The Epidemiological Characteristics of Deaths with COVID-19 in The Early Stage in Wuhan, China

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Keywords: COVID-19, Coronavirus Disease 2019, Wuhan city, Epidemiological characteristic, Death

Posted Date: October 26th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-93945/v1

Version of Record: A version of this preprint was published on December 21st, 2020. See the published version at https://doi.org/10.1186/s41256-020-00183-y.

Abstract

Objectives To analyze the epidemiological characteristics of deaths of COVID-19 in Wuhan, China and understand the changing trends of the COVID-19 epidemic and the effects of prevention and control measures in Wuhan.

Methods Through the China's Infectious Disease Information System, we collected deaths' information in Wuhan. We analyzed the patient's demographic characteristics, drew epidemiological curve, made distribution map of epidemic situation, etc. @Risk for fitting distribution, SPSS for statistical analysis, and ArcGIS for mapping.

Results As of February 24, 2020, a total of 1833 unique deaths were extracted. Among the deaths with COVID-19, the mild type accounted for the most, 37.2%, followed by severe type, 30.1%. The median age was 70.0 (inter quartile range: 63.0-79.0) years, most of the deaths were distributed in 50-89 age group; no deaths occurred in 0-9 age group; and the male to female ratio was 1.95. A total of 65.7% of the deaths in Wuhan combined with underlying diseases, and the deaths with underlying diseases were mainly male; the main combined underlying diseases were hypertension, diabetes and cardiovascular diseases. The peak of daily deaths appeared on February 14 and then declined after February 14. The median interval from symptom onset to diagnosis was 10.0 (6.0-14.0) days; the interval from onset to diagnosis gradually shortened. The median interval from diagnosis to death was 6.0 (2.0-11.0)days; The median interval from symptom onset to deaths was 17.0 (12.0-22.0)days, respectively. In terms of geographical distribution, the central urban area was more serious. Wuchang District had the highest number of deaths, and Jianghan District had the highest death rate.

Conclusion COVID-19 posed a greater threat to the elderly and more men than women, especially elderly men with underlying diseases. The geographical distribution showed that the epidemic in the central area of Wuhan is more serious than in the surrounding areas. Analysis of deaths as of February 24 indicates that the COVID-19 epidemic in Wuhan has achieved a tremendous improvement, and the strong epidemic control measures taken by Wuhan Government were very effective.

Background

The outbreak of new infectious diseases in recent years has caused great harm to human health, quality of life and economic activities. SARS in 2003, MERS in 2012, Ebola in 2014, Zika virus in 2015, and the plague of Madagascar in 2017 had caused millions of infections worldwide[1−3].

In December 2019, a new coronavirus began to spread in Wuhan and even the whole country. On December 31, the first group of experts from the Chinese Center for Disease Control and Prevention (China CDC) rushed to Wuhan and notified the World Health Organization (WHO), neighboring countries and regions of relevant information. Epidemiological investigation implicated this pneumonia epidemic was different from the previous ones and Wuhan's Huanan Seafood Wholesale Market was a possible source of infection. On January 1, Wuhan Government shut down the Huanan Seafood Wholesale

Market. On January 20, China's "National Infectious Diseases Law" was amended to make 2019-novel coronavirus diseases (COVID-19) a Class B notifiable disease and its "Frontier Health and Quarantine Law" was amended to support the COVID-19 outbreak response effort. On January 23, the Chinese Government began to limit movement of people in and out of Wuhan. As of February 5, two newly established COVID-19 designated hospitals and a number of mobile cabin hospitals have been opened.

The WHO officially named this unexplained pneumonia as Coronavirus Disease 2019 (COVID-19) on February 11, 2020. Based on the genetic structure of the virus, The International Committee on Taxonomy of Viruses officially named the virus Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)[4], which is more contagious than both SARS-CoV and MERSCoV.

On March 11, the WHO officially declared the epidemic caused by COVID-19 as Pandemic. This is the first time in this century that coronavirus infection (SARS, MERS, COVID-19) has been evaluated as Pandemic.

As of February 24, 2020, 77658 cases diagnosed with COVID-19 had been reported in Mainland China, among which 64786 (83.42%) cases were reported in Hubei Province and 47071 (60.61%) were in Wuhan city. Among the 2663 deaths across Mainland China, 2563 (96.24%) deaths occurred in Hubei Province and 2043 (76.72%) deaths in Wuhan city. The epidemiological features of COVID-19 is crucial for the development and implementation of effective control strategies. Here, we report the results of a descriptive analysis of deaths found through February 24, 2020 in Wuhan.

Methods

Data sources

As a retrospective cross-sectional study, all data were extracted from China's Infectious Disease Information System. Specific details of data collection were provided elsewhere.[5] Through the Wuhan Statistics Bureau, the permanent resident population of Wuhan in 2018 was 11.081 million. After excluding duplicate cases and those who inability to obtain a unique identifying card, a total of 1833 unique COVID-19 deaths in Wuhan were eligible for this study finally.

Variables

Demographic data in this study included age, sex, occupation, residential area, area of reporting units. Other available data included clinical outcomes, disease severity, report date, date of onset, date of diagnosis, the interval time from onset to diagnosis, the interval time from diagnosis to death and the interval time from onset to death. The comorbid conditions variable was determined upon epidemiological investigation by patient self-reported medical history. The severity of symptoms variable was categorized as mild type, common type, severe type or critical type. The crude death rate was estimated as the number of deaths divided by the number of permanent resident population of Wuhan. The date of onset was defined as the day when the symptom was observed.

