

BMJ Open Descriptive study of causes of death and COVID-19-associated morbidities from the New York City electronic death record: first wave of the pandemic March–July 2020

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ABSTRACT

Objective Assessing excess deaths from benchmarks across causes of death during the first wave of the COVID-19 pandemic and identifying morbidities most frequently mentioned alongside COVID-19 deaths in the death record.

Methods Descriptive study of death records between 11 March 2020 and 27 July 2020, from the New York City Bureau of Vital Statistics. Mortality counts and percentages were compared with the average for the same calendar period of the previous 2 years. Distributions of morbidities from among forty categories of conditions were generated citywide and by sex, race/ethnicity and four age groups. Causes of death were assumed to follow Poisson processes for Z-score construction.

Results Within the study period, 46 563 all-cause deaths were reported; 132.9% higher than the average for the same period of the previous 2 years (19 989). Of those 46 563 records, 19 789 (42.5%) report COVID-19 as underlying cause of death. COVID-19 was the most prevalent cause across all demographics, with respiratory conditions (prominently pneumonia), hypertension and diabetes frequently mentioned morbidities. Black non-Hispanics had greater proportions of mentions of pneumonia, hypertension, and diabetes. Hispanics had the largest proportion of COVID-19 deaths (52.9%). Non-COVID-19 excess deaths relative to the previous 2-year averages were widely reported.

Conclusion Mortality directly due to COVID-19 was accompanied by significant increases across most other causes from their reference averages, potentially suggesting a sizable COVID-19 death undercount. Indirect effects due to COVID-19 may partially account for some increases, but findings are hardly dispositive. Unavailability of vaccines for the time period precludes any impact over excess deaths. Respiratory and cardiometabolic-related conditions were most frequently reported among COVID-19 deaths across demographic characteristics.

INTRODUCTION

SARS-CoV-2^{1 2} rapidly spreads in Wuhan, China in November–December 2019 and quickly thereafter throughout the world,

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Large and diverse data source of a major metropolitan area severely impacted by COVID-19 in the early stages of the pandemic, before vaccine administration.
- ⇒ Simple, effective and efficient methodology to represent the morbidity/mortality profile space of a jurisdiction.
- ⇒ Individual death certificate data shortcomings may be robustly counterbalanced in the aggregate due to size and multiplicity of sources in the complete mortality file analysed.
- ⇒ Pairwise associations of the methodology although informative do not provide a complete assessment of the morbidity composition related to death as reported.

with New York City the early epicentre of the pandemic in the USA. As of 1 June 2020, there were 203 793 cases diagnosed and reported in the city, and 18 679 deaths.³ The number of deaths rapidly accelerated following the first identified lab-confirmed COVID-19 death on 11 March 2020, the same day the WHO declared COVID-19 a pandemic. On average, there are 150 deaths per day in New York City during a non-pandemic year. During the peak of the first wave, there were approximately 600–800 deaths per day⁴ over a 2-week period in March and April 2020. [Figure 1](#) dramatically illustrates the impact of COVID-19 during the first wave.

COVID-19 was also a leading cause of death nationwide from March to October 2020, and at times was the leading cause of death as measured by daily counts.⁵ COVID-19 mortality rate increased with age with the 85-plus group being the most adversely impacted. Data for the USA for 2020 ranked COVID-19 as the third leading cause of death

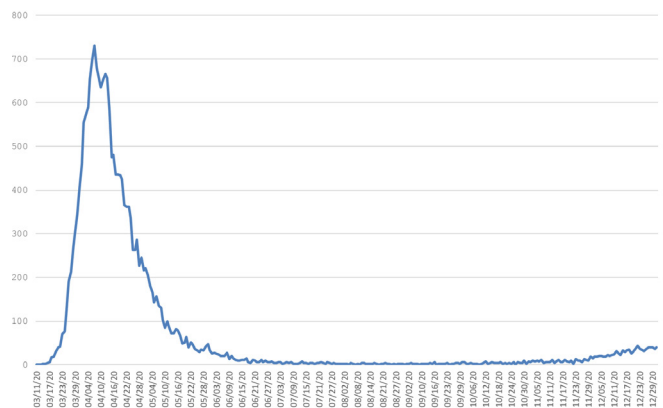


Figure 1 Daily COVID-19 death counts in New York City (11 March 2020 to 31 December 2020).

