COVID-19 in China and the US: Differences in hospital admission co-variates and outcomes

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Abstract

Background

Although there are extensive data on admission co-variates and outcomes of persons with coronavirus infectious disease-2019 (COVID-19) at diverse geographic sites there are few if any subject-level comparisons between sites in regions and countries. We aim to comparatively investigate differences in hospital admission co-variates and outcomes of hospitalized people with COVID-19 between Wuhan City, China and the New York City region, USA.

Methods

We retrospectively collected clinical data on 1859 Hospitalized subjects with COVID-19 in Wuhan City, China 20 January to 4 April, 2020. Data on those 5700 hospitalized subjects with COVID-19 in the New York City region, USA 1 March to 4 April, 2020 was drawn from a published article by Richardson *et al*. Hospital admission co-variates (epidemiological, demographic and laboratory co-variates) and outcomes (rate of intensive care unit(ICU) admission, invasive mechanical ventilation(IMV), major organ failure and death and length of hospital stay) were compared between the two cohorts.

Results

Wuhan subjects were younger, more likely female, less likely to have co-morbidities and fever, more likely to have a blood lymphocyte concentration > 1×10E+9/L and less likely to have abnormal liver and cardiac function tests compared with the New York subjects. There were outcomes data on all Wuhan subjects and 2,634 New York subjects. Wuhan subjects had higher blood nadir median lymphocyte concentrations and longer hospitalizations, were less likely to receive IMV, ICU hospitalization and kidney replacement therapy. Amongst subjects not receiving IMV those in Wuhan were less likely to die compared with New York subjects. In contrast, risk of death was similar in subjects receiving IMV at both sites.

Conclusions

We found different hospital admission co-variates and outcomes between hospitalized persons with COVID-19 between Wuhan City and the New York region, which should be useful developing a comprehensive global understanding of the SARS-CoV-2 pandemic and COVID-19.

Background

The severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic which causes coronavirus infectious disease-2019 (COVID-19) began in Wuhan City, China in December, 2019. By March 1, 2020 the pandemic had spread to the New York City region. [1] Molecular studies indicate SARS-CoV-2 mutated substantially in this interval.[2, 3] Whether this affected infectivity and/or virulence is unknown.

Several studies report risk factors for SARS-CoV-2-infection and for developing COVID-19. For example, older age, male sex, cancer and chronic diseases. [4–6] There are also considerable data regarding risk factors for death from COVID-19 such as older age, male sex, co-morbidities such as arterio-sclerotic cardio- and vascular disease (ASCVD), chronic obstructive pulmonary disease (COPD), diabetes and cancer, and abnormal laboratory covariates including high D-dimmer concentration, high neutrophil-to-lymphocyte ratio, low blood platelet concentration, high procalcitonin concentration and increased interleukin-6 concentration.[7–10] In addition to these risk factors there are substantial differences in diagnostic criteria for COVID-19 and for hospital admission between different geographic regions, countries and cities.

We interrogated data on hospital admission co-variates and outcomes of persons with COVID-19 in Wuhan City, China and the New York City region and detected substantial differences. These data should be useful developing a comprehensive global understanding of the SARS-CoV-2 pandemic and COVID-19.

Methods

[9-11] For the Wuhan cohort, the following details of methods are consistent with those in our previous publications.

Subjects

1,859 consecutive persons ≥ 18 years 20 January to 4 April 2020 from Union Hospital (main part, Union West Hospital and Union Tumor Hospital), Wuhan Central Hospital, General Hospital of Central Theater Command, PLA, Wuhan Third Hospital and Wuhan Jin-Yin-Tan Hospital were studied. These hospitals were re-constructed and designated as COVID-19 treatment centers. Between 4 February and 18 February, 2020 persons with clinical symptoms and a lung computed tomography (CT) scan consistent with COVID-19 were diagnosed as having COVID-19 without confirmation of SARS-CoV-2-infection by quantitative reverse transcript polymerase chain reaction (qRT-PCR). After hospitalization subjects were tested by qRT-PCR to confirm the diagnosis and monitor their course. Beginning 29 February, 2020, anti-SARS-CoV-2 IgM and/or IgG antibodies were assayed at Union Hospital and Wuhan Central Hospital by the centers to confirm the diagnosis and to evaluate suspected cases of COVID-19 which were qRT-PCR-negative. Subjects in whom we could not confirm SARS-CoV-2-infection by a qRT-PCR, IgM/IgG assay or both were excluded from the study. Subjects recovering from COVID-19 were discharged and transferred to designated hotels, Fangcang shelter hospitals or Leishenshan Hospital for 2-4 weeks of isolation or further care if needed. [12] For the New York region cohort we used data reported by Richardson *et al*. [13]

