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Epidemiological Characteristics of An Outbreak of Severe Acute Respiratory Syndrome in Dongcheng District of Beijing From March to May 2003

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Objective To describe epidemiologic features of an outbreak of severe acute respiratory syndrome (SARS) in Dongcheng District, Beijing occurred in a period between March and May 2003. **Methods** Data of SARS cases notified from Dongcheng District Center for Disease Control and Prevention(CDC)and supplemented by other channels were collected. Clinicians and officials of local hospitals were interviewed in groups and medical records of fatal cases of SARS were reviewed to verify the diagnosis. Stored serum specimens of the patients were detected for IgG antibody against SARS Co-V by enzyme-linked immunosorbent assay (ELISA). All the data were input into dataset files by Microsoft Excel-2000 software and analyzed with SPSS version 10.0 software. **Results** Outbreak of SARS in Dongcheng District started on March 14, 2003 with a peak in mid- and late April, and dropped in early May. A total of 572 reported cases were collected during this period in Dongcheng District, Beijing, and 99 of them were excluded from SARS, because of diagnosis of common cold, regular pneumonia, measles and rubella, *etc*. Actually, 473 SARS cases, which included 390 (82.5%) probable cases and 83 (17.5%) suspect cases, were analyzed. About 90% of the probable cases were positive for IgG antibody. Attack rate of SARS in permanent residents of Dongcheng District was 28.3 per 100 000. Forty-one of them died, with a case-fatality rate of 8.7%. Persons were all susceptible to infection of SARS Co-V, with the highest proportion at ages of 20-50 years, which accounted for 68.7% of the total cases. Average age of the patients at their onset was 40.7 years. No gender difference in SARS cases was found. Number of SARS cases in health-care workers (HCWs) accounted for 18.0% and that in retired workers accounted for 15.4% of the total cases. Cases occurred in all 10 sub-districts of Dongcheng, with the highest in Beixinqiao and Andingmen Sub-districts. Totally, 230 of the 572 notified cases (40.2%) were hospitalized at local hospitals under the jurisdiction of Dongcheng District. Eighteen of 85 cases of SARS occurred in HCWs of local hospitals, accounting for 4.5% of the total number of HCWs working at wards caring for SARS patients or fever clinics. There were 34.7% of SARS cases without any histories of contact before the onset of the disease. Familial aggregation phenomena were observed in 41.8% of the cases and 18.1% of households. And 7.4%(attack rate)of those exposed to SARS cases suffered from the illness during the periods of quarantine. **Conclusions** SARS appeared to be infectious in origin and caused outbreak in Dongcheng District, Beijing introduced by an imported case traveling from Hong Kong in a period between March and May 2003. People are all susceptible to infection of SARS Co-V, which mainly threatens the young adults and the middle-aged, as well as HCWs and the retired workers. The main mode of transmission is direct exposure to SARS patients in a near distance at hospitals or families via droplets spread. Prevention and control of SARS should be focused on early isolation of

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patients and quarantine for close contacts. Current available measures to prevent and control SARS are proved to be effective.

Key words: Beijing; Dongcheng District; Outbreak; Severe acute respiratory syndrome (SARS); Epidemiology; SARS coronavirus (SARS Co-V) ; Health-care workers (HCWs)

INTRODUCTION

Severe acute respiratory syndrome (SARS), an atypical pneumonia highly transmissible to health-care workers (HCWs)[1] is a new clinical entity caused by a novel coronavirus, and occurred in Guangdong Province of China in November 2002. Some important issues regarding its transmission, infection control, diagnosis and management have not been fully understood[2]. The first case of SARS in Beijing was imported from Shanxi Province on March 1, 2003, who traveled to Guangzhou, a southern city in Guangdong Province, within two weeks before the onset of the disease. The first case in Dongcheng District of Beijing was introduced from Hong Kong by a domestic traveler, who visited his brother in December 2002 and returned to Beijing on March 15, 2003. He was admitted to hospital on March 16 with high fever, chills, headache, short of breath and malaise two days before his admission. A lot of HCWs, without adequate respiratory protection, cared for him during his hospitalization, especially when he was intubated, leading to rapid spread of infection in HCWs, and then in local residential communities, and consequently, an outbreak of SARS occurred in the district, without immediate adequate control measures. Outbreak reached the peak in mid- and late April, started to decrease in early May, and no probable case occurred after May 22. Epidemiological features of SARS outbreak in one of 18 districts in Beijing is described here, reflecting an overview of its epidemic in the Spring of 2003 in the city.