for the whole year, while significant increases across several other conditions were also reported.^{6 7}

In this analysis, we describe the distribution of the underlying causes of death in New York City for our study reference period and compare those deaths with the average of 2018 and 2019 for the same time span. We report on the distributions of conditions/morbidities frequently reported when COVID-19 was the underlying cause of death (UCOD). The main purpose of this analysis is to provide official statistics of the morbidity/mortality profile of the city during the early crisis days of the pandemic as a robust benchmark for contrast with other jurisdictions, national or international, especially concerning investigations of excess deaths.

METHODS/DATA

We analysed 40 mutually exclusive and collectively exhaustive causes or conditions (see [table 1](#)) across chapters of the International Classification of Diseases, 10th Revision (ICD-10) classification system of diseases, injuries and causes of death.⁸ 27 of the conditions were selected and ranked because they are routinely reported in the City of New York Summary of Vital Statistics and by the National Center for Health Statistics^{9–11} with emphasis on some specific causes that research has related to COVID-19.^{12–16} The remaining conditions are rest of causes within an ICD-10 chapter. Death counts from ICD-10 chapters with small numbers were not explicitly addressed, for example, chapter XII ‘Diseases of the Skin and the Subcutaneous Tissue (L00–L99)’, and placed within ‘All Other Natural Causes’. We include external causes of death to particularly gauge conditions associated with deaths of despair as defined by Case and Deaton.¹⁷

We analysed the final electronic death record from the New York City Bureau of Vital Statistics covering the period of 11 March to 27 July 2020, 2019, and 2018. Death count averages between the years 2018 and 2019 constitute our baseline reference measures. Conditions were taken from the Record Axis of the multiple causes of death section of the electronic death record to identify the frequency of conditions with COVID-19. The Record Axis lists all

Table 1 Selected ICD-10 classes of conditions related to death

ICD-10 codes	Conditions (UCOD-MCOD)
B15–B19	Viral hepatitis*
B20–B24	HIV*
Rest of A00–B99	All other infectious diseases
C00–C97	Cancer*
C98–D49	All other neoplasms
D50–D89	Diseases of the blood-forming organs and certain disorders involving the immune mechanism
E66	Obesity*
E10–E14	Diabetes*
Rest of E00–E99	All other endocrine, nutritional and metabolic diseases
F10	Mental and behavioural disorders due to alcohol*
F11–F16, F18, F19	Mental and behavioural disorders due to psychoactive substances, excluding alcohol and tobacco*
Rest F00–F99	Rest of mental and behavioural disorders
G20–G21	Parkinson’s disease*
G30	Alzheimer’s disease*
Rest of G00–G99	All other diseases of the nervous system
I21, I22	Acute myocardial infarction*
I20, I25	Chronic ischaemic heart disease*
I11	Hypertensive heart disease*
I00–I09, I13, I23, I24, I26–I51	All other diseases of the heart
I10, I12, I15	Hypertension*
I60–I69	Cerebrovascular disease*
Rest of I00–I99	All other cardiovascular diseases
J09–J11	Influenza*
J12–J18	Pneumonia*
J45–J46	Asthma*
J40–J44, J47	Other chronic lower respiratory disease*
J80	Respiratory distress syndrome*
J96	Respiratory failure*
Rest of J00–J99	All other respiratory diseases
K70	Alcoholic liver disease*
K73–K74	Other chronic liver disease*
Rest of K00–K99	Other diseases of the digestive system
N00–N07, N17–N19, N25–N27	Kidney disease*
Rest of N00–N99	All other diseases of the genitourinary system

Continued

Table 1 Continued

ICD-10 codes	Conditions (UCOD-MCOD)
U071	COVID-19*
Rest of A00–R99	All other natural causes†
X40–X45, Y10–Y15, Y45, Y47, Y49	Accidental poisoning by psychoactive substances or alcohol regardless of intent*
X60–X84, Y870	Suicide*
X85–Y09, Y871	Homicide*
Rest of V00–Y99	Rest of external causes