Data collection

[10] The data collection procedures are routinely followed as described in detail in our previous publications. For Wuhan cohort we obtained epidemiological, demographic, clinical, laboratory, radiological, therapy and outcomes data from electronic medical records (EMRs) using a standardized data collection form. Interventions included antibiotics, anti-viral drugs, corticosteroids and supportive care including supplemental oxygen, mechanical ventilation (with and without intubation) and extra-corporeal membrane oxygenation (ECMO). Data were independently entered and cross-validated by two researchers (WH and JY). A third researcher (QL) adjudicated discordances. Missing data were retrieved from the relevant hospital.

Definitions

For Wuhan cohort exposure history was defined as exposure to persons with confirmed SARS-CoV-2-infection or visiting the Huanan Wholesale Seafood Market, possible origin site of the SARS-CoV-2 epidemic in Wuhan City. Smoking history was defined as current or former smoker (stopping > 5 years ago) with exposure of ≥ 20 cigarettes per day for ≥ 1 year (1 pack year). Fever was defined as temperature ≥ 37.3 °C on ≥ 2 measurement > 4 h apart. Acute kidney injury, acute respiratory distress syndrome (ARDS) and acute cardiac injury were diagnosed according to guidelines or as reported. [14-16] Acute liver damage was defined as an elevation in aspartate aminotransferase or alanine aminotransferase of > 15 x upper limit of normal. Severity of COVID-19 was classified as: (1) mild; (2) moderate; (3) severe; or (4) critical according to the Chinese guideline for COVID-19 (version 7) .[17, 18] Recovery was defined as complete resolution of all clinical signs and symptoms, normalization of the lung computed tomography (CT) scan (if abnormal) and ≥ 2 negative quantitative real-time polymerase chain reaction (qRT-PCR) tests for SARS-CoV-2. Subjects dying of unrelated causes were excluded from analyses of COVID-19-related deaths.

Statistical analyses

Demographics and clinical co-variates were presented using descriptive statistics with frequencies (percentage) for discrete variables and median (interquartile range, IQR) and range for continuous variables. Descriptive statistics with frequencies (percentage) for discrete variables were compared using $\chi 2$ test, a two-sided alpha of < 0.05 was considered significant. Median (IQR) and range for continuous variables are displayed. It was not possible to calculate *P*-values for comparisons of continuous co-variates because of limitations of the New York data.

Results

Comparison of hospitalized subjects from Wuhan and New York Cities by admission clinical co-variates

Subjects in Wuhan cohort were younger (median 59 years [IQR 45-68 years] *versus* 63 years [IQR 52-75]; Table 1), more likely female (50%,925/1859 *versus* 40%,2263/5700; $P < 0.001$) and less likely smokers (6%,111/1859 *versus* 16%,558/5700; $P < 0.001$). Wuhan subjects were less likely to have co-morbidities, such as ASCVD (14%,268/1859 *versus* 18%,966/5700; $P < 0.001$), hypertension (31%,579/1859 *versus* 57%,3026/5700; $P < 0.001$), diabetes (14%,262/1859 *versus* 34%,1808/5700; $P < 0.001$), chronic obstructive pulmonary disease (COPD; 3%,61/1859 *versus* 5%,287/5700; $P < 0.001$), cancer (3%,61/1859 *versus* 6%,320/5700; $P < 0.001$), chronic kidney disease (2%,45/1859 *versus* 9%,454/5700; $P < 0.001$), and to have > 1 co-morbidity ($P < 0.001$). Subjects from Wuhan were less likely to have temperature > 38°C on admission (10%,189/1859 *versus* 31%,1734/5700; $P < 0.001$).

Table 1
Hospital admission co-variates.