Statistical analysis

Use Excel and SPSS to sort the database and ensure the completeness of the indicators needed for the study. We present continuous measurements as mean (SD) if they are normally distributed or median (IQR) if they are not, and categorical variables as count (%). The probability distributions of age and interval time were fitted and the distribution with the lowest AIC value was selected as optimal distribution. The map of epidemic situation in Wuhan was drawn based on the number of new deaths each day. @Risk for fitting distribution, SPSS for statistical analysis, and ArcGIS for cartography.

Ethics approval

Data collection, which determined by the National Health Commission of the People's Republic of China, was exempt from institutional review board approval because it was part of outbreak investigation. Study design and data analysis have been reviewed and approved by the Medical Ethical Committees of Wuhan University (WHU2020-2020YF0031).

Results

Patients

As of February 24, 2020, a total of 1833 unique deaths with COVID-19 were extracted and data from all records were included in the analysis. Baseline characteristics of deaths are presented in Table 1. A majority were aged 50–89 years (89.9%), male (66.1%), retirees (46.8%). Among the composition of disease severity, mild type accounted for the largest proportion(37.2%), followed by severe type(30.1%), then 13.6% for critical type and 5.5% for common type.

Table 1
The epidemiological characteristics of deceased patients of COVID-19 infection with different severities in Wuhan during the early stage.

Baseline characteristics	**Total**	**Classification of severity (%)****				
		Mild	**Common**	**Severe**	**Critical**	**Missing**
Total	1833	682(37.2)	101(5.5)	551(30.1)	249(13.6)	250(13.6)
Age						
*M (IQR)**	70.0 (63.0–79.0)	70.0 (62.0–78.0)	72.0 (64.0-78.5)	71.0 (64.0–80.0)	69.5 (62.0–77.0)	71.0 (62.0–79.0)
Sex						
Male	1211(66.1)	438(64.2)	71(70.3)	371(67.3)	155(62.3)	176(70.4)
Female	622(33.9)	244(35.8)	30(29.7)	180(32.7)	94(37.8)	74(29.6)
Occupation						
Child and student	2(0.1)	1(0.2)	0(0.0)	1(0.2)	0(0.0)	0(0.0)
Cadre	35(1.9)	14(2.1)	1(1.0)	15(2.7)	4(1.6)	1(0.4)
Freelancer	7(0.4)	2(0.3)	1(1.0)	1(0.2)	3(1.2)	0(0.0)
Physical labor	23(1.3)	15(2.2)	1(1.0)	4(0.7)	3(1.2)	0(0.0)
Public service staff	25(1.4)	14(2.1)	0(0.0)	8(1.5)	2(0.8)	1(0.4)
Housework	324(17.7)	138(20.2)	23(22.8)	105(19.1)	51(20.5)	7(2.8)
Retirees	858(46.8)	345(50.6)	56(55.5)	297(53.9)	130(52.2)	30(12.0)
Farmer or worker	66(3.6)	29(4.3)	4(4.0)	22(4.0)	10(4.0)	1(0.4)
Nosocomial infections	14(0.8)	6(0.9)	1(1.0)	5(0.9)	1(0.4)	1(0.4)
Missing	479(26.1)	118(17.3)	14(13.9)	93(16.9)	45(18.1)	209(83.6)
Underlying diseases						
Suffering	1204(65.7)	430(63.1)	59(58.4)	367(66.6)	172(69.1)	176(70.4)

*M = Medians; IQR = Interquartile ranges;

** The classification of severity were according to the diagnostic criteria of the new coronavirus infection pneumonia diagnosis and treatment plan (trial fifth version)

Baseline characteristics	Total	Classification of severity (%)**				
		Mild	Common	Severe	Critical	Missing
No	583(31.8)	234(34.3)	38(37.6)	173(31.4)	68(27.3)	70(28.0)
Missing	46(2.5)	18(2.6)	4(4.0)	11(2.0)	9(3.6)	4(1.6)
Specific Underlying diseases						
Hypertension						
Yes	742(40.5)	264(38.7)	37(36.6)	231(41.9)	112(45.0)	98(39.2)
No	1045(57.0)	400(58.7)	60(59.4)	309(56.1)	128(51.4)	148(59.2)
Diabetes						
Yes	357(19.5)	133(19.5)	18(17.8)	110(20.0)	50(20.1)	46(18.4)
No	1430(78.0)	531(77.9)	79(78.2)	430(78.0)	190(76.3)	200(80.0)
Cardiovascular disease						
Yes	329(17.9)	119(17.4)	16(15.8)	109(19.8)	36(14.5)	50(20.0)
No	1458(79.5)	545(79.9)	81(80.2)	431(78.2)	204(81.9)	196(78.4)
Respiratory disease						
Yes	152(8.3)	47(6.9)	9(8.9)	57(10.3)	18(7.2)	21(8.4)
No	1635(89.2)	617(90.5)	88(87.1)	483(87.7)	222(89.2)	225(90.0)
Cancer (any)						
Yes	82(4.5)	29(4.3)	5(5.0)	29(5.3)	9(3.6)	10(4.0)
No	1705(93.0)	635(93.1)	92(91.1)	511(92.7)	231(92.8)	236(94.4)
Date of onset						
2019.12-2020.1.9	147(8.0)	27(4.0)	5(5.0)	37(6.7)	32(12.9)	46(18.4)
2020.1.10–1.21	525(28.6)	154(570.4)	11(10.9)	149(27.0)	79(31.7)	132(52.8)

*M = Medians; IQR = Interquartile ranges;

