A Century of Transitions in New York City's Measles Dynamics
Electronic Supplementary Material

Journal of the Royal Society Interface (2015)

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S1 The Data

Two data files that we compiled accompany this paper and can be downloaded from the web site of the *Journal of the Royal Society Interface* or from the International Infectious Disease Data Archive (IIDDA, http://iidda.mcmaster.ca).

`meas_us_ny_nyc_1890-1984_wk.csv`
: Weekly measles cases in New York City (NYC).

`vital_us_ny_nyc_1890-1984_yr.csv`
: Annual vital statistics in NYC (population, births, deaths, infant mortality, proportion vaccinated).

These datasets span 4 October 1890 to 30 December 1983, and were pieced together from four different sources.

S1.1 The Health Dept. Bulletins: 1891–1932 Weekly Data

Near the end of the 19th century and in the first half of the 20th, the NYC Health Department published weekly bulletins containing information regarding a wide variety of public health related issues (see §S3 for sample photographs of such a bulletin). Some of the details provided in these bulletins were incidence rates for numerous infectious diseases, including measles. Spanning the years 1891–1932, the weekly bulletins were published in two volumes. We acquired access to these through the NYC Academy of Medicine Library [1]

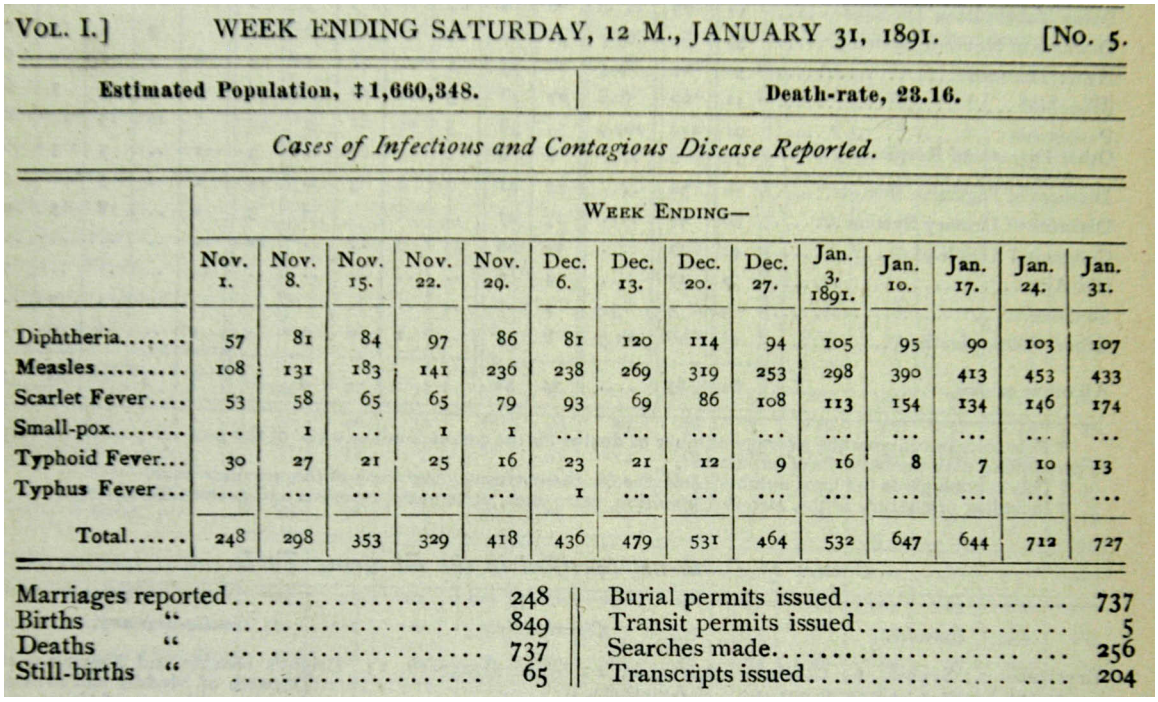
As noted previously, vital statistics for the whole of NYC were acquired through the NYC Health Dept., which provides data going back to 1900 [2]. However, we require data going back to the beginning of measles incidence data in 1891. To fill in the missing years of 1891–1899, we extracted vital statistics from the health bulletins.