	Wuhan n = 1859	New York n = 5700	*P*-value
Age, median (IQR*), years	59 (45, 68)	63 (52, 75)	
Female	925 (50)	2263 (40)	<0.001
Smoker	111 (6)	558 (16)	<0.001
Co-morbidity			
ASCVD*	268 (14)	966 (18)	<0.001
Hypertension	579 (31)	3026 (57)	<0.001
Diabetes	262 (14)	1808 (34)	<0.001
COPD*	61 (3)	287 (5)	<0.001
Cancer	65 (3)	320 (6)	<0.001
Chronic kidney disease	45 (2)	454 (9)	<0.001
Comorbidities			
None	954 (51)	350 (6)	<0.001
1	537 (29)	359 (6)	
>1	368 (20)	4991 (88)	
Temperature >38°C	189 (10)	1734 (31)	<0.001
Temperature (°C)	37 (37, 37)	38 (37, 38)	
Laboratory co-variates			
Neutrophils ×10E+9/L	3 (2, 5)	5 (4, 8)	
Lymphocytes ×10 E+9/L	1 (0.8, 1.6)	0.88 (0.6, 1.2)	
Lymphocyte, <1000×10 E+9/L	736 (40)	3387 (60)	<0.001
CRP*, mg/L	13 (3, 51)	130 (64, 269)	
Procalcitonin, ng/ml (< 0.5)	0.06 (0.05, 0.1)	0.2 (0.1, 0.6)	
LDH*, U/L (109-245)	212 (170, 292)	404 (300, 552)	
Ferritin, ng/ml (4.6-204)	567 (246, 1218)	798 (411, 1515)	
ALT*, U/L (5-35)	38 (22, 67)	33 (21, 55)	
ALT >60U/L	533 (29)	2176 (39)	<0.001
AST*, U/L (8-40)	32 (22, 49)	46 (31, 71)	
AST >40U/L	645 (35)	3263 (58)	<0.001
Creatine kinase, U/L (26-140)	88 (54, 165)	171 (84, 397)	
BNP*, pg/ml (< 100)	61 (18, 242)	386 (106, 1997)	
Troponin I above test-specific upper limit of normal	203 (19)	801 (23)	0.006

Data are median (IQR) or n (%).

*IQR, interquartile range; *ASCVD, arterio-sclerotic cardio-vascular disease; *COPD, chronic obstructive pulmonary disease; *CRP: C-reactive protein; *LDH: lactate dehydrogenase; *ALT: alanine aminotransferase; *AST: aspartate aminotransferase; *BNP: B-type natriuretic peptide.

On admission Wuhan subjects were less likely to have a blood lymphocyte concentration < 1×10E+9/L (40%,736/1859 *versus* 60%,3387/5700; *P* < 0.001), lower median blood neutrophil concentration (3 x 10 E+9/L [IQR 2-5 x 10 E+9/L] *versus* 5.3 x 10E+9/L [IQR 3.7-7.7 x 10 E+9/L], alanine aminotransferase (ALT) > 60 U/L (29%,533/1859 *versus* 39%,2176/5700; *P* < 0.001), serum aspartate aminotransferase (AST) > 40 U/L (35%,645/1859 *versus* 58%,3263/5700; *P* < 0.001), lactate dehydrogenase (LDH) (212 U/L [IQR 170-292 U/L] *versus* 404 U/L [IQR 300-552 U/L]), troponin-I > upper limit of normal (19%,203/1859 *versus* 23%,801/5700; *P* = 0.006), B-type natriuretic peptide (BNP; 61 pg/ml [IQR 18-242 pg/ml] *versus* 386 pg/ml, [IQR 106-1997 pg/ml]), creatine kinase (88 U/L [IQR 54-165 U/L] *versus* 171 U/L [IQR 84-397 U/L]), C-reactive protein (CRP)(13 mg/L [IQR 3-51 mg/L] *versus* 130 mg/L [IQR 64-269 mg/L], ferritin (567 ng/mL [IQR 246-1218] *versus* 798 ng/mL [IQR 411-1515 ng/mL]) and procalcitonin (0.06 ng/ml [IQR 0.05-0.1 ng/mL] *versus* 0.2 ng/ml [IQR 0.1-0.6 ng/mL]). These data are displayed in Table 1.