** The classification of severity were according to the diagnostic criteria of the new coronavirus infection pneumonia diagnosis and treatment plan (trial fifth version)

Baseline characteristics	Total	Classification of severity (%)**				
		Mild	Common	Severe	Critical	Missing
2020.1.22–2.1	869(47.4)	391(253.9)	42(41.6)	288(52.3)	107(43.0)	41(16.4)
2020.2.2–2.24	288(15.7)	110(28.1)	43(42.6)	77(14.0)	31(12.4)	27(10.8)
Missing	4(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(1.6)
District of residence						
Central urban area	1384(75.5)	574(84.2)	87(86.1)	428(77.7)	199(79.9)	96(38.4)
Surrounding urban area	286(15.6)	102(15.0)	13(12.9)	108(19.6)	41(16.5)	22(8.8)
Out of city	28(1.5)	6(0.9)	1(1.0)	12(2.2)	5(2.0)	4(1.6)
Missing	135(7.4)	0(0.0)	0(0.0)	3(0.5)	4(1.6)	128(51.2)
Days from onset to death, M (IQR)	70.0(63.0–79.0)	70.0(62.0–78.0)	72.0(64.0-78.5)	71.0(64.0–80.0)	69.5(62.0–77.0)	16.0(10.0–23.0)
Days from onset to diagnosis, M (IQR)	10.0(6.0–14.0)	10.0(6.0–14.0)	9.0(4.0–15.0)	11.0(7.0–15.0)	11.0(7.0–15.0)	10.0(5.0–14.0)
Days from diagnosis to deaths, M (IQR)	6.0(2.0–11.0)	6.0(3.0–10.0)	5.0(2.0–10.0)	6.0(3.0–10.0)	6.0(2.0–10.0)	5.0(2.0–12.0)
*M = Medians; IQR = Interquartile ranges;						
** The classification of severity were according to the diagnostic criteria of the new coronavirus infection pneumonia diagnosis and treatment plan (trial fifth version)						

Age Distribution and Sex Ratio

As shown in Fig. 1 and Table 1. The age of deaths obeyed the Weibull distribution (8.2152, 89.42, -14.41). The minimum, maximum and median ages of the deaths were14, 100 and 70.0 (IQR: 63.0–79.0), respectively. The proportion of deaths 50–89 years of age at baseline (i.e. date of diagnosis) was 89.9%, with a total of 1647 deaths. In addition, the age distribution of different disease severity was similar.

Among the 1833 deaths, male deaths accounted for 66.1%, and the male to female ratio was 1.95 in Wuhan. As shown in Fig. 1, in all age groups, male deaths were significantly more than female deaths. The male to female ratio of different disease severity was similar.

Underlying diseases

There were 1,204 COVID-19 deaths with underlying diseases (65.7%) and 676 deaths with more than one underlying disease (56.2%). Among these underlying diseases, hypertension accounts for the largest proportion—61.6%, then 29.7% for diabetes, 27.4% for cardiovascular diseases, 12.6% for respiratory diseases, and 6.8% for cancer.

The median age of deaths with underlying diseases was higher than that of those who died without underlying diseases. In addition, there were 820 male deaths and 384 female deaths with underlying diseases, the male to female ratio for deaths with underlying diseases was 2.14.

Temporal distribution

Figure 2 shows the COVID-19 epidemic curve with number of deaths plotted by date of patient's onset of symptoms, diagnosis and death. The peak onset of symptoms for COVID-19 deaths occurred on January 23, 2020. Since then, onset of illness has declined. The number of diagnosis reached a peak of 122 on February 1, 2020, and the daily deaths reached the peak of 97 on February 14.

As shown in Fig. 3. The median interval from symptom onset to diagnosis was 10.0 (IQR: 6.0–14.0) days and obeyed the LogLogistic distribution. Moreover, for those whose onset date was before January 15, between January 15–31, and after January 31, the median intervals from onset to diagnosis were 15.0, 11.0, and 5.0 days, respectively. The interval from onset to diagnosis gradually shortened, the efficiency of diagnosis is improving. The median interval from diagnosis to death was 6.0 (IQR: 2.0–11.0) days and obeyed the InvGauss distribution. The median interval from symptom onset to deaths was 17.0 (IQR: 12.0–22.0) days and obeyed the LogLogistic distribution. The distribution fit is shown in Table 2.

Table 2
Distributional fits to key COVID-19 distributions

Variable	Distribution	Parameter1	Parameter2	Parameter3	Median	25%	75%
Age	Weibull	8.2152	89.42	-14.41	71.1	62.4	78.6
Days from onset to death	LogLogistic	-14.513	31.184	6.8020	16.7	12.0	22.1
Days from onset to diagnosis	LogLogistic	-7.7179	17.669	4.7575	10.0	6.3	14.5
Days from diagnosis to deaths	InvGauss	9.8986	19.1904	-2.4969	5.4	2.6	10.0

Geographical distribution

A total of 13 administrative regions constitute Wuhan, of which Jiang'an District, Jianghan District, Qiaokou District, Hanyang District, Wuchang District, Qingshan District and Hongshan District are the central urban area, Dongxihu District, Hannan District, Caidian District, Jiangxia District, Huangpi District and Xinzhou District are the surrounding urban area.

Figure 4 showed the geographical distribution of daily new COVID-19 deaths in Wuhan. The deaths were few in early January 2020, and gradually increased in late January. The epidemic situation in Wuhan was serious from the end of January to early February, and then the number of daily deaths in each district gradually decreased in the middle and late February.