MATERIALS AND METHODS

Source of Data

All data of SARS cases were collected from daily notification of the Dongcheng District CDC, and supplemented by the Dongcheng District Institute for School Health, Dongcheng District Construction Commission, local hospitals in the District, and the District Health Bureau. Discussions with HCWs and managers were conducted in several hospitals where SARS patients were taken care of. Medical records of some suspected cases were reviewed and clinical pathological consultations for some suspected cases were conducted to verify diagnosis. The discharged patients and their family members were communicated by phone call with helps from HCWs at local communities.

Diagnostic Criteria

All the cases were diagnosed based on their epidemiological histories and clinical features, with or without serum evidence of SARS Co-V infection, according to the interim diagnostic criteria set by the Ministry of Health of China[3].

Stored serum specimens of the patients were detected for IgG antibody against SARS Co-V by enzyme-linked immunosorbent assay（ELISA）only at late stage of outbreak or after their discharge from hospitals.

Diagnostic reagent kit for IgG antibody against SARS Co-V by ELISA was prepared by Huada Biological Technology Co, Ltd., Beijing.

Statistical Analysis

Data were input into a dataset file with Microsoft Excel-2000 software and analyzed with SPSS version 10.0, and figures were made with Harvard Graphics version 3.0.

RESULTS

The first case of SARS in Dongcheng District, Beijing was detected on March 14, 2003 and was admitted to DZM Hospital on March 16. Up to June 10, 572 cases of SARS were notified, including 342 cases (59.8%) who were living, working or studying in Dongcheng District, 193 cases (33.7%) in other districts, 30 cases (5.2%) outside Beijing, one alien case (0.2%) and six cases (1.0%) unspecified.

With treatment and follow-up after hospitalization, 99 reported cases were excluded from SARS. Actually, 473 cases of SARS were analyzed, with 390 probable cases (82.5%) and 83 suspected cases (17.5%). About 90% of probable cases were positive for IgG antibody against SARS Co-V. Forty-one cases died, with a case-fatality rate of 8.7%, and 35 cases died as probable SARS (case-fatality rate of 9.0%) and six died as suspected SARS (case-fatality rate of 7.1%).

Distribution of Cases

By age People were universally susceptible to SARS infection, with the youngest case at ten, the oldest one at 88 and averaged 40.7 years of age. Distribution of cases and deaths by age are shown in Table 1.

TABLE 1

Distribution of SARS Cases and Deaths by Age (Dongcheng, Beijing, 2003)

Ages (yrs.)	No. Cases	%	No. Deaths	Case-fatality (%)
0-9	0	0	0	0
10-19	28	6.0	0	0
20-29	120	25.8	1	0.8
30-39	98	21.0	3	3.1
40-49	102	21.9	5	5.9
50-59	42	9.0	5	11.9
60-69	36	7.7	9	25.0
70-79	27	5.8	10	37.0%
80-	13	2.8	8	61.5
Total	466	100.0	41	8.7

By gender No gender difference in 473 probable and suspected cases of SARS was found, with 231 men (48.8%), 226 women (47.8%), and 16 of unspecified gender (3.4%).

By occupation Cases in HCWs, officials and clerks, and retired workers accounted for 50.4% of the total cases (Table 2).