Comparison Of Outcomes By Co-variates After Admission

There were outcomes data on the 1859 Wuhan subjects and 2634 New York subjects (Table 2). Wuhan subjects had higher blood nadir median lymphocyte concentrations (1.0 ×10E+9/L [0.8-1.6 ×10E+9/L] *versus* 0.88 ×10 E+9/L [0.6-1.2 ×10 E+9/L]) and longer hospital stays (18 days [range, 12-23 days] *versus* 4 [range, 2-7 days]). They were less likely to receive invasive mechanical ventilation (5%,85/1859 *versus* 12%,320/2634; *P* < 0.001), ICU care (6%,106/1859 *versus* 14%,373/2634; *P* < 0.001), to have acute kidney injury (5%,99/1859 *versus* 22%,523/2634; *P* < 0.001) but not acute liver injury (1%,27/1859 *versus* 2%,56/2634; *P* = 0.116) and to receive therapy of kidney failure (1%,23/1859 *versus* 3%,81/2634; *P* < 0.001). Wuhan subjects were less likely to die (11%,209/1859 *versus* 21%,553/2634; *P* < 0.001). In subjects not receiving mechanical ventilation those in Wuhan were less likely to die compared with those in New York (8%,136/1774 *versus* 12%,271/2314; *P* < 0.001). In contrast, death rates were similar in subjects in both cities in subjects receiving mechanical ventilation (86%,73/85 *versus* 88%,282/320; *P* = 0.58).

Table 2
Hospital course and outcomes.

	Wuhan **n = 1859**	**New York** **n = 2634**	***P*-value**
Nadir lymphocyte concentration	1.0 (0.6, 1.4)	0.8 (0.5, 1.14)	
IMV*	85 (5)	320 (12)	<0.001
ICU* admission	106 (6)	373 (14)	<0.001
Acute kidney injury	99 (5)	523 (22)	<0.001
Kidney replacement therapy	23 (1)	81 (3)	<0.001
Acute hepatic injury	27 (1)	56 (2)	0.116
Length of stay	18 (12, 23)	4 (2, 7)	
Died	209 (11)	553 (21)	<0.001
no IMV	136/1774 (8)	271/2314 (12)	<0.001
Died, received IMV	73/85 (86)	282/320 (88)	0.576

Data are median (IQR) or n (%);

*IMV, invasive mechanical ventilation; *ICU, intensive care unit.

Comparison of deaths by sex and 10-year intervals of age

In the Wuhan cohort males ages 40-49, 80-89 and ≥ 90 years were less likely to die compared with similar age New York males whereas those > 49 years to < 80 years had similar risks of death (Table 3). In the Wuhan cohort females of all ages were less likely to die compared with New York. In subjects who died those in Wuhan had longer median hospital stays compared with those in New York. (Table 3).

Table 3
Deaths by age and sex and hospitalization interval

	Wuhan Male (%)	New York Male (%)	*P*-value	Wuhan Female (%)	New York Female (%)	*P*-value	Wuhan-Hospitalization median (IQR), d	New York-Hospitalization median (IQR), d
Age intervals, y								
0-9	0/0	0/13	-	0/0	0/13	-	NA	NA
10-19	0/4	0/1	-	0/1	0/7	-	NA	NA
20-29	1/35 (3)	3/42 (7)	0.621	0/48 (0)	1/55 (2)	1.0	13 (13-13)	4 (1-7)
30-39	2/122 (2)	6/130 (5)	0.283	2/132 (2)	2/81 (3)	0.636	12 (7-24)	3 (2-4)
40-49	2/118 (2)	19/233 (8)	0.016	2/108 (2)	3/119 (3)	1.0	13 (3-43)	6 (3-8)
50-59	25/172 (15)	40/327 (12)	0.486	4/191 (2)	13/188 (7)	0.026	10 (6-18)	6 (3-10)
60-69	42/254 (17)	56/300 (19)	0.577	18/281 (6)	28/233 (12)	0.030	13 (7-20)	6 (3-8)
70-79	52/161 (32)	91/254 (36)	0.525	14/110 (13)	54/197 (27)	0.003	10 (6-19)	5 (3-8)
80-89	27/58 (47)	94/155 (61)	0.087	15/49 (31)	76/158 (48)	0.033	11 (6-19)	4 (2-7)
≥ 90	3/10 (30)	28/44 (64)	0.078	0/5 (0)	39/84 (46)	0.065	8 (7-NA)	3 (1-6)

Discussion

We compared hospital admission co-variates and outcomes of persons with COVID-19 between Wuhan City, China and the New York City region, two of the epicenters of the SARS-CoV-2 pandemic. [19, 20] We found many differences in baseline co-variates such as sex, age, co-morbidities and laboratory parameters associated and unassociated with COVID-19. There were also significant differences in outcomes. For example, Wuhan subjects were more likely female, younger and have fewer co-morbidities including ASCVD, hypertension, diabetes mellitus, COPD and kidney failure compared with New York subjects.