Meanwhile, the geographical map showed that the COVID-19 epidemic situation in Wuhan had obvious regional differences. The epidemic situation in the central urban areas represented by Wuchang District were relatively serious, while the surrounding urban areas were relatively mild.As shown in Table 3, as of February 24, sort by residence, the top 3 regions with the number of deaths were 299 in Wuchang District, 238 in Jiang'an District and 238 in Jianghan District. The top 3 regions in terms of death rate were 3.26‰ in Jianghan District, 2.65‰ in Hannan District and 2.47‰ in Jiang'an District.

Table 3
Death rate of COVID-19 cases in administrative districts of Wuhan

District	Permanent population (10,000)	Residence		Reporting Unit area	
		Deaths, N	Death rate per 10,000 residents	Deaths, N	Death rate per 10,000 residents
Caidian	76.16	43	0.56	153	2.01
Dongxihu	58.48	79	1.35	249	4.26
Hannan	13.58	36	2.65	88	6.48
Hanyang	66.42	161	2.42	112	1.69
Hongshan	167.73	159	0.95	164	0.98
Huangpi	101.19	58	0.57	54	0.53
Jiang'an	96.27	238	2.47	186	1.93
Jianghan	72.97	238	3.26	170	2.33
Jiangxia	96.20	29	0.30	32	0.33
Qiaokou	86.87	181	2.08	167	1.92
Qingshan	52.89	103	1.95	130	2.46
Wuchang	128.28	299	2.33	303	2.36
Xinzhou	91.06	41	0.45	25	0.27

According to the medical facility where the death was, the top 3 areas in the number of deaths were 303 in Wuchang District, 249 in Dongxihu District and 186 in Jiangan District. The top 3 regions ranked by death rate of the Reporting Unit area were 6.48‰ in Hannan District, 4.26‰ in Dongxihu District and 2.46‰ in Qingshan District.

The number of cumulative deaths were the largest in Wuchang District, Jiang'an District, Jianghan District and Qiaokou District, and the surrounding urban areas were minor. As of February 24, the cumulative deaths in the central urban area accounted for 82.8% of the total deaths. The death rate of the central urban areas(2.05‰) was heavier than that of the surrounding areas(0.65‰). Due to the small population in Hannan District, the death rate was relatively high.

Discussion

Wuhan is the capital of Hubei Province and a megacity in central China. After the COVID-19 epidemic occurred in December 2019, strong prevention and control measures were taken to prevent the epidemic from spreading. Based on the stochastic transmission model, Adam J Kucharski showed that the median daily reproduction number in Wuhan declined from 2.35 (95% CI 1.15–4.77) 1 week before travel restrictions were introduced on Jan 23, 2020, to 1.05 (0.41–2.39) 1 week after[6]. Research by Wang Xuyan showed that the COVID-19 epidemic in Hubei Province has gradually eased from mid to late February, and the prevention and control measures were very effective[7]. As of February 24, 2020, the number of daily deaths in Wuhan has shown a clear downward trend.

In the composition of deaths, mild type accounted for the largest proportion, 37.2%, followed by severe type deaths, accounting for 30.1%, and the initial diagnosis of the dead with underlying diseases is mostly mild type, so we should be alert to the deterioration of mild type.

Judging from the age distribution of diagnosed cases across the country, people of all ages are not resistant to the COVID-19[5]. The analysis of the expert group also supported this view[8]. Older people and those with underlying diseases such as asthma, diabetes and heart disease may be at increased risk of contracting the virus[9]. In our study, 65.7% of the deaths in Wuhan combined with underlying diseases, the main combined underlying diseases were hypertension, diabetes and cardiovascular diseases. Studies have shown that combination with underlying diseases such as hypertension, diabetes and cardiovascular disease may increase the mortality rate of COVID-19 patients[10–12]. It may be because the metabolic syndrome can downregulate the key mediator of the host's innate immune response to pathogenesis, affecting the function of the innate and humoral immune systems[13]. In addition, the pathogen of COVID-19, SARS-COV-2, is mainly bound to target cells by angiotensin-converting enzyme 2(ACE2) and ACE1 drugs are often used in cardiovascular disease patients, and long-term use of ACE1 can up-regulate the expression of ACE2 receptors in the body[14]. Thiazolidinedione in hypoglycemic drugs can also cause upregulation of ACE2 expression[15], which may aggravate the patient's symptoms.

The deaths in Wuhan were mainly middle-aged and elderly people, mainly concentrated in the age group of 50–89 years. It may be due to the weaker physical resistance of the middle-aged and elderly people and the higher probability of combining the underlying diseases. The minimum age of deaths is 14 years old, and no 0–9 years old deaths occurred. SARS also has a low impact on children, considering the commonness of coronaviruses, children may be relatively unsusceptible to COVID-19 based on cellular

structure or immunity[16]. There are no reports of COVID-19 causing maternal and infant deaths. In addition, the possibility of vertical transmission of coronavirus is very low. There are no recorded cases of vertical transmission of SARS or MERS[17,18], and the COVID-19 has not been confirmed vertical transmission [19–21].

The male to female ratio of national confirmed is 1.06: 1 issued by the China CDC and 0.99: 1 in Wuhan, which indicates that men and women are equally susceptible to COVID-19. However, the fact that the sex ratio of deaths in Wuhan is 1.95: 1 shows male patients have a higher risk of death. As coronaviruses, SARS and COVID-19 have similar sex differences, probably because the X chromosome and estrogen can protect women from fatal infections[22,23] .