International Classification of Diseases, 10th Revision, Vol. I, Geneva, WHO.
 *Rankable conditions.
 †One case unknown cause R99.
 ICD-10, International Classification of Diseases, 10th Revision; MCOD, multiple cause of death; UCOD, underlying cause of death.

conditions alongside the underlying cause after textual information on the death certificate has been processed for validity and consistency. Conditions are analysed as UCOD, that is, the condition that initiates the chain of events leading to death, and (other) multiple cause of death (MCOD) mentioned in the record. Conditions are coded using the ICD-10 classification system. COVID-19 deaths and mention were identified using ICD-10 code U07.1.¹⁸ **Table 1** lists the conditions and their ICD-10 codes.

Demographic information on the death certificate is reported by the informant, that is, next of kin or person responsible for the disposition of the decedent's remains. The race/ethnicity category of 'other' is partially composed of decedents identified as Alaska Natives/Native Americans or multiple races, where the bulk of the 3.8% of citywide deaths in this 'other' category is unknown (2.71% of citywide).

New York City matched lab results to death records for surveillance purposes to promote optimal determination of COVID-19-related deaths, among other things, to aid in the real-time calibrated public health response. However, this study solely uses death certificate data and standard ICD-10 classification protocols, hence differences in published aggregates are solely due to assessment approach.

For each condition, we calculated descriptive statistics, rankings, mortality difference from average of the preceding 2 years, and percentage (or relative) difference from the average. The full extent of the statistics has been placed in online supplemental material allowing for more detailed scrutiny. **Tables 2 and 3** in the text illustrate our approach. For the reference average analysis, we assume that death counts follow independent Poisson processes and generated Z-scores accordingly. Counts and percentages are reported for citywide and by sex. The mention of conditions from the multiple causes of death section of the electronic record is tabulated as

binary indication of their presence, that is, whether the condition is mentioned in the death record at all. Consequently, the reported per cent of a cause category refers to proportion of decedents where the condition appeared at least once in the death record. See online supplemental appendix for mathematical definitions of table columns. Analyses were conducted with SAS V.9.4¹⁹ and Microsoft Excel.

No patient or public involvement was present.

RESULTS

Table 2 lists the set of conditions reported and summarises the UCOD distribution by count and percent, including COVID-19, between 11 March 2020 and 27 July 2020. Details of citywide statistics are found in online supplemental table S1; similarly for all demographic tables (online supplemental tables S2–S4). Online supplemental table S5 provides an example of citywide proportion of morbidity mention given underlying cause across all conditions (see online supplemental appendix for definitions). The average number of deaths for the study period between 2018 and 2019 was 19 989. For the study period in 2020, there were a total of 46 563 deaths, an increase of 132.9% compared with the reference average. Of the 46 563 deaths, 19 789 (42.5%) were classified as due to COVID-19. The 26 774 non-COVID-19 deaths represent a 34.0% increase from the reference average. The top five rankable underlying causes of death for the study period in 2020 were: COVID-19 (42.5%), chronic ischaemic heart disease (16.0%), cancer (9.2%), hypertensive heart disease (4.0%) and diabetes (2.3%). In contrast, for the reference years, the top five rankable underlying causes were cancer (24.0%), chronic ischaemic heart disease (21.2%), hypertensive heart disease (4.4%), diabetes (3.5%) and cerebrovascular disease (3.4%). In what follows we list in parenthesis the absolute and relative differences of the top five conditions. The largest percentage (relative) differences between 2020 and the average of the reference years of rankable conditions were for respiratory failure (28, 323.5%), respiratory distress syndrome, (21, 233.3%), hypertensive heart disease (997, 114.2%), chronic ischaemic heart disease (3201, 75.6%) and pneumonia (382, 66.8%).