An important note must be made about these bulletins regarding their reporting area. The data tables in the bulletins provide data for only Manhattan Island up until 15 January 1898, after which the reporting area was enlarged to cover Manhattan, The Bronx, Brooklyn, Queens, and Richmond. We wish to retain as high consistency as possible between the reporting area of both measles incidence data and vital statistics. It is therefore advantageous to use disease incidence data and vital statistics from the same source, especially through a change in reporting area.

S1.1.1 Disease Incidence, Volume 1: 1891–1914

City-wide reported cases of measles were extracted from a table as shown in Figure S1.

[1] The NYC Academy of Medicine [1] is a public institution independent of the NYC Health Department. Its library maintains a collection of books and literature related to health in the NYC population throughout its history.



VOL. I.] WEEK ENDING SATURDAY, 12 M., JANUARY 31, 1891. [NO. 5.

Estimated Population, ‡1,660,348. | **Death-rate, 23.16.**

Cases of Infectious and Contagious Disease Reported.

	WEEK ENDING—													
	Nov. 1.	Nov. 8.	Nov. 15.	Nov. 22.	Nov. 29.	Dec. 6.	Dec. 13.	Dec. 20.	Dec. 27.	Jan. 3, 1891.	Jan. 10.	Jan. 17.	Jan. 24.	Jan. 31.
Diphtheria.....	57	81	84	97	86	81	120	114	94	105	95	90	103	107
Measles.....	108	131	183	141	236	238	269	319	253	298	390	413	453	433
Scarlet Fever....	53	58	65	65	79	93	69	86	108	113	154	134	146	174
Small-pox.....	...	1	...	1	1	...	...	...	...	...	...	...	...	...
Typhoid Fever...	30	27	21	25	16	23	21	12	9	16	8	7	10	13
Typhus Fever...	...	...	...	...	...	1	...	...	...	...	...	...	...	...
Total.....	248	298	353	329	418	436	479	531	464	532	647	644	712	727

Marriages reported	248	Burial permits issued	737
Births "	849	Transit permits issued	5
Deaths "	737	Searches made	256
Still-births "	65	Transcripts issued	204

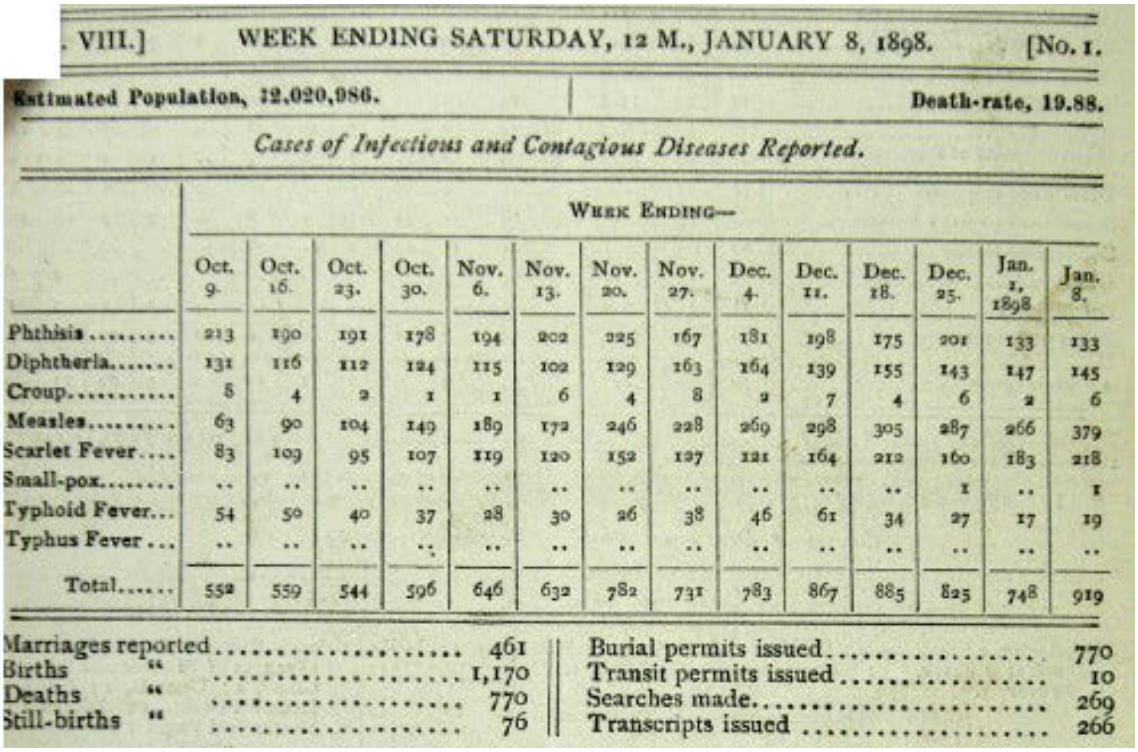
Figure S1: Health Bulletin table reporting weekly cases of infectious diseases. See §S3 for full page.

