20.7	combination	Working	16512	442	713.6	49.8
Ho.50	Hohhot	26	Unmarried	41.70	0	6.35	23.83	19.9	dry	Working	16082	733	2019.3	67.3

table S2. Relative average abundances of the 15 most abundant genera.

Genus	Relative abundance (%)				
	Beijing	Guangzhou	Kunming	Xi'an	Hohhot
<i>Propionibacterium</i>	28.47	27.05	15.95	11.7	11.97
<i>Enhydrobacter</i>	3.05	2.43	12.51	9.25	5.93
<i>Chryseobacterium</i>	2.73	1.14	10.26	13.67	3.71
<i>Staphylococcus</i>	9.17	9.43	4.51	4.64	4.84
<i>Sphingomonas</i>	0.95	1.11	15.07	5.89	2.77
<i>Bacteroides</i>	0.08	0	2.38	5.33	14.1
<i>Corynebacterium</i>	5.09	2.95	1.41	2.66	2.86
<i>Streptococcus</i>	4.16	3.82	1.52	1.9	1.12
<i>Deinococcus</i>	0.75	3.22	5.24	1.67	1.31
<i>Acinetobacter</i>	1.95	1.41	1.2	3.11	1.78
<i>Faecalibacterium</i>	0.06	0.01	1.01	1.46	4.5
<i>Paracoccus</i>	1.66	3.18	0.89	0.75	1.05
<i>Neisseria</i>	1.29	1.3	0.61	2.63	0.66
<i>Micrococcus</i>	2.24	1.53	0.88	1.02	0.74
<i>Oscillospira</i>	0.01	0	0.8	0.94	3.61

table S3. Environmental factors and city indices of five cities.

Index	Sample ID				
	Beijing	Guangzhou	Kunming	Xi'an	Hohhot
1	Buk.15	Kwang.24	Kun.22	Xi.30	Ne.46
2	Buk.11	Kwang.08	Kun.21	Xi.26	Ne.09
3	Buk.32	Kwang.07	Kun.01	Xi.04	Ne.28
4	Buk.36	Kwang.15	Kun.48	Xi.02	Ne.35
5	Buk.34	Kwang.28	Kun.03	Xi.24	Ne.16
6	Buk.27	Kwang.20	Kun.11	Xi.49	Ne.04
7	Buk.02	Kwang.16	Kun.05	Xi.40	Ne.12
8	Buk.48	Kwang.27	Kun.04	Xi.05	Ne.50
9	Buk.18	Kwang.01	Kun.32	Xi.29	Ne.03
10	Buk.01	Kwang.30	Kun.46	Xi.03	Ne.30
11	Buk.26	Kwang.25	Kun.34	Xi.42	Ne.22
12	Buk.21	Kwang.09	Kun.45	Xi.22	Ne.10
13	Buk.10	Kwang.13	Kun.50	Xi.23	Ne.13
14	Buk.16	Kwang.32	Kun.44	Xi.50	Ne.24
15	Buk.28	Kwang.03	Kun.09	Xi.28	Ne.48
16	Buk.07	Kwang.33	Kun.25	Xi.31	Ne.41
17	Buk.08	Kwang.17	Kun.24	Xi.06	Ne.15
18	Buk.37	Kwang.31	Kun.27	Xi.13	Ne.14
19	Buk.24	Kwang.11	Kun.06	Xi.01	Ne.02
20	Buk.25	Kwang.04	Kun.16	Xi.37	Ne.25
21	Buk.13	Kwang.22	Kun.13	Xi.11	Ne.05
22	Buk.09	Kwang.05	Kun.17	Xi.17	Ne.11
23	Buk.45	Kwang.23	Kun.10	Xi.16	Ne.27
24	Buk.29	Kwang.19	Kun.37	Xi.25	Ne.45
25	Buk.41	Kwang.10	Kun.43	Xi.47	Ne.38
26	Buk.23	Kwang.12	Kun.07	Xi.27	Ne.26
27	Buk.22	Kwang.14	Kun.02	Xi.43	Ne.17
28	Buk.05	Kwang.18	Kun.20	Xi.39	Ne.18
29	Buk.30	Kwang.21	Kun.18	Xi.12	Ne.06
30	Buk.04	Kwang.02	Kun.23	Xi.36	Ne.36
31	Buk.33	Kwang.29	Kun.33	Xi.46	Ne.47
32	Buk.39	Kwang.06	Kun.12	Xi.35	Ne.34

table S4. Environmental factors and city indices of five cities.

Factors	Beijing	Guangzhou	Kunming	Xi'an	Hohhot
Atmospheric environment					
Annual Average Concentration of SO ₂ (ug/m ³)	14	13	17	24	34
Annual Average Concentration of NO ₂ (ug/m ³)	50	47	30	44	39
Annual Average Concentration of PM ₁₀ (ug/m ³)	102	59	56	126	103
Annual Average Concentration of PM _(10-2.5) (ug/m ³)	21	20	26	68	60
95th Percentile Daily Average Concentration of CO (ug/m ³)	3.6	1.4	1.4	3.4	3.2
90th Percentile Daily Maximun 8 hours Average Concentration of O ₃ (ug/m ³)	203	145	110	145	145
Annual Average Concentration of PM _{2.5} (ug/m ³)	81	39	30	58	43
Days of Air Quality Equal to or Above Grade II (day)	186	312	350	250	276
Air Quality Index	113.1	55.6	54.1	88.4	95
Climatic environment					
Temperature (°C)	22	29	21	23	13
Rain Days	10	27	18	9	10
Wind speed (mph)	8.7	9.6	6	7.2	8.5
Wind gust (mph)	12.3	13.2	8.9	10.7	11.2
Pressure (mb)	1011.9	1011.2	1011.5	1015.5	1016.7
Cloud (%)	18	71	24	25	22
Humidity (%)	27	80	62	43	27
UV Index (1~11)	8	6	6	8	7
Sun Hours (hr)	142.3	50.8	116.3	108.3	124
Sun Days	21	2	10	22	19
Visibility (km)	9.8	8.7	9.3	9.7	9.7
City index					
Population (million people)	21	14	6.5	8.3	2.8
Density (population per km ²)	1289	1883	302	827	166
GDP (billion dollar)	200	154	31	47	27
Urbanization	86	68	39	53	59

table S5. The observed species pool of five cities.

	Beijing	Guangzhou	Kunming	Xi'an	Hohhot
Observed species pool (^a number of OTUs)	3499	4139	4260	4582	8039

^a The observed species pool was calculated from randomly selected 32 samples and 19,712 OTUs, which was rarefied to 4860 reads per sample.

data file S1. The information of OTUs in Fig. 3A.