Clearly, large relative differences do not necessarily indicate large absolute differences. However, most conditions showed an increase between the reference years and 2020. Chronic ischaemic heart disease and hypertensive heart disease had large absolute and relative increases from their reference average. When combining these two major component conditions of 'diseases of heart', the increase in deaths in 2020 was 82.2% higher compared with the reference average (from 5108 to 9306). Viral hepatitis (–23, –39.0%), cancer (–505, –10.5%), mental and behavioural disorders due to psychoactive substances, excluding alcohol and tobacco (–11, –22.6%) and alcoholic liver disease (–25, –15.9%) were the exceptions, with percentage drops from their reference averages.

**Table 2** Underlying causes of death, difference from reference average (Z-scores), and indication of mention of morbidity class given COVID-19 as underlying cause, New York City 11 March to 27 July 2020, 2019 and 2018

Underlying causes of death	2020 N=46 563		2019, 2018 Avg=19 889		2020 Relative to Avg.	SD* from Avg	(MCO COVID-19)	
	n	%	Avg	%		Z-score	N	%
Viral hepatitis	36	0.1	59	0.3	-39.0	-2.84	46	0.2
HIV	142	0.3	120	0.6	18.3	1.55	86	0.4
All other infectious diseases	421	0.9	286.5	1.4	46.9	5.66	779	3.9
Cancer	4289	9.2	4794	24.0	-10.5	-6.18	624	3.2
All other neoplasms	102	0.2	96.5	0.5	5.7	0.45	29	0.1
Diseases of the blood-forming organs and certain disorders involving the immune mechanisms	73	0.2	70.5	0.4	3.5	0.24	215	1.1
Obesity	73	0.2	64	0.3	14.1	0.88	365	1.8
Diabetes	1059	2.3	696.5	3.5	52.0	9.66	2670	13.5
All other endocrine, nutritional and metabolic diseases	304	0.7	178.5	0.9	70.3	6.33	994	5.0
Mental and behavioural disorders due to alcohol	145	0.3	117	0.6	23.9	1.96	45	0.2
Mental and behavioural disorders due to psychoactive substances, excluding alcohol and tobacco	36	0.1	46.5	0.2	-22.6	-1.36	22	0.1
Rest of mental and behavioural disorders	613	1.3	542.5	2.7	13.0	2.37	1197	6.0
Parkinson's disease	215	0.5	154.5	0.8	39.2	3.54	174	0.9
Alzheimer's disease	480	1.0	393.5	2.0	22.0	3.33	205	1.0
All other diseases of the nervous system	504	1.1	344	1.7	46.5	6.15	238	1.2
Acute myocardial infarction	801	1.7	661.5	3.3	21.1	4.15	106	0.5
Chronic ischaemic heart disease	7436	16.0	4235	21.2	75.6	32.75	1205	6.1
Hypertensive heart disease	1870	4.0	873	4.4	114.2	20.76	645	3.3
All other diseases of the heart	845	1.8	694	3.5	21.8	4.37	4969	25.1
Hypertension	689	1.5	476.5	2.4	44.6	6.98	3444	17.4
Cerebrovascular disease	840	1.8	670	3.4	25.4	4.96	447	2.3
All other cardiovascular diseases	310	0.7	177.5	0.9	74.6	6.64	190	1.0
Influenza	36	0.1	27	0.1	33.3	1.28	722	3.6
Pneumonia	953	2.0	571.5	2.9	66.8	10.84	7724	39.0
Asthma	107	0.2	65	0.3	64.6	3.56	320	1.6
Other chronic lower respiratory disease	675	1.4	622	3.1	8.5	1.69	608	3.1
Respiratory distress syndrome	30	0.1	9	0.0	233.3	3.58	3255	16.4
Respiratory failure	36	0.1	8.5	0.0	323.5	4.33	6145	31.1
All other respiratory diseases	275	0.6	236	1.2	16.5	1.97	434	2.2
Alcoholic liver disease†	130	0.3	154.5	0.8	-15.9	-1.70	11	0.1
Other chronic liver disease	69	0.1	62.5	0.3	10.4	0.65	39	0.2
Other diseases of the digestive system	395	0.8	358.5	1.8	10.2	1.52	204	1.0
Kidney disease	262	0.6	170	0.9	54.1	4.94	1341	6.8
All other diseases of the genitourinary system	175	0.4	117.5	0.6	48.9	3.76	331	1.7
COVID-19	19 789	42.5	0	0.0	-	-	19 789	100.0
All other natural causes‡	663	1.4	477	2.4	39.0	6.19	1998	10.1
Accidental poisoning by psychoactive substances or alcohol regardless of intent‡	797	1.7	546.5	2.7	45.8	7.66	3	0.0

