Preplanned Studies

Characteristics of Lung Function and Prevalence of Airflow Obstruction Among Individuals Aged 18–74 Years — Beijing, China, 2017–2018

Jiamin Wang[1,2]; Jing Du[2]; Yanlin Gao[2]; Yunping Shi[2]; Jianting Su[2]; Qingping Liu[2]; Yang Liu[2]; Ping Wang[2]; Chao Wang[2]; Bing Shao[3]; Gang Li[1,2,#]

Summary

What is already known about this topic?

Airflow obstruction is the hallmark of many chronic respiratory diseases and may indicate the potential for the development of other progressive diseases. There are currently no representative studies of lung function in Beijing. An up-to-date estimation of the characteristics of lung function and airflow obstruction is thus needed.

What is added by this report?

The estimated prevalence of airflow obstruction was 14.68% in Beijing, 2017–2018. The values of vital capacity, forced vital capacity, and forced expiratory volume in the first second were 3.09 L, 2.66 L, 2.22 L, respectively.

What are the implications for public health practice?

Effective public health strategy for lung in Beijing should target older people, current or former smokers, and individuals who live in urban environments, have a low education level, exhibit a high smoking index, and/or have an abnormal body mass index.

Pulmonary function is a crucial parameter for the comprehensive evaluation of respiratory system functions such as airway ventilation capacity. Pulmonary function tests are mainly used to detect the patency of the airway and the lung capacity, including a variety of diagnostics that assess how well the lungs work; the most basic pulmonary function test is spirometry (*1*). The interpretation of spirometric test results, such as airflow obstruction (AFO) levels, can help identify abnormal patterns that may be related to the presence of disease (*2*).

The physiological definition of AFO is a reduction in the ratio of forced expiratory volume in the first second (FEV_1) to forced vital capacity (FVC). Importantly, AFO has been found to be a critical element of certain diseases, such as chronic obstructive pulmonary disease (COPD) (*2*). Among individuals with AFO, 43%–74% are COPD patients (*3–5*), and COPD has become a major public health problem in China (*6*). The aim of this study was thus to estimate the level and characteristics of lung function and AFO in a sample population of adults living in Beijing in order to better serve populations such as those suffering from COPD.

The study was performed using baseline data (from September 2017 to May 2018) obtained from the Beijing Population Health Cohort Study. It is a large, prospective dynamic cohort study with a total of 24,990 subjects aged 18–74 years. The details of this study's design are discussed in another publication (*7*). This study's methodology excluded individuals who did not meet the age requirements and/or lacked important information, such as lung function indicator values, which left 21,426 participants in the analysis.

A standardized questionnaire was administered by trained staff. Smoking severity was determined by the smoking index (SI) [SI, calculated as (daily smoking count) × (years of smoking). Light: SI≤200; Moderate: 200<SI<400; Severe: SI≥400]. Weight and height were measured by trained staff, and body mass index (BMI) was subsequently calculated. Spirometry tests were conducted by trained technicians on participants in a sitting position with a nose clip using a spirometer. The spirometer was calibrated daily. Participants completed three tests of lung function. This study then used the GOLD lung function criteria (FEV_1/FVC <70%) to define individuals with AFO. The participants provided written informed consent. The Ethics Review Committee of the Beijing Center for Disease Prevention and Control approved the study protocol [No. 2017D(6)].

This study estimated standardized prevalence using the 2010 census of the Chinese population. Categorical data are shown as numbers (percentages). The mean±standard deviation is used to represent the continuous variables. This investigation assessed the statistical significance of differences either by one-way ANOVA or the Kruskal-Wallis H test for continuous variables and used the chi-squared test to compare prevalence. *P* values for trends were calculated using the Cochran-Armitage trend test for proportions. All statistical tests were two-sided, and *P*<0.05 was considered statistically significant. All statistical analyses were performed using Stata 16.0 (StataCorp LLC, College Station, Texas, USA).

The basic characteristics of the study subjects are listed in Table 1 and Table 2. Of the 21,426 subjects, 9,876 were males and 11,550 were females. Overall, males had higher vital capacity (VC), FVC, and FEV_1, but males had slightly lower FEV_1/FVC than females. The results of lung function testing are shown in Table 3. In males, the mean values of VC and FVC

TABLE 1. Basic characteristics of the sample population.