S1.1.2 Vital Statistics, Volume 1: 1890–1899

Tables of the form shown in Figure S1 in volume 1 of the bulletins provide needed vital data where it could otherwise not be found.

S1.1.3 Vital Statistics, Volume 1: 1898 Change in Reporting Area

The bulletin published for the week of Jan 15, 1898 was the first to include the larger reporting area mentioned previously. Vital statistics tables for that week and the one prior are shown in Figure S2 and Figure S3 to demonstrate the transition. Notice that though these consecutive bulletins occur in the same volume, their format changes to include data from the different boroughs.



. VIII.] WEEK ENDING SATURDAY, 12 M., JANUARY 8, 1898. [No. 1.

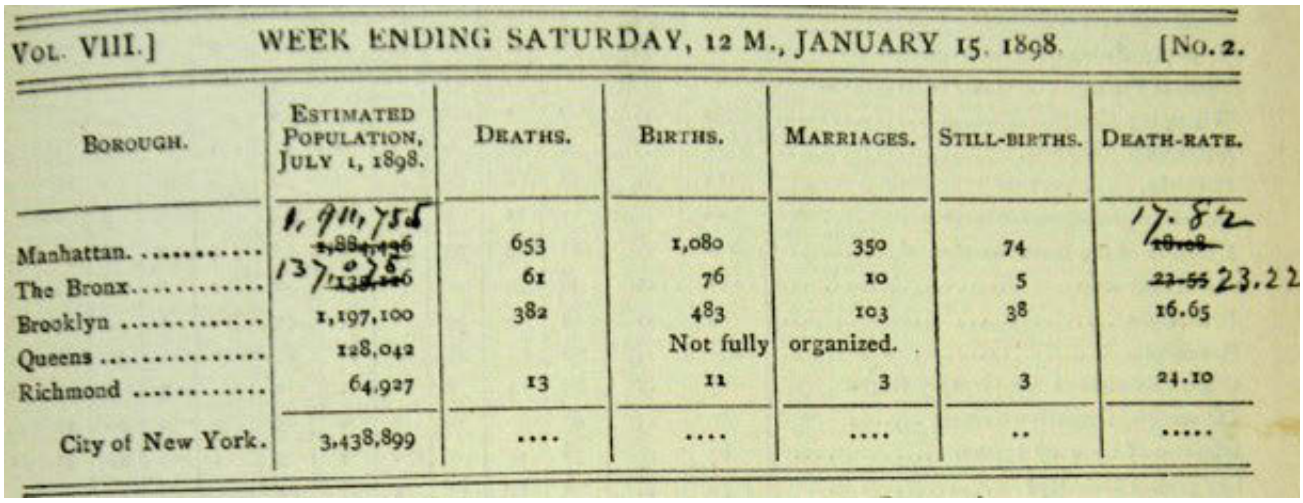
Estimated Population, 12,020,986. **Death-rate, 19.88.**

Cases of Infectious and Contagious Diseases Reported.

	Week Ending—												
	Oct. 9.	Oct. 16.	Oct. 23.	Oct. 30.	Nov. 6.	Nov. 13.	Nov. 20.	Nov. 27.	Dec. 4.	Dec. 11.	Dec. 18.	Dec. 25.	Jan. 1, 1898	Jan. 8.
Phthisis	213	190	191	178	194	202	225	167	181	198	175	201	133	133
Diphtheria	131	116	112	124	115	102	129	163	164	139	155	143	147	145
Croup	8	4	2	1	1	6	4	8	2	7	4	6	2	6
Measles	63	90	104	149	189	172	246	228	269	298	305	287	266	379
Scarlet Fever	83	109	95	107	119	120	152	127	121	164	212	160	183	218
Small-pox	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Typhoid Fever	54	50	40	37	28	30	26	38	46	61	34	27	17	19
Typhus Fever	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	552	559	544	596	646	632	782	731	783	867	885	825	748	919

Marriages reported	461	Burial permits issued	770
Births "	1,170	Transit permits issued	10
Deaths "	770	Searches made	269
Still-births "	76	Transcripts issued	266

Figure S2: Health Bulletin table reporting vital statistics for only Manhattan Island, week of Jan. 8, 1898.