Among all occupational categories, the number of retirees' deaths was the largest, accounting for 46.8%. And medical staff and family members of patients often have close contact with patients during treatment, nursing, accompanying and visiting patients, the risk of nosocomial infection is high. Among the deaths, the number of deaths caused by nosocomial infection is 14, accounting for 0.8% of the total deaths. Children and students accounted for the least percentage of deaths, at 0.1%. Studies have shown that the SARS-CoV-2 can use multiple homologous genes of angiotensin converting enzyme II (ACE2) to effectively replicate in human respiratory tract cells [24]. The relatively low incidence of child deaths may be due to the relatively weak function of ACE2 receptors in children, or low expression, which limits the path of viral invasion and avoids large-scale outbreaks in children[16].

Analysis of 1833 deaths in Wuhan found that the mean interval from onset to diagnosis was 11.2 days; the median time was 10.0 days. Moreover, the interval from onset to diagnosis gradually shortened. For deaths with onset before January 15, between January 15–31 and after January 31, the median interval from onset to diagnosis is 15.0d, 11.0d and 5.0d, respectively, indicating that the ability to discover and diagnose COVID-19 cases has gradually improved. And the deaths of different severity classifications have similar interval from onset to diagnosis, from diagnosis to death, and from onset to death.

According to the death data as of February 24, the first case of COVID-19 death in Wuhan was located in Huangpi District. The geographical map showed the distribution of COVID-19 epidemic in Wuhan had obvious regional differences. The central urban area was more serious than the surrounding urban areas. The cumulative deaths reported in the central urban area accounted for 82.8%. Wuchang District was the most serious, followed by Jiang'an District and Jianghan District. The death rate of COVID-19 in Wuhan was also the highest in the central urban area. This regional difference may be due to the fact that the Huanan Seafood Wholesale Market, the outbreak point, was located in Jianghan District, and the traffic in the central urban area was convenient, and the designated COVID-19 hospitals in the early stage of the epidemic were also located in the central urban area.

This study also has some limitations. First, some variables in this study have missing records, which may slightly affect the results. Second, this study traced the patients' death outcome to February 24, when

many patients had not yet had disease outcomes. Third, the onset date of this study was obtained from the patient's self-report, and there may be a recall bias.

In summary, the COVID-19 posed a greater threat to the elderly and more men than women, especially elderly men with underlying diseases. The geographical distribution showed that the epidemic in the central area of Wuhan is more serious than in the surrounding areas. The reduction in the interval from onset to diagnosis also indicates a gradual improvement in the ability to detect and diagnose COVID-19 cases. The number of daily deaths in Wuhan had continued to decline after February 14, indicating that the COVID-19 epidemic in Wuhan has achieved a tremendous improvement, and the strong epidemic control measures taken by Wuhan Government were very effective.

Declarations

Ethics approval and consent to participate

Study design and data analysis have been reviewed and approved by the Medical Ethical Committees of Wuhan University (WHU2020-2020YF0031).

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from China CDC but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of China CDC.

Competing interests

The authors declare that they have no competing interests.

Funding

This project was supported by the National Key Research and Development Program of China (Grant No. 2017YFC1200502, 2018YFC1315302), the National Natural Science Foundation of China (Grant No. 81773552), Special Foundation for Basic Scientific Research of Central Universities (Grant No. 2020YJ066).

Authors' contributions

CY supervised the study. CY, CJ, JB and FS designed the study. CY, JB, FS and HW collected and organized the data. JB and FS analyzed the data. JB, FS, FW, SM, XL, YU and JD interpreted the results.

JB wrote the first draft. All authors read and approved the final manuscript

Acknowledgements

Not applicable.

References

1. Al-Osail AM, Al-Wazzah MJ. The history and epidemiology of Middle East respiratory syndrome corona virus. *Multidiscip Respir Med* 2017; **12**: 20.
2. Chen X, Chughtai AA, MacIntyre CR. Application of a Risk Analysis Tool to Middle East Respiratory Syndrome Coronavirus (MERS-CoV) Outbreak in Saudi Arabia. *Risk Anal* 2020; **40**(5): 915-25.
3. Yang Y, Peng F, Wang R, et al. The deadly coronaviruses: The 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China. *J Autoimmun* 2020; **109**: 102434.
4. WHO. Naming the coronavirus disease (COVID-19) and the virus that causes it. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it
5. TNCPERE. T. The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020. *China CDC Weekly* 2020; **2**(8): 113-22.
6. Kucharski AJ, Russell TW, Diamond C, et al. Early dynamics of transmission and control of COVID-19: a mathematical modelling study. *Lancet Infect Dis* 2020; **20**(5): 553-8.
7. Xuyan W, Yong Y, Ying H, Chuanhua Y. COVID-19 analysis and forecast based on Exponential Smoothing Model in Hubei Province. *Journal of Public Health and Preventive Medicine* 2020; **31**(01): 1-4.
8. YangY LQ L, et al. Epidemiological and clinical features of the 2019 novel coronavirus outbreak in China. *medRxiv preprint* 2020.
9. World Health Organization. Novel Coronavirus (2019-nCoV) advice for the public:Myth busters. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters.
10. Onder G, Rezza G, Brusaferro S. Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy. *Jama* 2020.
11. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med* 2020; **8**(5): 475-81.
12. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020; **395**(10229): 1054-62.
13. Justin I. Odegaard AC. Connecting Type 1 and Type 2 Diabetes through Innate Immunity. *Cold Spring Harb Perspect Med* 2012; **2**(3): a007724.
14. Li XC, Zhang J, Zhuo JL. The vasoprotective axes of the renin-angiotensin system: Physiological relevance and therapeutic implications in cardiovascular, hypertensive and kidney diseases.