Variable	Total (*n*=21,426)	Male (*n*=9,876)	Female (*n*=11,550)
Age (years), mean (±SD)	45.97 (14.28)	45.95 (14.52)	45.99 (14.08)
Age group, *n* (%)			
18–29	3,332 (15.55)	1,620 (16.40)	1,712 (14.82)
30–39	4,876 (22.76)	2,226 (22.54)	2,650 (22.94)
40–49	4,079 (19.04)	1,723 (17.45)	2,356 (20.40)
50–59	4,274 (19.95)	1,996 (20.21)	2,278 (19.72)
60–74	4,865 (22.71)	2,311 (23.40)	2,554 (22.11)
BMI (kg/m^2), mean (±SD)	25.14 (3.84)	25.91 (3.67)	24.47 (3.86)
BMI group, *n* (%)			
<18.5	496 (2.31)	117 (1.18)	379 (3.28)
18.5–23.9	8,783 (38.19)	2,871 (29.07)	5,312 (45.99)
24.0–27.9	8,277 (38.63)	4,362 (44.17)	3,915 (33.90)
≥28.0	4,470 (20.86)	2,526 (25.58)	1,944 (16.83)
Residence, *n* (%)			
Urban	7,400 (34.54)	3,095 (31.34)	4,305 (37.27)
Suburban	14,026 (65.46)	6,781 (68.66)	7,245 (62.73)
Education level, *n* (%)			
Primary and below	1,765 (8.24)	657 (6.65)	1,108 (9.59)
Middle and high school	8,793 (41.04)	4,434 (44.90)	4,359 (37.74)
College and above	10,868 (50.72)	4,785 (48.45)	6,083 (52.67)
Smoking status, *n* (%)			
Current smoker	5,090 (23.76)	4,839 (49.00)	251 (2.17)
Former smoker	1,143 (5.33)	1,083 (10.97)	60 (0.52)
Never smoker	15,193 (70.91)	3,954 (40.04)	11,239 (97.31)
Smoking index level*, *n* (%)			
Light	1,418 (32.07)	1,334 (31.51)	84 (44.68)
Moderate	1,008 (22.80)	962 (22.72)	46 (24.47)
Severe	1,996 (45.14)	1,938 (45.77)	58 (30.85)
VC (L), mean (±SD)	3.09 (0.90)	3.59 (0.87)	2.66 (0.68)
FVC (L), mean (±SD)	2.66 (0.89)	3.12 (0.90)	2.27 (0.67)
FEV_1 (L), mean (±SD)	2.22 (0.83)	2.60 (0.87)	1.90 (0.63)
FEV_1/FVC (%), mean (±SD)	83.63 (15.04)	83.41 (15.31)	83.82 (14.81)

Note: Data are the number (percentage) for categorical variables and the mean±standard deviation for continuous variables.
* For smoking index level, the total number was 4,422, including 4,234 males and 188 females.
Abbreviation: SD=standard deviation; BMI=body mass index; VC=vital capacity; FVC=forced vital capacity; FEV_1=forced expiratory volume in the first second.

TABLE 2. Distribution of sample population by residence, educational level and smoking status by age group.