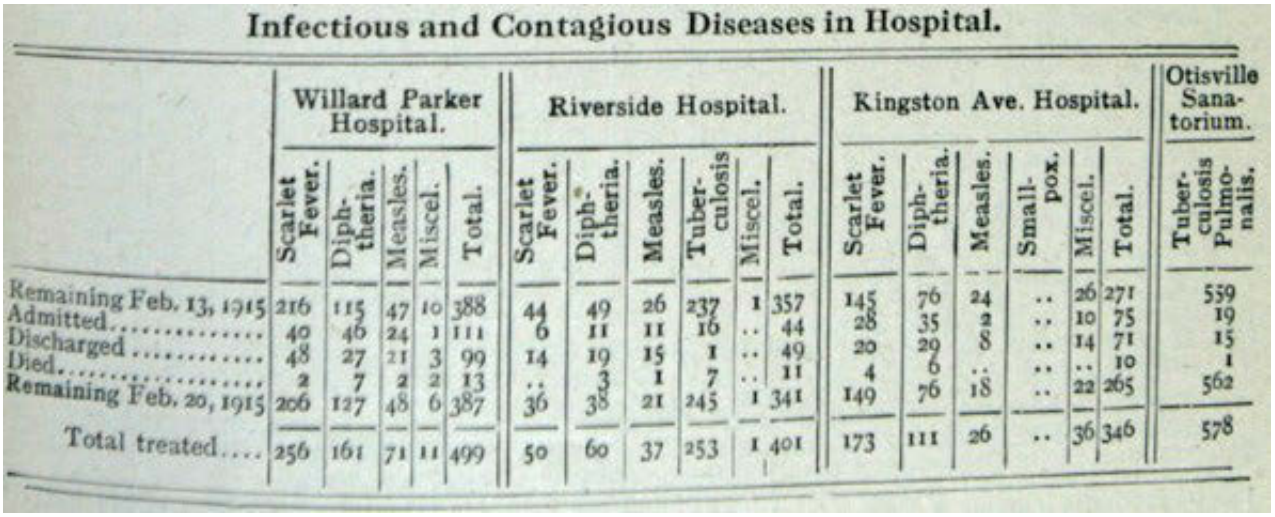
VOL. VIII.] WEEK ENDING SATURDAY, 12 M., JANUARY 15, 1898. [No. 2.

Borough.	Estimated Population, July 1, 1898.	Deaths.	Births.	Marriages.	Still-births.	Death-rate.
Manhattan	1,911,756 ~~1,884,496~~	653	1,080	350	74	17.82 ~~18.08~~
The Bronx	137,025 ~~138,106~~	61	76	10	5	~~23.55~~ 23.22
Brooklyn	1,197,100	382	483	103	38	16.65
Queens	128,042		Not fully	organized.		
Richmond	64,927	13	11	3	3	24.10
City of New York.	3,438,899	....	....	....	..	.....

Figure S3: Health Bulletin table reporting vital statistics for Manhattan, The Bronx, Brooklyn, Queens, and Richmond, week of Jan 15, 1898. The handwritten corrections are uncommon in these documents; they are the result of Health Dept. reorganization.

S1.1.4 Disease Incidence: 1915

Sometime between 1914 and 1916, the NYC Health Dept. adjusted the form of its bulletins, and the transitional year, 1915, presents some difficulty. Figure S4 shows the only available data tables regarding cases of reportable infectious diseases found for that year.



Infectious and Contagious Diseases in Hospital.