Continued

Table 2 Continued

Underlying causes of death	2020 N=46 563		2019, 2018 Avg=19 889		2020 Relative to Avg.	SD* from Avg	(MCO COVID-19)	
	n	%	Avg	%		Z-score	N	%
Suicide†	222	0.5	220.5	1.1	0.7	0.08	1	0.0
Homicide	187	0.4	124	0.6	50.8	3.99	2	0.0
Rest of external causes	479	1.0	468	2.3	2.4	0.41	132	0.7

Source: NYC Bureau of Vital Statistics, 2023.
 *SD (see online supplemental appendix).
 †Conditions associated with deaths of despair.¹⁷
 ‡There is one case classified as undetermined death ICD-10 code R99.
 ICD-10, International Classification of Diseases, 10th Revision; MCO|COVID-19, multiple cause of death.

In general, assuming independent Poisson processes for 2020, 2019 and 2018 counts, we find that most causes in 2020 had counts that were several SD away from their reference average. Chronic ischaemic heart disease, hypertensive heart disease, pneumonia and diabetes death counts were all at least 9.6 SD away from their reference averages (see table 2). Of note is that HIV, influenza and obesity were not statistically different from prior years.

The last two columns report indication of multiple cause mention given COVID-19 as the underlying cause, that is, (MCO|COVID-19). Citywide, pneumonia (39.0%), respiratory failure (31.1%), hypertension (17.4%), respiratory distress syndrome (16.4%), followed by diabetes (13.5%), were the highest percentage of conditions indicated given COVID-19 as underlying cause.

Showing that respiratory and cardiometabolic conditions were prominent with first wave COVID-19 deaths.

Table 3 reports the counts and percentages by sex for the underlying causes of death, alongside the distribution of conditions mentioned given COVID-19 as the underlying cause. A greater proportion of males died from COVID-19 (46.5%) than females (37.7%). The most frequently mentioned morbidities with COVID-19 as underlying cause across sex categories included pneumonia, respiratory failure, respiratory distress syndrome and hypertension. The set of morbidities did not differ by sex except for the relative rankings, particularly respiratory distress and hypertension. For example, female decedents had a higher proportion of hypertension mentions (18.8%) than male decedents (16.5%) placing it as the fifth ranked for females and sixth for males.

As shown in online supplemental tables S3a,b, white non-Hispanic decedents accounted for the highest proportion of all-cause mortality (32.7%), followed by black non-Hispanic (28.9%), Hispanic/Latino (Hispanic) (25.3%), Asian/Pacific Islanders (Asian P.I.) (9.4%) and 'other' (3.8%). Among Hispanic deaths, 52.9% were reported with COVID-19 as the underlying cause; black non-Hispanic (42.6%) and among Asian P.I. (43.3%). Notably, Hispanics had a full 10.4 percentage points above the citywide per cent (42.5%) of COVID-19 deaths,

while white non-Hispanics had 9.1 percentage points lower than that of the overall population (at 33.4%). The proportion of deaths with cancer as underlying cause was closer between Asian P.I. (11.2%), and white non-Hispanic (12.0%), whereas black non-Hispanic, Hispanic and 'other' were similar, but much smaller in magnitude (6.4%–7.6%). Chronic ischaemic heart disease as underlying cause was most frequent with white non-Hispanic (20.7%), followed by Asian P.I. (16.4%), black non-Hispanic (15.2%), 'other' (14.7%) and Hispanic (10.7%).