Variable	Total (*n*=21,426)	18–29 (*n*=3,332)	30–39 (*n*=4,876)	40–49 (*n*=4,079)	50–59 (*n*=4,274)	60–74 (*n*=4,865)
Residence, *n* (%)						
Urban	7,400 (34.54)	1,234 (37.03)	1,616 (33.14)	1,239 (30.38)	1,485 (34.74)	1,826 (37.53)
Suburban	14,026 (65.46)	2,098 (62.97)	3,260 (66.86)	2,840 (69.62)	2,789 (65.26)	3,039 (62.47)
Education level, *n* (%)						
Primary and below	1,765 (8.24)	18 (0.54)	30 (0.62)	82 (2.01)	315 (7.37)	1,320 (27.13)
Middle and high school	8,793 (41.04)	751 (22.54)	826 (16.94)	1,312 (32.16)	2,778 (65.00)	3,126 (64.25)
College and above	10,868 (50.72)	2,563 (76.92)	4,020 (82.44)	2,685 (65.82)	1,181 (27.63)	419 (8.61)
Smoking status, *n* (%)						
Current smoker	5,090 (23.76)	783 (23.50)	1,116 (22.89)	899 (22.04)	1,169 (27.35)	1,123 (23.08)
Former smoker	1,143 (5.33)	83 (2.49)	145 (2.97)	192 (4.71)	261 (6.11)	462 (9.50)
Never smoker	15,193 (70.91)	2,466 (74.01)	3,615 (74.14)	2,988 (73.25)	2,844 (66.54)	3,280 (67.42)
Smoking index level, *n* (%)*						
Light	1,418 (32.07)	545 (88.33)	501 (54.22)	152 (19.64)	110 (10.26)	110 (10.63)
Moderate	1,008 (22.80)	67 (10.86)	337 (36.47)	240 (31.01)	237 (22.11)	127 (12.27)
Severe	1,996 (45.14)	5 (0.81)	86 (9.31)	382 (49.35)	725 (67.63)	798 (77.10)
BMI group, *n* (%)						
<18.5	496 (2.31)	254 (7.62)	147 (3.01)	36 (0.88)	15 (0.35)	44 (0.90)
18.5–23.9	8,183 (38.19)	1,726 (51.80)	2,159 (44.28)	1,539 (37.73)	1,267 (29.64)	1,492 (30.67)
24.0–27.9	8,277 (38.63)	818 (24.55)	1,639 (33.61)	1,641 (40.23)	1,994 (46.65)	2,185 (44.91)
≥28.0	4,470 (20.86)	534 (16.03)	931 (19.09)	863 (21.16)	998 (23.35)	1,144 (23.51)

Note: Data are the number (percentage).
* For smoking index level, the total number was 4,422.
Abbreviation: BMI=body mass index.

were significantly different in the age, residence, education level, smoking status, smoking index level, and BMI groups. The mean value of FEV_1 was not significantly different among the different BMI groups. In females, the mean value of VC was significantly different in the age, education level, and BMI groups. The mean values of FVC and FEV_1 were not significantly different among the different smoking index levels.

A total of 3,415 (15.94%) participants had a FEV_1:FVC ratio less than 70% and were therefore diagnosed with AFO. The standardized prevalence of AFO in Beijing adults aged 18–74 years was estimated to be 14.68%. The prevalence of AFO did not differ significantly (P=0.062) between men (16.44%) and women (15.51%). The prevalence was significantly different by age group, residence, education level, and smoking status (Table 4). People with poor lung function and high prevalence of AFO were mainly those who were older, lived in an urban environment, were current or former smokers, and/or had a low education level, high smoking index, and an abnormal BMI.

DISCUSSION

To date, this is the first large-scale, community-based study working to estimate the level of lung function and the prevalence of AFO among adults in Beijing. Based on results, this research concluded that the prevalence of AFO among adults aged 18–74 years in Beijing was 15.94%, and that the standardized prevalence of AFO was 14.68%. Compared to the 2010 census data, the proportion of people aged 18–29 and 40–49 in this study is higher, and the proportion of people aged 50–59 and 60–74 is lower. With increased age, lung function decreases and the prevalence of AFO increases. Therefore, the crude prevalence in this study will decrease after standardization. Compared to the China Pulmonary Health (CPH) Study, which was a survey of 10 provincial-level administrative divisions (PLADs) in China (Beijing Municipality, Shanghai Municipality, Liaoning, Shanxi, Shaanxi, Sichuan, Guizhou, Hubei, Zhejiang and Guangdong Provinces) from June 2012 to May 2015, this study revealed a higher prevalence of AFO than the prevalence of COPD in adults aged 20

TABLE 3. Levels of pulmonary function indicators in the sample population aged 18–74 years old.