By date of onset The first case was imported from Hong Kong and occurred on March 14, 2003 and was admitted to hospital on March 16. The outbreak reached its peak in mid- and late April, decreased from May 5, and no probable case of SARS occurred after May 22. Three suspected cases of SARS occurred on May 24 and June 10, respectively, but all were

excluded from SARS later (Fig. 1).

Distribution of cases by date of onset is shown in Table 3, based on complete data of 402 probable and suspected cases of SARS.

TABLE 2

Occupational Distribution of SARS Cases (Dongcheng, Beijing, 2003)

Occupation	No. Cases	%	Occupation	No. Case	%
Healthcare Worker	85	18.0	Official/ Clerk	82	17.3
Retired Worker	73	15.4	Industrial Worker	37	7.8
Migrant Laborer	34	7.2	Commercial	23	4.9
Unemployed	23	4.9	Farmer	7	1.5
College Student*	13	2.7	High School Student	15	3.2
Primary School Pupil	1	0.2	Police	3	0.6
Food Handler	7	1.5	Household Chores	19	4.0
Self-employed	3	0.6	Unspecified	30	6.3
Others	22	4.7	Total	473	100.0

Note. *Two postgraduate students in a medical university were infected when working as interns at ward caring for SARS patients, so their occupation was listed as health-care workers.

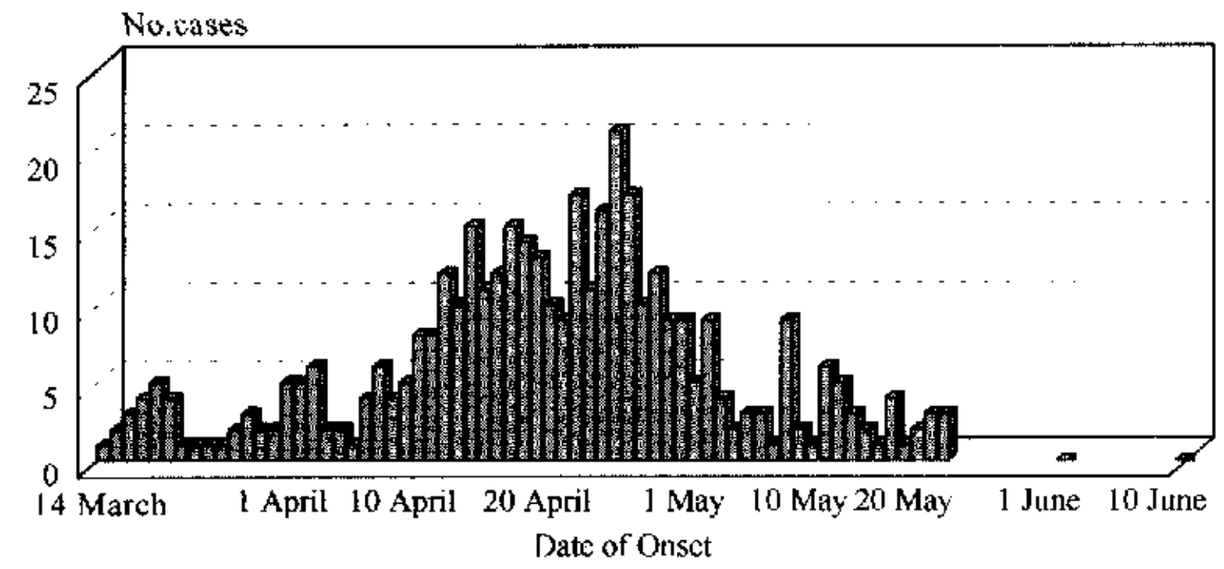

FIG. 1. SARS case distribution by date of onset in Dongcheng District, Beijing 2003.