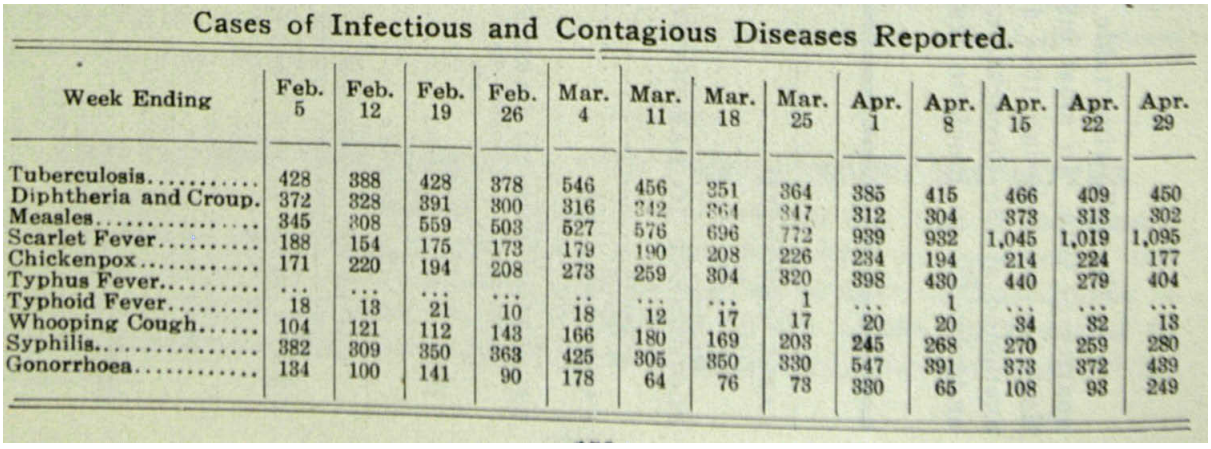
	Willard Parker Hospital.					Riverside Hospital.						Kingston Ave. Hospital.						Otisville Sanatorium.
	Scarlet Fever.	Diphtheria.	Measles.	Miscel.	Total.	Scarlet Fever.	Diphtheria.	Measles.	Tuberculosis	Miscel.	Total.	Scarlet Fever.	Diphtheria.	Measles.	Smallpox.	Miscel.	Total.	Tuberculosis Pulmonalis.
Remaining Feb. 13, 1915	216	115	47	10	388	44	49	26	237	1	357	145	76	24	..	26	271	559
Admitted	40	46	24	1	111	6	11	11	16	..	44	28	35	2	..	10	75	19
Discharged	48	27	21	3	99	14	19	15	1	..	49	20	29	8	..	14	71	15
Died	2	7	2	2	13	..	3	1	7	..	11	4	6	..	..	..	10	1
Remaining Feb. 20, 1915	206	127	48	6	387	36	38	21	245	1	341	149	76	18	..	22	265	562
Total treated	256	161	71	11	499	50	60	37	253	1	401	173	111	26	..	36	346	578

Figure S4: Health Bulletin table showing reportable infectious diseases, week of Feb. 20, 1915. See §S3 for full page.

Notice that city-wide totals of cases are not reported. Instead measles cases are reported only for three hospitals within the city. These numbers are themselves not representative of the entire city, but fortunately we can re-scale them using an independent data source (see §S1.4).

S1.1.5 Disease Incidence, Volume 2: 1916–1932

The format of the tables from which disease incidence data were drawn changed slightly compared to the previous volume, and tables appeared as shown in Figure S5.



Cases of Infectious and Contagious Diseases Reported.

Week Ending	Feb. 5	Feb. 12	Feb. 19	Feb. 26	Mar. 4	Mar. 11	Mar. 18	Mar. 25	Apr. 1	Apr. 8	Apr. 15	Apr. 22	Apr. 29
Tuberculosis	428	388	428	378	546	456	351	364	385	415	466	409	450
Diphtheria and Croup.	372	328	391	300	316	242	264	347	312	304	373	313	302
Measles	345	308	559	503	527	576	696	772	939	932	1,045	1,019	1,095
Scarlet Fever	188	154	175	173	179	190	208	226	234	194	214	224	177
Chickenpox	171	220	194	208	273	259	304	320	398	430	440	279	404
Typhus Fever	...	...	...	...	..	...	...	1	...	1	...	...	...
Typhoid Fever	18	13	21	10	18	12	17	17	20	20	34	32	18
Whooping Cough	104	121	112	143	166	180	169	203	245	268	270	259	280
Syphilis	382	309	350	363	425	305	350	330	547	391	373	372	439
Gonorrhoea	134	100	141	90	178	64	76	73	330	65	108	93	249

Figure S5: Health Bulletin table reporting weekly cases of infectious diseases. See §S3 for full page.