Across all racial/ethnic groups, over one-third of COVID-19 deaths had pneumonia as mention. Pneumonia appeared in higher proportion among black non-Hispanic with 42.3% of decedents, as compared with 40.1% for white non-Hispanic, and 35.8% for Hispanic. The top two morbidity mentions (pneumonia, respiratory failure) were shared by all race/ethnicities. Black non-Hispanic had the highest proportion of COVID-19 decedents with a contributing cause of diabetes (16.2%) as compared with Hispanic (14.8%), Asian P.I. (12.7%) and 'other' (14.1%). In contrast white non-Hispanic had the lowest percentage (9.0%). In addition, when COVID-19 was the underlying cause, hypertension appeared in 19.9% of black non-Hispanic deaths, whereas all other race/ethnicities varied within a lower range (16.0%–17.9%).

Online supplemental tables S4a,b reports on age groups. Decedents less than 45 years old had the lowest proportion of deaths with underlying cause of COVID-19 (28.6%), followed by those 85 years and older (33.2%). Higher proportions were found between the 45–64 (47.7%) and 65–84 (47.8%) years groups. Pneumonia, respiratory failure and respiratory distress were the top three multiple-cause mentions for all age groups except the 85 and older. The 85 and older group ranks hypertension third.

Hypertension ranked highest within the 65 and older groups, whereas diabetes was higher ranked among the younger than 65. Chronic ischaemic heart disease was reported at a higher proportion among individuals 85 years and older (8.9%). The younger three groups (from lower to higher) had percentages of 0.4%, 3.7% and 6.3%, respectively. Obesity mentions appeared most

Table 3 Underlying causes and indication of morbidity class given COVID-19 as underlying cause by sex, New York City 11 March 2020 to 27 July 2020

Conditions (UCOD-MCOD)	Male N=24415 (54.6%)				Female N=21148 (45.4%)			
	UCOD		(MCOD COVID-19)		UCOD		(MCOD COVID-19)	
	N	%	N	%	N	%	N	%
Viral hepatitis	20	0.1	30	0.3	16	0.1	16	0.2
HIV	94	0.4	63	0.5	48	0.2	23	0.3
All other infectious diseases	229	0.9	484	4.1	192	0.9	295	3.7
Cancer	2122	8.3	364	3.1	2167	10.2	260	3.3
All other neoplasms	51	0.2	11	0.1	51	0.2	18	0.2
Diseases of the blood-forming organs and certain disorders involving the immune mechanisms	37	0.1	113	1.0	36	0.2	102	1.3
Obesity	31	0.1	187	1.6	42	0.2	178	2.2
Diabetes	543	2.1	1601	13.5	516	2.4	1069	13.4
All other endocrine, nutritional and metabolic diseases	140	0.6	556	4.7	164	0.8	438	5.5
Mental and behavioural disorders due to alcohol	122	0.5	35	0.3	23	0.1	10	0.1
Mental and behavioural disorders due to psychoactive substances, excluding alcohol and tobacco	29	0.1	19	0.2	7	0.0	3	0.0
Rest of mental and behavioural disorders	188	0.7	600	5.1	425	2.0	597	7.5
Parkinson's disease	118	0.5	119	1.0	97	0.5	55	0.7
Alzheimer's disease	132	0.5	82	0.7	348	1.6	123	1.5
All other diseases of the nervous system	195	0.8	138	1.2	309	1.5	100	1.3
Acute myocardial infarction	417	1.6	65	0.5	384	1.8	41	0.5
Chronic ischaemic heart disease	3762	14.8	740	6.3	3674	17.4	465	5.8
Hypertensive heart disease	914	3.6	379	3.2	956	4.5	266	3.3
All other diseases of the heart	414	1.6	2880	24.4	431	2.0	2089	26.2
Hypertension	321	1.3	1945	16.5	368	1.7	1499	18.8
Cerebrovascular disease	386	1.5	267	2.3	454	2.1	180	2.3
All other cardiovascular diseases	139	0.5	101	0.9	171	0.8	89	1.1
Influenza	14	0.1	464	3.9	22	0.1	258	3.2
Pneumonia	535	2.1	4572	38.7	418	2.0	3152	39.6
Asthma	44	0.2	139	1.2	63	0.3	181	2.3
Other chronic lower respiratory disease	344	1.4	322	2.7	331	1.6	286	3.6
Respiratory distress syndrome	19	0.1	1996	16.9	11	0.1	1259	15.8
Respiratory failure	24	0.1	3674	31.1	12	0.15	2471	31.0
All other respiratory diseases	141	0.6	243	2.1	134	0.65	191	2.4
Alcoholic liver disease*	92	0.4	8	0.1	38	0.2	3	0.0
Other chronic liver disease	35	0.1	22	0.2	34	0.2	17	0.2
Other diseases of the digestive system	182	0.7	122	1.0	213	1.0	82	1.0
Kidney disease	144	0.6	852	7.2	118	0.6	489	6.15
All other diseases of the genitourinary system	72	0.3	243	2.1	103	0.5	88	1.1
COVID-19	11 821	46.5	11 821	100.0	7968	37.7	7968	100.0
All other natural causes†	276	1.1	1155	9.8	387	1.8	843	10.6