TABLE 3

Distribution of SARS Cases by Date of Onset (Dongcheng, Beijing, 2003)

Dtae of Onset	No. Cases	%	Cumulative%
March 14-March 20	13	3.2	3.2
March 21-March 31	26	6.5	9.7
April 1-April 10	43	10.7	20.4
April 11-April 20	120	29.9	50.3
April 21-April 30	131	32.6	82.9
May 1-May 10	39	9.7	92.6
May 11-May 20	24	6.0	98.6
May 21-May 31	6	1.5	100.0
June 1-June 10	0	—	—
Total	402	—	—

According to the complete data from 390 probable and suspected cases of SARS, there was an average interval of 4.3 days (standard deviation of 1.6 days) between their onset and admission, with an interval of one day in 281 cases (72.1%), two days in 43 cases (11.0%), three days in 27 cases (6.9%) and more than four days in 39 cases (10.0%). The longest interval during the early stage of outbreak was 11 days between onset and admission.

There was an average interval of 2.1 days (standard deviation of 3.2 days) between admission and notification, with an interval of one day in 119 case (30.5%), two days in 53 cases (13.6%), three days in 52 cases (13.3%), and more than four days in 166 cases (42.6%). The longest interval during the early stage of outbreak was eight days between admission and notification.

By neighborhood Among 179 cases of SARS living in Dongcheng District with detailed home address recorded, they were distributed in all the ten neighborhoods (subdistricts) of Dongcheng, and most in Beixinqiao and Andingmen neighborhoods, accounting for 28.5% and 17.9% of the total cases. Attack rate of SARS in this outbreak was 28.3 per 100 000 population, based on the statistics in permanent residents of Dongcheng (Table 4).

TABLE 4

Distribution of SARS Cases by Neighborhood (Dongcheng, Beijing, 2003)

Neighborhood	No. Case	%	Population	Attack Rate (1×10^{-6})
Beixinqiao	41	22.9	79 662	51.5
Andingmen	24	13.4	48 116	49.9
Dongzhimen	22	12.3	47 971	45.9
Dongsi	14	7.8	47 879	29.2
Hepingli	39	21.8	113 341	34.4
Jiaodaokou	12	6.7	52 939	22.7
Jianguomen	10	5.6	66 430	15.1
Chaoyangmen	4	2.2	45 343	8.8
Donghuamen	6	3.4	83 869	7.2
Jiangshan	7	3.9	47 133	14.9
Total	*179*	*100.0*	*632 683*	*28.3*

By hospital Among 572 reported cases, 230 cases were admitted to local hospitals at first, accounting for 40.2% of the total cases, 127 cases in S-Hospital (22.2%), 76 in H-Hospital (13.3%), 10 in L-Hospital (1.7%) and 10 in G-Hospital (1.7%), indicating an important role played by local hospital in providing emergency care for SARS patients during the outbreak.

Infections in High-risk Population

In health-care workers Infections among HCWs have been a common feature of SARS since its emergence. During this outbreak, 85 HCWs suffered from SARS, and 18 of them occurred at local hospitals, with no death, accounting for 4.5 % of the total staff caring for SARS patients or working at fever clinics (Table 5).

In migrant laborers in construction sites There are 157 construction sites in Dongcheng, which are employing more than thirty thousand laborers migrant from other provinces outside Beijing. They were living in a very simple, shabby and crowded condition. Infections of SARS occurred in 16 of them, accounting for 10.8% of the total construction sites, with 55 notified cases of SARS, including 41 probable and suspected cases of SARS and 14 cases excluded from SARS.

For example, JG-101 Construction Site was the first one in Beijing with infection of SARS among migrant laborers. The index case occurred on April 16, 2003 and was admitted to hospital on April 20, and then SARS was spread to other ten of 399 migrant laborers. Immediate infection control precautions were instituted, including isolation of patients, quarantine of close contacts, disinfection of foci of infection, improvement of their living condition, health education, *etc.*, and as a result no transmission was continued among them.

TABLE 5

Infections of SARS in HCWs at Local Hospitals (Dongcheng, Beijing, 2003)

Hospital	No. Exposed Staff	No. Infected Staff	Attack Rate (%)
S	212	9	4.2
H	84	4	4.8
G	55	4	7.3
L	51	1	2.0
Total	402	18	4.5

In Students Thirty-nine cases of SARS occurred in students of Dongcheng District, 18 college students and three postgraduates, 17 high school students and one primary school pupil. No case cluster phenomenon in schools was found in Dongcheng.