There are several possible reasons for these discordances. One could be people in Wuhan population are healthier than those in New York. This seems unlikely based on estimated life expectancies of the 2 cities. [21] However, we cannot exclude selection biases. Persons hospitalized in the New York region were skewed towards racial groups and ethnicities known to have poor baseline health and limited health care access for social and financial reasons. However, it is more likely hospital admission criteria were less stringent in Wuhan compared with New York. This bias would also explain several of the more favorable laboratory co-variates and the overall better outcomes in Wuhan.

For example, in Wuhan beginning February, 2020 persons with confirmed COVID-19, even SARS-CoV-2-infection, suspected cases, febrile patients who might be infected would be hospitalized,[22] though the subjects without confirmed COVID-19 were excluded from this study. This differs markedly from the situation in New York where only persons suspected of having moderately severe to severe COVID-19 signs and symptoms were typically hospitalized. For example, most subjects of Wuhan cohort had two-thirds of cases in the Wuhan cohort had moderate COVID-19 and only 8 died. In contrast, subjects in New York cohort had to be sufficiently medically ill to be admitted.

Second, hospitalization for COVID-19 in Wuhan was free. [22] This contrasts with most US hospitals where potentially-hospitalized persons face substantial costs which may discourage them from seeking entry unless severely ill.[23] The consequence is it is likely

there were fewer less severe cases hospitalized in Wuhan cohort compared with the New York cohort. Another possibility is mutations in SARS-CoV-2 might result in a more virulent infection and more sever COVID-19 in New York compared with Wuhan. Data supporting this hypothesis are so far lacking.

There are important limitations to our study. 1st, we lacked subject-level data from subjects in the New York cohort and had to rely on published data. Also, we do not know the interval from the onset of symptoms consistent with COVID-19 and hospitalization nor criteria for hospital admission in the New York cohort. Criteria for COVID-19 severity are known for the Wuhan but not New York cohort. Also, therapy strategies and details may have differed as well as criteria for hospital discharge. 2nd, we could not calculate *P*-values for non-normally distributed continuous variables. 3rd, because the pandemic began earlier in Wuhan, we had final data on all our subjects but whereas 2634 of 5700 subjects (46%) of subjects in the New York cohort had outcome data for comparison.

Conclusions

we found different hospital admission co-variates and outcomes between hospitalized persons with COVID-19 between Wuhan City and New York. These data should be useful developing a comprehensive global understanding of the SARS-CoV-2 pandemic and COVID-19.

Abbreviations

SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus-2
COVID-19	Coronavirus Infectious Disease-2019
ICU	Intensive Care Unit
IMV	Invasive Mechanical Ventilation
ASCVD	Arterio-sclerotic Cardio- and vascular disease
COPD	Chronic Obstructive Pulmonary Disease
CT	Computed Tomography
EMRs	Electronic Medical Records
QRT-PCR	Quantitative Reverse Transcript Polymerase Chain Reaction
ECMO	Extra-corporeal Membrane Oxygenation
ARDS	Acute Respiratory Distress Syndrome
IQR	Interquartile Range
ALT	Alanine Aminotransferase
AST	Aspartate Aminotransferase
LDH	Lactate Dehydrogenase
BNP	B-type Natriuretic Peptide
CRP	C-reactive Protein

Declarations

Ethics approval and consent to participate

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the *Helsinki Declaration* of 1975, as revised in 2000. The study was approved by the Ethics Committees of Union Hospital (2020-0095) and of Wuhan Central Hospital (2020-007). Subject informed consent was waived by the Ethics Committees of Union Hospital (2020-0095) and of Wuhan Central Hospital (2020-007).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interest to declare.

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Authors' contributions

QL, ZC, and RPG designed the study. YC, DW, KZ, Le C, JY, WH, LC, WR, FG, WC, and HW collected the data. All authors had full access to the data, were involved in data interpretation and vouch for the accuracy of the analyses. DW, YC, QL, and RPG prepared the typescript which all authors approved final approval and supported the decision to submit for publication.

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