Variable	Total (*n*=21,426)				Male (*n*=9,876)				Female (*n*=11,550)			
	n	**VC (L) (mean)**	**FVC (L) (mean)**	**FEV_1 (L) (mean)**	***n***	**VC (L) (mean)**	**FVC (L) (mean)**	**FEV_1 (L) (mean)**	***n***	**VC (L) (mean)**	**FVC (L) (mean)**	**FEV_1 (L) (mean)**
Age group (years)												
18–29	3,332	3.45 (0.94)	2.97 (1.01)	2.54 (0.91)	1,620	4.02 (0.83)	3.50 (0.99)	2.98 (0.90)	1,712	2.92 (0.70)	2.47 (0.73)	2.11 (0.68)
30–39	4,876	3.36 (0.90)	2.93 (0.92)	2.50 (0.84)	2,226	3.95 (0.81)	3.46 (0.90)	2.96 (0.83)	2,650	2.87 (0.64)	2.49 (0.68)	2.12 (0.63)
40–49	4,079	3.12 (0.84)	2.71 (0.82)	2.30 (0.75)	1,723	3.68 (0.79)	3.23 (0.81)	2.75 (0.76)	2,356	2.70 (0.59)	2.34 (0.59)	1.98 (0.55)
50–59	4,274	2.91 (0.82)	2.51 (0.77)	2.06 (0.72)	1,996	3.37 (0.76)	2.91 (0.76)	2.40 (0.73)	2,278	2.51 (0.64)	2.15 (0.58)	1.76 (0.56)
60–74	4,865	2.69 (0.80)	2.28 (0.74)	1.80 (0.67)	2,311	3.07 (0.75)	2.62 (0.71)	2.04 (0.70)	2,554	2.34 (0.67)	1.96 (0.61)	1.57 (0.56)
P value		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Residence												
Urban	7,400	3.03 (0.90)	2.47 (0.87)	2.04 (0.79)	3,095	3.53 (0.88)	2.90 (0.91)	2.40 (0.85)	4,305	2.66 (0.72)	2.15 (0.69)	1.79 (0.63)
Suburban	14,026	3.12 (0.90)	2.77 (0.88)	2.31 (0.83)	6,781	3.62 (0.86)	3.22 (0.87)	2.69 (0.86)	7,245	2.65 (0.66)	2.34 (0.65)	1.96 (0.63)
P value		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		0.422	<0.001	<0.001
Education level												
Primary and below	1,765	2.61 (0.83)	2.16 (0.73)	1.68 (0.68)	657	3.05 (0.79)	2.57 (0.78)	1.96 (0.78)	1,108	2.35 (0.73)	1.92 (0.58)	1.52 (0.55)
Middle and high school	8,793	2.92 (0.86)	2.49 (0.83)	2.04 (0.77)	4,434	3.35 (0.81)	2.89 (0.82)	2.37 (0.80)	4,359	2.48 (0.66)	2.09 (0.62)	1.71 (0.57)
College and above	10,868	3.30 (0.89)	2.88 (0.90)	2.45 (0.82)	4,785	3.89 (0.82)	3.41 (0.89)	2.90 (0.83)	6,083	2.84 (0.64)	2.46 (0.66)	2.10 (0.62)
P value		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Smoking status												
Current smoker	5,090	3.52 (0.87)	3.07 (0.90)	2.56 (0.86)	4,839	3.57 (0.85)	3.12 (0.89)	2.60 (0.85)	251	2.60 (0.75)	2.14 (0.64)	1.73 (0.60)
Former smoker	1,143	3.41 (0.88)	2.94 (0.88)	2.38 (0.86)	1,083	3.45 (0.87)	2.99 (0.87)	2.41 (0.86)	60	2.61 (0.68)	2.17 (0.69)	1.83 (0.63)
Never smoker	15,193	2.92 (0.86)	2.50 (0.83)	2.09 (0.78)	3,954	3.66 (0.88)	3.15 (0.91)	2.64 (0.88)	11,239	2.66 (0.68)	2.27 (0.67)	1.90 (0.63)
P value		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		0.425	0.003	<0.001
Smoking index level												
Mild	1,418	3.80 (0.89)	3.35 (0.94)	2.84 (0.88)	1,334	3.87 (0.84)	3.42 (0.91)	2.91 (0.85)	84	2.67 (0.80)	2.20 (0.65)	1.81 (0.58)
Moderate	1,008	3.62 (0.88)	3.14 (0.91)	2.64 (0.86)	962	3.67 (0.85)	3.19 (0.88)	2.68 (0.84)	46	2.58 (0.82)	2.04 (0.68)	1.69 (0.66)
Severe	1,996	3.25 (0.77)	2.83 (0.78)	2.30 (0.77)	1,938	3.27 (0.76)	2.86 (0.77)	2.32 (0.76)	58	2.44 (0.66)	2.09 (0.63)	1.59 (0.57)
P value		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		0.210	0.368	0.105
BMI group												
<18.5	496	2.92 (0.84)	2.49 (0.82)	2.13 (0.78)	117	3.39 (0.90)	2.95 (0.96)	2.47 (0.92)	379	2.77 (0.76)	2.34 (0.72)	2.02 (0.69)
18.5–23.9	8,183	3.00 (0.86)	2.59 (0.86)	2.17 (0.80)	2,871	3.56 (0.89)	3.09 (0.93)	2.58 (0.89)	5,312	2.70 (0.67)	2.32 (0.68)	1.95 (0.65)
24.0–27.9	8,277	3.14 (0.91)	2.72 (0.90)	2.25 (0.83)	4,362	3.61 (0.84)	3.14 (0.88)	2.61 (0.85)	3,915	2.61 (0.67)	2.24 (0.65)	1.86 (0.61)
≥28.0	4,470	3.17 (0.96)	2.72 (0.92)	2.27 (0.86)	2,526	3.61 (0.89)	3.12 (0.90)	2.61 (0.86)	1,944	2.61 (0.73)	2.20 (0.64)	1.81 (0.60)
P value		<0.001	<0.001	<0.001		0.004	0.021	0.151		<0.001	<0.001	<0.001