Attack Rates in Close Contacts With SARS Patients

Among 473 probable and suspected cases of SARS, 243 cases (51.4%) had histories of close contacts with SARS patients, or visiting hospitals to care for SARS patients or attending fever clinics within 14 days before their onset. And 164 cases had not any contact histories within 14 days before their onset (34.7%), 64 cases with no records and two cases unspecified (0.4%).

Totally, 474 close contacts with 182 cases of SARS with complete records were placed *into quarantine for medical observations in the District, and 35 cases of SARS were found* among them during the period of quarantine, with an attack rate of 7.4% in close contacts (Table 6).

TABLE 6

Attack Rates in Close Contacts (Dongcheng, Beijing, 2003)

Neighborhood	No. Contacts	No. Cases	Attack Rates (%)
Dongzhimen	43	10	23.3
Dongsi	29	4	13.8
Jiaodaokou	23	3	13.0
Hepingli	89	8	9.0
Andingmen	38	3	7.9
Beixinqiao	87	5	5.8
Jingshan	38	1	2.6
Donghuamen	59	1	1.7
Chaoyangmen	9	0	0
Jianguomen	59	0	0
Total	474	35	7.4

Familial Aggregation of Cases

Cluster of SARS cases in families was obviously found in this outbreak. Based on the data of 203 cases of SARS in 144 households with complete records, there were 1.4 cases of SARS in average in each household. Familial aggregation phenomena were observed in 41.8% (26/144) of SARS cases and 18.1% (85/203) of the households with SARS cases. And 7.4% (attack rate) in those exposed to SARS cases suffering from the illness during the periods of quarantine (Table 7).

TABLE 7

Familial Aggregation of SARS Cases (Dongcheng, Beijing, 2003)

	No. Cases per Household						Total
	1	2	3	4	6	11	
No. Households	118	12	4	8	1	1	144
%	81.9	8.3	2.8	5.6	0.7	0.7	100.0

For example, Madam Gong, aged 76, was admitted to the surgical ward of DZM-Hospital due to her hand trauma on April 12, 2003. On April 21, she was diagnosed as SARS due to fever, respiratory illness and radiographic evidence of pneumonia, and transferred to SARS ward. During her hospitalization, ten of her relatives took care of or visited her without adequate personal protection, including her three sons, two daughters-in-law, three daughters and two grandchildren. Unfortunately, Madam Gong and her two sons died.

Analysis for Fatal Cases

Forty-one cases of SARS died at an average age of 63.2 years, the oldest one at 88 and the youngest one at 23. Twenty-seven deaths at age of 60 or over, accounted for 65.9% of the total deaths. Interval averaged 12.8 days between their onset and death in 23 cases with complete records, ranging from 4 to 31 days. And interval averaged 9.4 days between admission and death in 41 cases of deaths, ranging from 2 to 31 days. There was a slight difference in age at death (Table 8).

TABLE 8

Distribution of Fatal Cases by Age at Death (Dongcheng, Beijing, 2003)

Age (yrs.)	No. Deaths	Interval Between Admission and Death (Days)
20-	1	6.0
30-	3	19.0
40-	5	15.8
50-	5	8.0
60-	9	4.3
70-	14	6.9
80-	8	11.0
Total	41	9.4

Among the 41 fatal cases, 26 were retired persons (61.9%), seven doing household chores (16.6%), four officials (9.5%), three industrial workers (7.1%) and two HCWs (4.8%).

Twenty-two of 41 deaths were permanent residents in Dongcheng (52.4%), 19 living in other districts of Beijing (45.2%) and one (2.4%) from other province outside Beijing.

Thirty-two of 41 deaths (78.0%) had histories of close contacts with SARS patients within 14 days before their onset, and nine (22.0%) had no such histories.