S1.1.6 Tabulation

For the tables containing disease incidence rates in volumes 1 and 2, notice that for each week's bulletin, a full quarter-year of previous weeks' worth of reported cases are shown. This means that in order to extract a year's worth of data, no more than five sample bulletins are required. As a result, we did not photograph

all Weekly Bulletin pages, but instead sampled pages periodically such that completely overlapping disease incidence tables were acquired.

Notice that the table providing vital statistics shows only information for the week in question. For the total population of NYC at the time, this did not present a problem; weekly changes in population are not significant compared to the total population, we can therefore estimate a yearly average population from these numbers. Birth rates oscillate throughout the year [8], and so for years in which a full set of bulletin photographs had not been acquired, we use weekly data points available periodically throughout the year to estimate the yearly value.

S1.2 Health Dept. Records 1958–1976 Weekly Disease Incidence Data

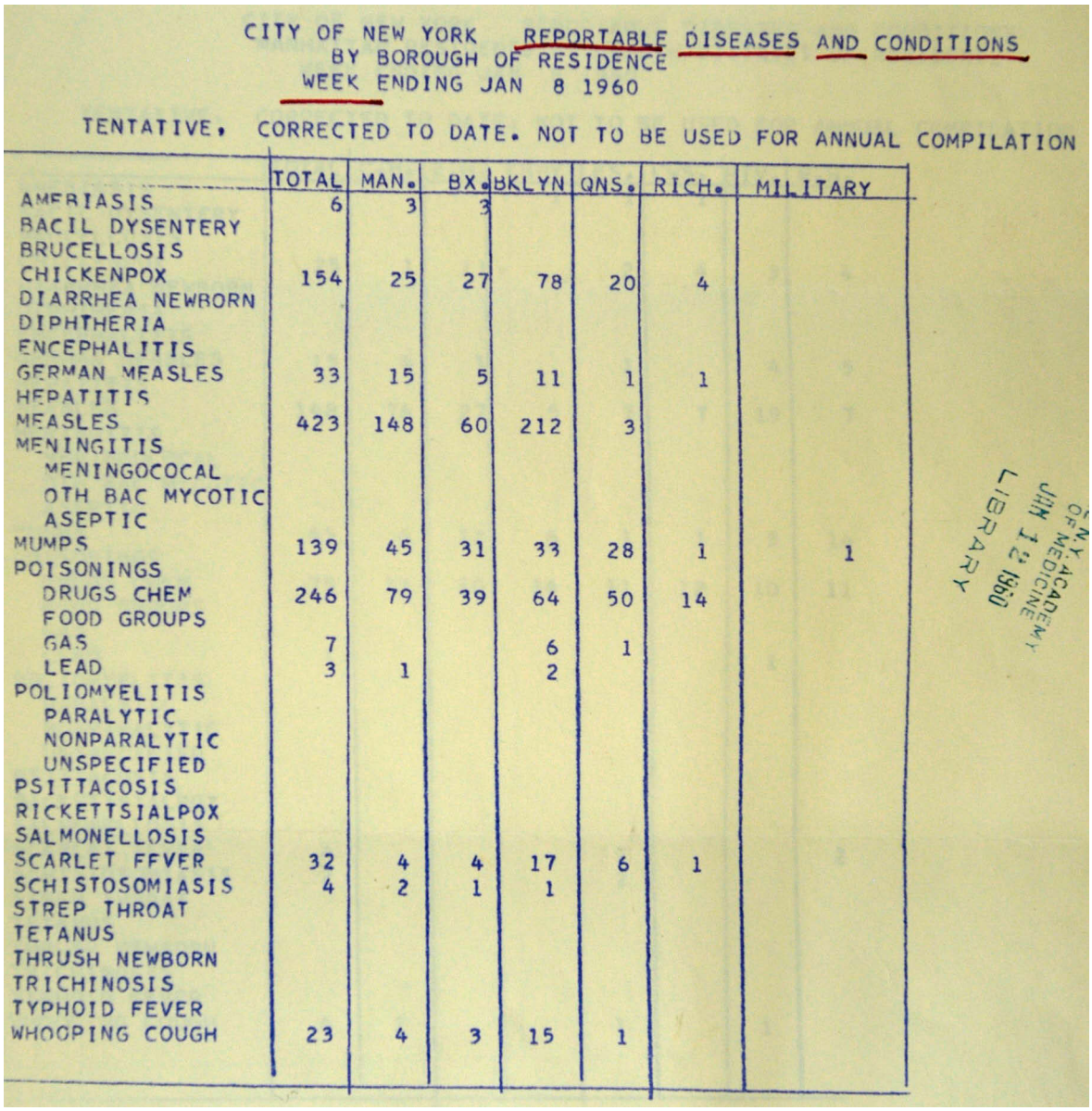
The NYC Health Department kept detailed records of the incidence of many diseases and conditions, including infectious diseases of interest to us. In particular, from 1958–1976, weekly records were kept of the incidence of diseases and conditions by health district of residence, of which there are 27 in NYC (this date range represents only what we were able to find, but all indications suggest that such data were collected for a wider range of dates). These are organized by boroughs and city-wide totals are available for our purposes. See Figure S6 for a sample table providing city-wide totals, and §S3 for a sample of a full weekly report.