Abbreviation: BMI=body mass index; VC=vital capacity; FVC=forced vital capacity; FEV_1=forced expiratory volume in the first second.

TABLE 4. Prevalence of airflow obstruction in the sample population aged 18–74 years old.

Variable	Total (*n*=21,426)		Male (*n*=9,876)		Female (*n*=11,550)	
	Cases/*N*	Prevalence of AFO (%) (95% *CI*)	Cases/*N*	Prevalence of AFO (%) (95% *CI*)	Cases/*N*	Prevalence of AFO (%) (95% *CI*)
Age group (years)						
18–29	423/3,332	12.70 (11.60–13.86)	205/1,620	12.65 (11.10–14.34)	218/1,712	12.73 (11.22–14.38)
30–39	562/4,876	11.53 (10.65–12.44)	242/2,226	10.87 (9.63–12.22)	320/2,650	12.08 (10.88–13.36)
40–49	509/4,079	12.48 (11.49–13.52)	202/1,723	11.72 (10.27–13.31)	307/2,356	13.03 (11.72–14.44)
50–59	758/4,274	17.74 (16.61–18.90)	360/1,996	18.04 (16.40–19.77)	398/2,278	17.47 (15.95–19.07)
60–74	1,163/4,865	23.91 (22.72–25.12)	615/2,311	26.61 (24.84–28.44)	548/2,554	21.46 (19.90–23.08)
P value*		<0.001		<0.001		<0.001
Residence						
Urban	1,300/7,400	17.57 (16.71–18.45)	563/3,095	18.19 (16.86–19.58)	737/4,305	17.12 (16.02–18.27)
Suburban	2,115/14,026	15.08 (14.49–15.68)	1,061/6,781	15.65 (14.80–16.53)	1,054/7,245	14.55 (13.75–15.37)
P value		<0.001		0.002		<0.001
Education level						
Primary and below	478/1,765	27.08 (25.05–29.19)	211/657	32.12 (28.63–35.76)	267/1,108	24.10 (21.65–26.68)
Middle and high school	1,688/8,793	18.97 (18.16–19.80)	857/4,434	19.33 (18.19–20.51)	811/4,359	18.61 (17.47–19.78)
College and above	1,269/10,868	11.68 (11.08–12.29)	556/4,785	11.62 (10.73–12.55)	713/6,083	11.72 (10.93–12.55)
P value*		<0.001		<0.001		<0.001
Smoking status						
Current smoker	832/5,090	16.35 (15.35–17.38)	780/4,839	16.12 (15.10–17.18)	52/251	20.72 (16.06–26.05)
Former smoker	226/1,143	19.77 (17.54–22.16)	220/1,083	20.31 (18.00–22.79)	6/60	10.00 (4.28–19.45)
Never smoker	2,357/15,193	15.51 (14.94–16.10)	624/3,954	15.78 (14.67–16.94)	1,733/11,239	15.42 (14.76–16.10)
P value		<0.001		0.001		0.036
Smoking index level						
Mild	188/1,418	13.26 (11.57–15.10)	169/1,334	12.67 (10.97–14.53)	19/84	22.62 (14.69–32.39)
Moderate	138/1,008	13.69 (11.67–15.92)	132/962	13.72 (11.66–16.00)	6/46	13.04 (5.63–24.92)
Severe	419/1,996	20.99 (19.25–22.82)	403/1,938	20.79 (19.03–22.64)	16/58	27.59 (17.37–39.97)
P value*		<0.001		<0.001		0.583
BMI group						
<18.5	69/496	13.91 (11.08–17.16)	21/117	17.95 (11.82–25.64)	48/379	12.66 (9.60–16.29)
18.5–23.9	1,267/8,183	15.48 (14.71–16.28)	485/2,871	16.89 (15.56–18.30)	782/5,312	14.72 (13.79–15.69)
24.0–27.9	1,373/8,277	16.59 (15.80–17.40)	740/4,362	16.96 (15.87–18.10)	633/3,915	16.17 (15.04–17.35)
≥28.0	706/4,470	15.79 (14.75–16.89)	378/2,526	14.96 (13.61–16.40)	328/1,944	16.87 (15.26–18.59)
P value*		0.233		0.057		0.003