Exclusion From SARS

Among a total of 572 cases notified, 99 were excluded from SARS during hospitalization, later with diagnoses of common cold in 29 cases (29.3%), regular pneumonia in 32 cases (32.3%), measles and rubella in three cases (3.0%), other conditions in five cases (tonsillitis in one, HIV infection in two, deep venous thrombosis in one, myocardial infarction in one) (5.1%), unspecified cause in 28 cases (28.3%), and voluntary discharge in two case (2.0%).

DISCUSSION

Dongcheng District located in the center of Beijing, a densely populated downtown area, occupies an area of 25.4 square kilometers with a density of 24 800 population per square kilometer. The first case of SARS was introduced from Hong Kong by a domestic traveler. At beginning of the outbreak, no strict infection-control precautions were taken due to poor information communication and lack of knowledge about SARS in HCWs and general population, thus causing a serious consequence of extensive transmission among HCWs in various settings and residents in local communities. Infection was spread from the first case (Mr. Li) to HCWs and his family members, then from one HCW to another HCW, or to local residents, from person to person in several generations, leading to the spread of infection to involve totally more than 60 persons , and locations all over the District. Mr. Li became the so-called "super spreader"[4], just similar to someone in Hong Kong and Canada[5,6]. The majority of these infections occurred in locations where proper infection-control measures had not been taken or had been taken without follow up. With improved understanding of SARS, a series of recommended infection-control precautions, including adequate respiratory protection for HCWs, isolation of patients and quarantine of close contacts, were taken and followed up, and as a result the spread of infection was contained within 69 days in Dongcheng. In controlling this outbreak, local government played a very important leading role by rapidly mapping out a series of forceful strategies and measures, coordinating with various sectors and ensuring their implementation to prevent and control SARS spread, by investigating source of infection and route of transmission, including enforced management of construction sites, standardization of fever clinics, setting-up quarantine rooms at railway and long-distance bus stations where floating population aggregated, *etc.*

Since analysis of data was based on accurate, reliable and timely information, complete collection of case data is of vital importance. In addition to daily notification of SARS from District CDC, data about more than seventy cases were collected from other channels, including hospitals, health administration sector, education sector, construction commission responsible for management of local construction projects. Data of some cases, who registered their households in the District but worked outside, or worked in the District but registered their households outside, should be paid special attention and collected carefully. Furthermore, all collected data of cases should be verified, particularly for their outcomes and prognoses of the cases transferred to other hospitals.

Timely notification of SARS cases should be further improved. There was an average interval of 2.1 days from admission to notification among the cases in this outbreak, more than three days in half of them, which delayed immediate quarantine of close contacts and

disinfection of their households.

Results of analysis showed that SARS appeared to spread by close person-to-person contacts. Most cases of SARS have involved people who cared for or lived with someone with SARS, or people who had direct contacts with infectious materials (e.g., respiratory secretions) from a person with SARS. In this outbreak, 175 probable cases of SARS were infected as a result of close contacts in hospitals, households and construction sites, with an obvious familial aggregation phenomenon, indicating importance of controlling spread of SARS by isolation of patients and quarantine of close contacts. But aggregation of SARS cases in family members and HCWs occurred mainly in the early stage of outbreak, because SARS was not fully understood by people and no adequate personal protective measures were taken at that time. With a better understanding of SARS, people can protect themselves properly with infection-control precautions.

About 50% of the cases in this outbreak had no histories of close contacts with SARS patients, or their contact histories were not specified, suggesting that other potential route of transmission and carrier status of SARS should be studied further. Ninety-nine patients (17.3%) were excluded from SARS in this outbreak. All the cases were diagnosed mainly based on their clinical features according to the criteria set by the Ministry of Health due to lack of pathogen-specific diagnostic tests for SARS at that time and there still were 83 suspected cases of SARS in this outbreak, six of them died without specific diagnosis. It is necessary to verify all the cases with specific laboratory tests for stored serum specimens.

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