S1.3 NYC Health Dept. Vital Statistics Reports: 1900–1984

The NYC Health Dept. website has made historical vital statistics reports available to the general public [2]. These reports, for the years of 1976–1984, contain tables showing city-wide monthly aggregated cases of reportable diseases. For years outside of this range and going back to 1935, yearly aggregated data is provided in the reports we obtained. For disease incidence, yearly data is by no means sufficient for our purposes. However, these vital statistics reports, as the name would imply, contain population and vital statistics data, for which yearly numbers are adequate. Furthermore, 5-year estimates are reported from 1900–1935.

S1.4 1915

We noted previously that we must further discuss the Weekly Bulletin data for the year 1915. Disease incidence numbers prior to 1915 come from Volume 1 of the Health Bulletins, and after 1915 come from Volume 2, as noted previously. The data before and after 1915 represent measles cases for all of NYC, whereas the data we have for 1915 represent counts taken for only three hospitals within the city. Using yearly aggregated reported measles cases taken from the NYC Vital Statistics Reports [2] and comparing them with yearly totals from the Health Bulletin data (see Figure S10), we determine a scaling factor (5.04) with which to adjust the weekly Health Bulletin Data. Figure S7 shows measles incidence rates recorded for the years surrounding 1915 before we re-sale the 1915 data. We conclude from the apparent consistency in the pattern of outbreaks that the adjustment is appropriate.



CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
BY BOROUGH OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE, CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	MAN.	BX.	BKLYN	QNS.	RICH.	MILITARY
AMEBIASIS	6	3	3				
BACIL DYSENTERY							
BRUCELLOSIS							
CHICKENPOX	154	25	27	78	20	4	
DIARRHEA NEWBORN							
DIPHTHERIA							
ENCEPHALITIS							
GERMAN MEASLES	33	15	5	11	1	1	
HEPATITIS							
MEASLES	423	148	60	212	3		
MENINGITIS							
MENINGOCOCAL							
OTH BAC MYCOTIC							
ASEPTIC							
MUMPS	139	45	31	33	28	1	1
POISONINGS							
DRUGS CHEM	246	79	39	64	50	14	
FOOD GROUPS							
GAS	7			6	1		
LEAD	3	1		2			
POLIOMYELITIS							
PARALYTIC							
NONPARALYTIC							
UNSPECIFIED							
PSITTACOSIS							
RICKETTSIALPOX							
SALMONELLOSIS							
SCARLET FEVER	32	4	4	17	6	1	
SCHISTOSOMIASIS	4	2	1	1			
STREP THROAT							
TETANUS							
THRUSH NEWBORN							
TRICHINOSIS							
TYPHOID FEVER							
WHOOPING COUGH	23	4	3	15	1		

N.Y. ACADEMY OF MEDICINE JAN 12 1960 LIBRARY

Figure S6: NYC Health Dept. table showing reportable diseases and conditions. See §S3 for full weekly report.