Continued

Table 3 Continued

Conditions (UCOD-MCOD)	Male N=24415 (54.6%)				Female N=21148 (45.4%)			
	UCOD		(MCOD COVID-19)		UCOD		(MCOD COVID-19)	
	N	%	N	%	N	%	N	%
Accidental poisoning by psychoactive substances or alcohol regardless of intent*	616	2.4	2	0.0	181	0.9	1	0.0
Suicide*	169	0.7	1	0.0	53	0.3	0	0.0
Homicide	163	0.6	2	0.0	24	0.1	0	0.0
Rest of external causes	320	1.3	75	0.6	159	0.8	57	0.7

Source: NYC Bureau of Vital Statistics, 2023.
 *Conditions associated with deaths of despair Case and Deaton, 2015.
 †There is one case classified as undetermined cause of death ICD-10 code R99.
 ICD-10, International Classification of Diseases, 10th Revision; MCOD, multiple cause of death; UCOD, underlying cause of death.

frequently in the younger age groups and declined as age increased, appearing most prominently in the less-than-45 age group with 8.8% of decedents. Reporting of obesity as a contributing cause dropped in frequency to 3.9%, 1.2% and 0.1% for the subsequent older age categories.

DISCUSSION

Relatively large positive differences of underlying causes of death (table 2) from their previous 2-year average, across most conditions studied, demonstrate that an inordinate number of deaths occurred simultaneously with the onset of massive levels of COVID-19 deaths over the first wave. These differences from reference averages are dramatically displayed by the large Z-scores over most of the conditions listed. Increased number of deaths across conditions is consistent with national data (6, 7). In any event, the increase in non-COVID deaths, especially for cardiovascular diseases and diabetes, may have possibly been COVID-19 deaths partially due to the inadequate COVID-19 testing capacity during early stage of the pandemic. This suggests that our total COVID deaths may be undercounted for the study period. Of note is that the period precludes vaccinations as cause or contributor to death.²⁰

The greater frequency of mention of respiratory and cardiometabolic conditions in the multiple causes of COVID-19 deaths while being clear risk factors for COVID-19 complications may support the undercount of COVID-19 deaths hypothesis. Not only did chronic ischaemic heart disease, hypertension, pneumonia and diabetes display strong statistically remarkable deviations from reference, but these conditions are also prominent morbidities noted in the context of COVID-19 deaths. There is also the possibility that the increase in non-COVID-19 deaths may be partially due to indirect effects related to the pandemic response from several dimensions (eg, incomplete knowledge by healthcare providers of COVID-19 as a novel condition impacting treatment strategies, policy implementation, lockdowns, social and economic dislocations, treatment and lapses in care).^{21–28}

However, although plausible, our analysis is inadequate to inform on this issue in a dispositive manner. A comprehensive analysis of international data on excess deaths^{29–31} demonstrates that the New York City experience was not unique, representing perhaps an early template of mortality patterns to be seen elsewhere.