Pharmacological research 2017; **125**(Pt A): 21-38.

15. Dariya B, Nagaraju GP. Understanding novel COVID-19: Its impact on organ failure and risk assessment for diabetic and cancer patients. *Cytokine Growth Factor Rev* 2020; **53**: 43-52.
16. FANG F LX. Facing the major epidemic of new coronavirus infection in 2019: Thinking of pediatricians. *Chin J Pediatr* 2020; **58**(2): 81-5.
17. Alserehi H, Wali G, Alshukairi A, Alraddadi B. Impact of Middle East Respiratory Syndrome coronavirus (MERS-CoV) on pregnancy and perinatal outcome. *BMC Infect Dis* 2016; **16**(3): 105.
18. Wong S F CKM, Leung T N, et al. Pregnancy and perinatal outcomeof women with severe acute respiratory syndrome. *Am J Obstet Gynecol* 2004; **191**(1): 292-7.
19. Schwartz DA, Graham AL. Potential Maternal and Infant Outcomes from (Wuhan) Coronavirus 2019-nCoV Infecting Pregnant Women: Lessons from SARS, MERS, and Other Human Coronavirus Infections. *Viruses* 2020; **12**(2): 194.
20. Zhu H, Wang L, Fang C, et al. Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia. *Transl Pediatr* 2020; **9**(1): 51-60.
21. Chen H, Guo J, Wang C, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *Lancet* 2020; **395**(10226): 809-15.
22. Channappanavar R, Fett C, Mack M, Ten Eyck PP, Meyerholz DK, Perlman S. Sex-Based Differences in Susceptibility to Severe Acute Respiratory Syndrome Coronavirus Infection. *J Immunol* 2017; **198**(10): 4046-53.
23. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 2020; **395**(10223): 507-13.
24. Heurich A, Hofmann-Winkler H, Gierer S, Liepold T, Jahn O, Pohlmann S. TMPRSS2 and ADAM17 cleave ACE2 differentially and only proteolysis by TMPRSS2 augments entry driven by the severe acute respiratory syndrome coronavirus spike protein. *J Virol* 2014; **88**(2): 1293-307.