Abbreviation: AFO=airflow obstruction; BMI=body mass index; *CI*=confidence interval.

* *P* value from Cochran-Armitage trend test for prevalence.

years or older (8.6%) (*8*). In the study mentioned above, bronchodilators were used to identify patients with COPD. The use of bronchodilators could lead to the exclusion of some patients with bronchial asthma. Therefore, the prevalence of AFO is higher than that of COPD, which is a finding that is consistent with other studies (*3,5*).

Males always have higher index values of lung function. The results of this study were consistent with this phenomenon. With increasing age, various organs of the human body gradually age, and because people are exposed to risk factors such as smoking starting when they are young, the cumulative effect of these factors increases with age, causing lung function to decline with age. According to a previous study, the prevalence of COPD was higher in rural areas (*6*). This may be due to the lower economic status in rural areas, which leads to people being exposed to many risk factors that affect lung function. Beijing, the capital of China, is a modern international city with generally favorable economic conditions and lower exposure to life-threatening factors than rural areas. People in urban areas, however, may be exposed to more car exhaust than people in suburban areas due to traffic congestion. Urban populations had worse lung function and a higher prevalence of AFO in this study. People with lower education levels had lower levels of lung function and a higher prevalence of AFO, possibly because they are less aware of lung function protection and are more likely to be exposed to risk factors. People with low BMI are generally more likely to develop COPD, whereas being overweight or obese is often a protective factor for COPD (*9*), which is not entirely consistent with this study's findings. In this study, females had worse lung function and a higher prevalence of AFO with increasing BMI. This result is however consistent with the findings of a study in the United States demonstrating that overweightness and obesity are risk factors for COPD (*10*). A BMI that is too high or too low can have an impact on lung function, so maintaining a normal weight is vital for health. Women who were current smokers and men who were former smokers had the worse lung function and the highest prevalence of AFO. The findings in males are consistent with another Chinese study (*11*). It may be that former smokers who are male have too much damage to lung function due to prior smoking habits and that their lung function has not fully recovered with smoking cessation. Nonsmokers have the best lung function, so it is essential to avoid cigarettes for health.

This study had several limitations. First, this study used the GOLD criteria ($FEV_1/FVC<70\%$). The ERS and the ATS promote the use of the lower limit of normal (LLN). However, using the LLN as a threshold can potentially exclude subjects with mild AFO. Therefore, this study decided to use the GOLD criteria. Second, this study did not use bronchodilators. In fact, bronchodilators have many side effects, such as dizziness. For safety reasons, bronchodilators were not used. Thirdly, when considering the prevalence of AFO in different age groups, it is necessary to analyze prevalence across different risk factors by age group. In this study, however, there were some overlapping risk factors exhibited by the same study participants.

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[#] Corresponding author: Gang Li, ligang@bjcdc.org.

[1] School of Public Health, China Medical University, Shenyang City, Liaoning Province, China; [2] Department of Information and Statistics, Beijing Center for Disease Prevention and Control, Beijing Municipality, China; [3] Beijing Key Laboratory of Diagnostic and Traceability Technologies for Food Poisoning, Beijing Center for Disease Prevention and Control, Beijing Municipality, China.

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