The difference in distribution for cancer deaths between 2020 and the reference year average may at first suggest that the COVID-19 pandemic may have led to some transference of cases to COVID-19 presumably because the affected decedents may have been more vulnerable to adverse outcomes related to COVID-19 after infection. Yet, although possible in a small number of cases, further analysis (not here presented) shows that the drop in cancer deaths was more closely related to drops in non-resident deaths, likely due to travel restrictions.

While the number of obesity mentions in the multiple cause is small, the association between obesity and adverse outcomes due to COVID-19 has been overwhelmingly observed by others.^{12–16} However, obesity as a contributing cause to COVID-19 seems to have been reported more frequently among the young and progressively less so with increasing age. Thus, generating a surprisingly low overall proportion of obesity in COVID-19 deaths at 1.8%. Considering obesity's heightened risk for hospitalisation or death among COVID-19 patients should elicit increased efforts to better understand the reason for this seemingly low percentage of mention in the death record.

Alcoholic liver disease, accidental poisoning by psychoactive substances or alcohol regardless of intent and suicide are key components of deaths of despair.¹⁷ But only the accidental poisoning component showed a strong statistical increase (table 2). This may point to the possibility that the pandemic may have played an exacerbating effect on an already upwardly trending cause of death.³²

Our findings by demographic characteristics closely track those citywide. However, COVID-19 has been shown to be disparately distributed by race/ethnicity.^{33–38} Our results illustrate such disparities; with among Hispanics

having the highest proportion of COVID-19 deaths, and black non-Hispanics with higher proportions in reported morbidities, such as diabetes and hypertension. In addition, the greater proportion of black non-Hispanic with pneumonia may suggest that inadequate medical care or delay in care may have brought about the condition or exacerbated it in many. The distribution of morbidities by racial/ethnic groups mirrors long-standing health disparities in New York City, but the impact of the pandemic has prominently displayed the pervasiveness of these disparities.

Overall, across all demographic categories, that is, sex, race/ethnicity and age, there was a strong consistency in the ranking of morbidities associated with COVID-19 as underlying cause, with the most pronounced differences in rankings related to age.

As our data indicate, non-COVID-19 excess deaths were prominent in this first wave and seem to be a feature of the pandemic, given the growing evidence of excess non-COVID-19 deaths reported across jurisdictions.³⁰

Strengths and limitations

We believe we are one of the first to include a broad set of granular multimorbidity conditions of death in COVID-19 mortality analysis. However, the pairwise comparison approach of our analysis is limited since decedents often have more than one condition mentioned alongside the underlying cause. This results in non-mutually exclusive counts. Future work examines full combinations of conditions which allow for mutually exclusive category reporting. The usual caveats concerning the potential incompleteness of death certificate data also apply.^{39–44} Common mistakes may include improbable sequencing, and the listing of non-specific conditions or processes as underlying cause. Quality control efforts have allowed us to use the most complete and accurate data available for this analysis. However, insufficient capacity of COVID-19 testing, the rapid developments during the pandemic, strains on the healthcare systems and limited understanding of how to fill out a death certificate to indicate COVID-19 could have contributed to under-reporting of mortality due to COVID-19 during the early stages of the pandemic; overarching considerations for all studies examining the first wave of this pandemic.

CONCLUSION

This paper reports on the most frequently mentioned conditions among COVID-19 deaths in the first wave of the pandemic in New York City within the context of the overall underlying causes of death distribution. Respiratory conditions (mainly pneumonia), hypertension, and diabetes, were frequently mentioned when COVID-19 was the underlying cause. This was true across all race/ethnicity categories. There were several disparities of note, particularly concerning black non-Hispanic persons who were more likely to have the above conditions reported in conjunction with COVID-19, and Hispanics who suffered

a higher proportion of COVID-19 deaths than any other racial/ethnic group. The increase in deaths across many causes of death, relative to the average of the past 2 years, suggests that COVID-19 deaths may have been undercounted for the time frame studied. The unavailability of vaccines for the time period precludes any impact over excess deaths. However, there may be indirect COVID-19-related deaths which future analyses should address as they are critical to better understanding of the non-COVID-19 excess deaths phenomena.

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