Figures

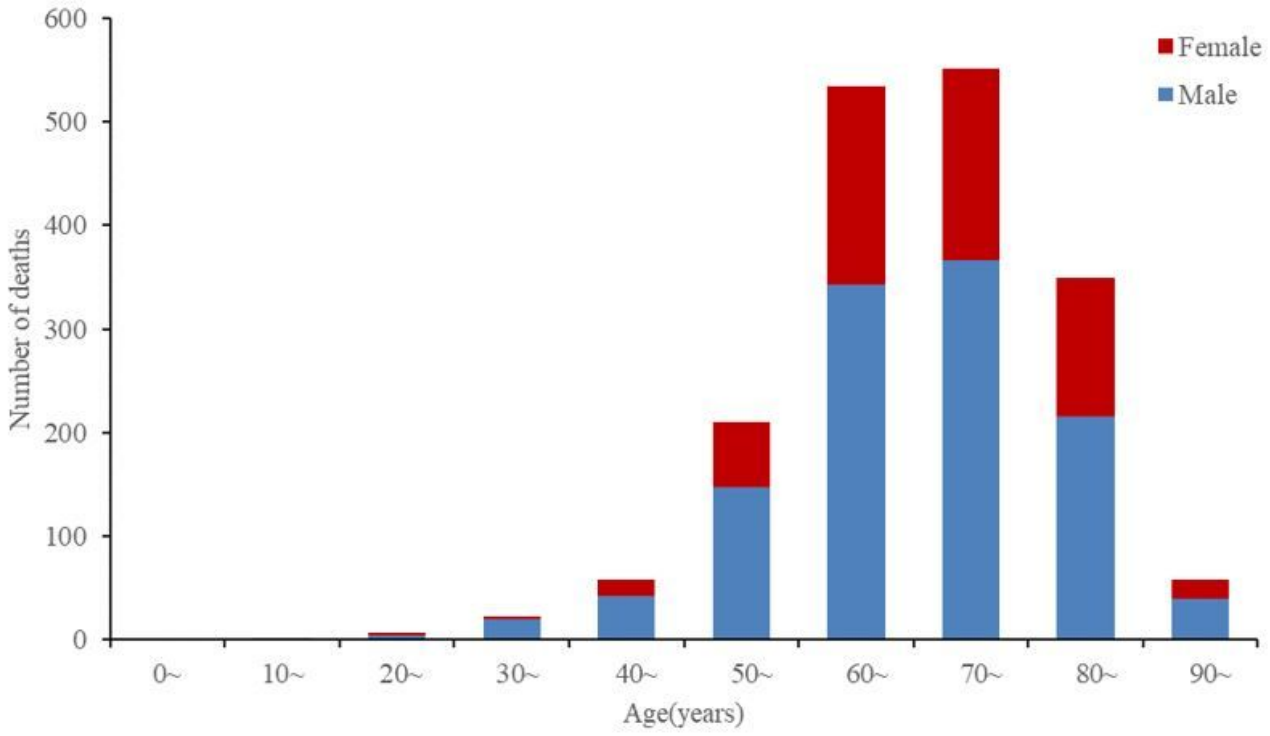

Figure 1

The age distribution of deaths in Wuhan

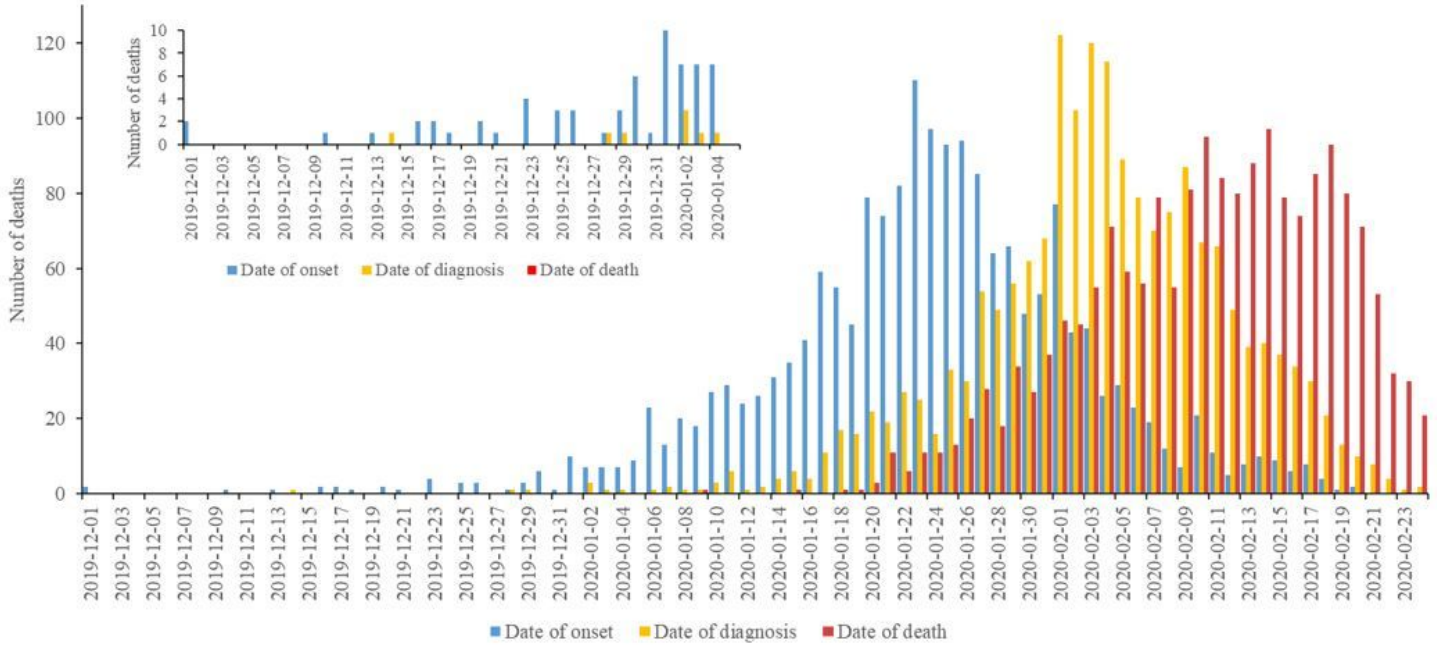

Figure 2

The epidemiological curves by date of symptom onset, date of diagnosis and date of death in Wuhan

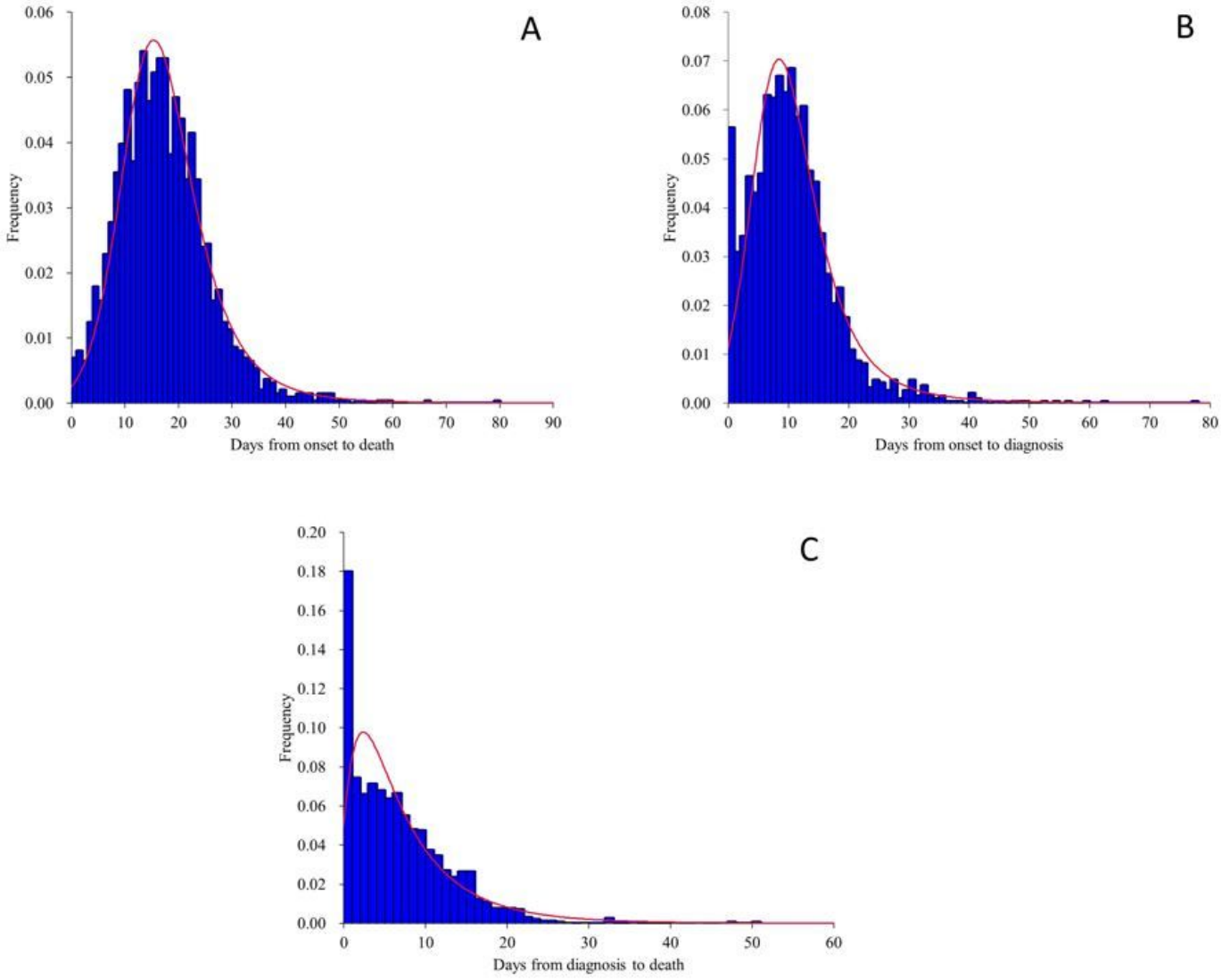

Figure 3

Time distribution of interval from onset to death(A), interval from onset to diagnosis(B) and interval from diagnosis to death(C)

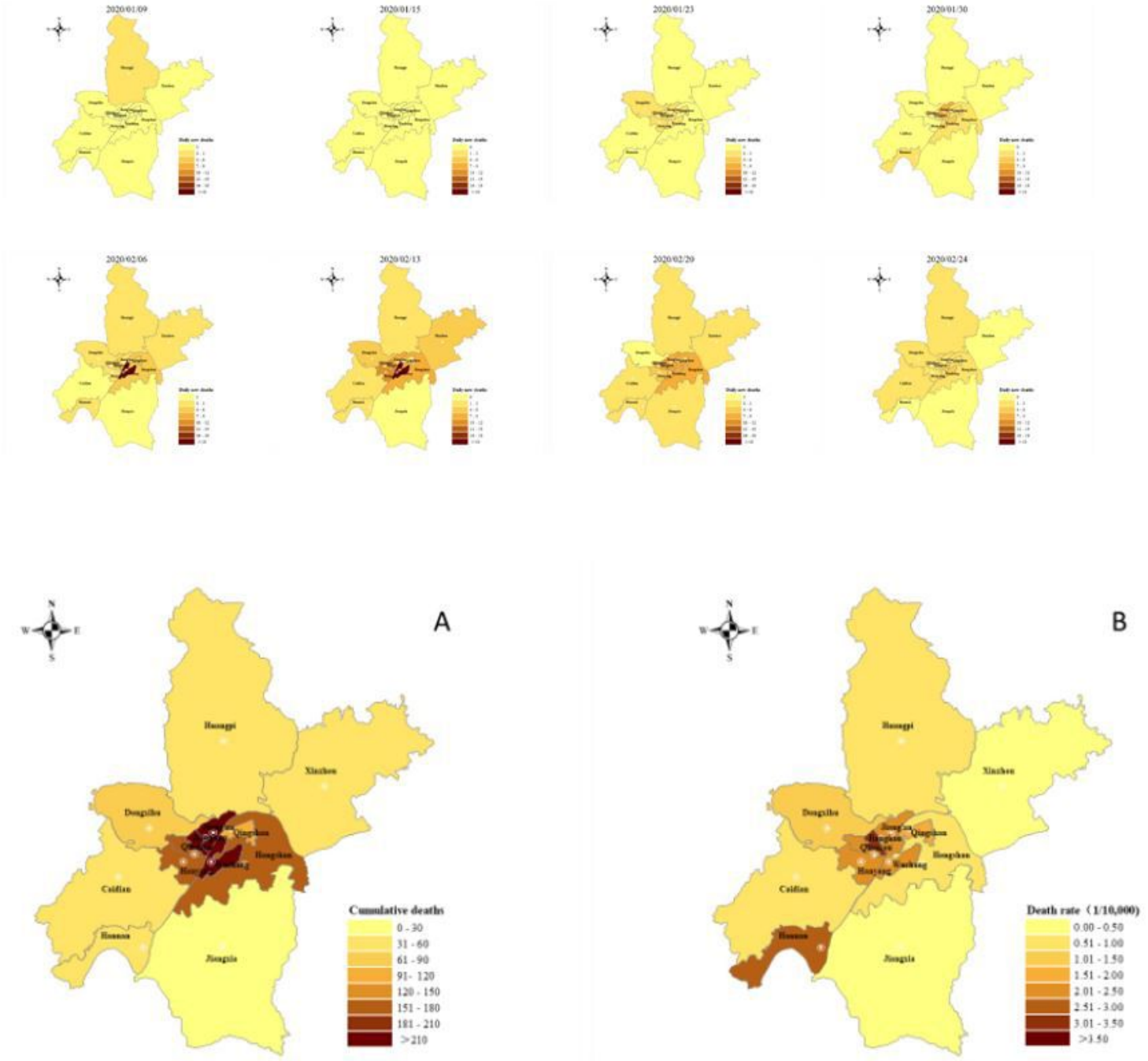

Figure 4

(a). Daily new death cases in administrative districts of Wuhan (2019/01 / 09 - 2020 / 2/24) (b). The geographical disparity of cumulative deaths(A) and death rates(B) Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.