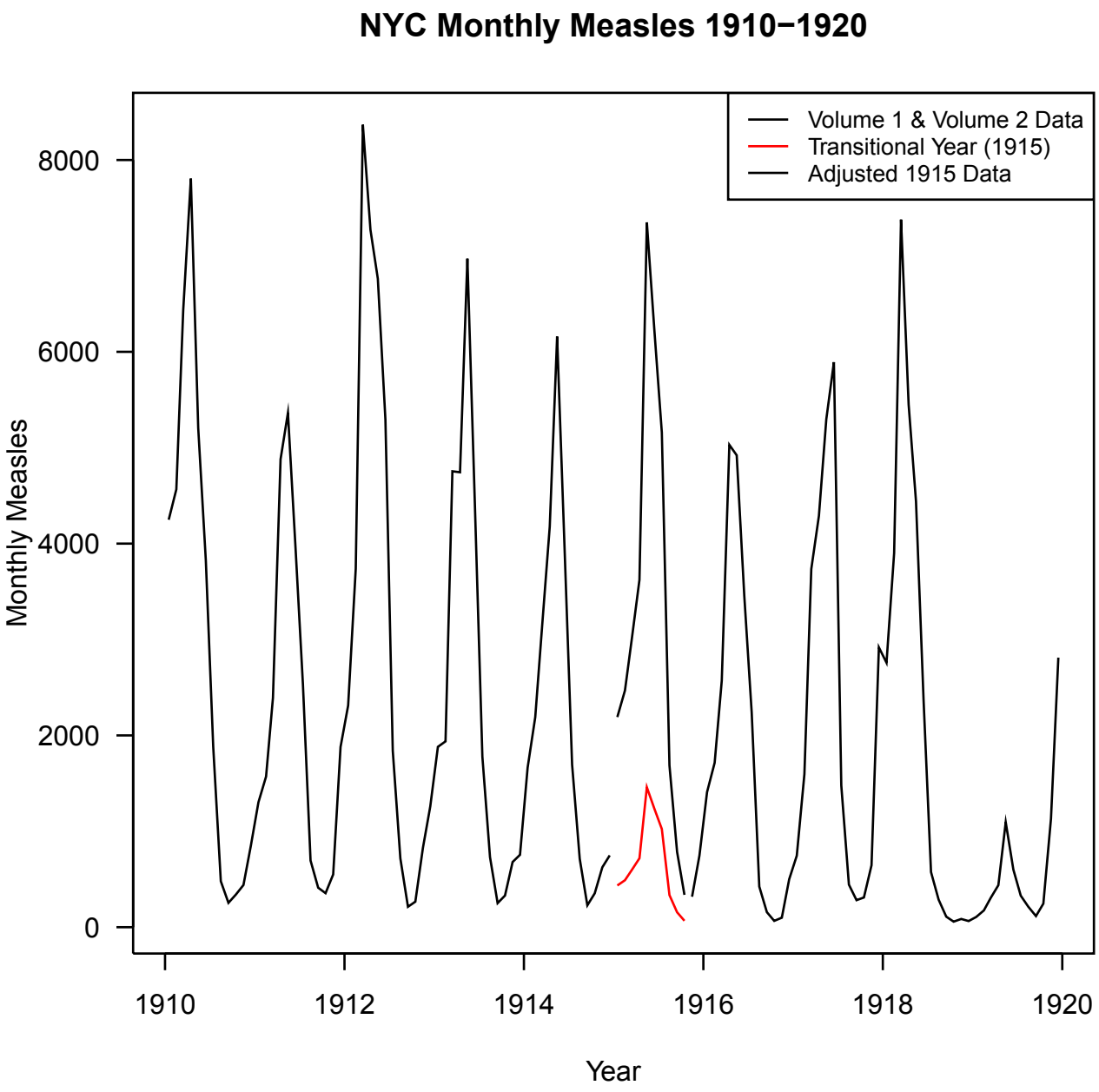


Figure S7: Time series plot of tabulated Health Bulletin data from 1910–1920, showing original and adjusted 1915 reported measles cases from three hospitals in the context of city-wide measles cases for other years.

S1.5 Formatting the Data

For our analysis, we make use of weekly and monthly aggregated measles data, and yearly vital data. For large time spans (namely 1932–1958 and 1976–1984), we have only monthly data, hence we interpolate pseudo-weekly data from the monthly data points.

For vital statistics, we obtain yearly total population and birth rates from the NYC Health Bulletins for 1891–1900 as detailed previously §S1.1.2, and from the NYC Dept. of Health vital statistics reports for 1900–1984. Note that the vital statistics reports contain only data points every 5 years from 1900–1935.

We do not interpolate yearly points from this because the Vital Statistics Reports give a single estimate for each of the 5-years.

S1.6 Summary of Available and Compiled Data

Since we are using data from various overlapping sources, we need to pick time points where we transition from one source to the next. Since it is better to do analyses using originally recorded weekly data rather than pseudo-weekly interpolation, we will use as much originally recorded weekly data as possible.

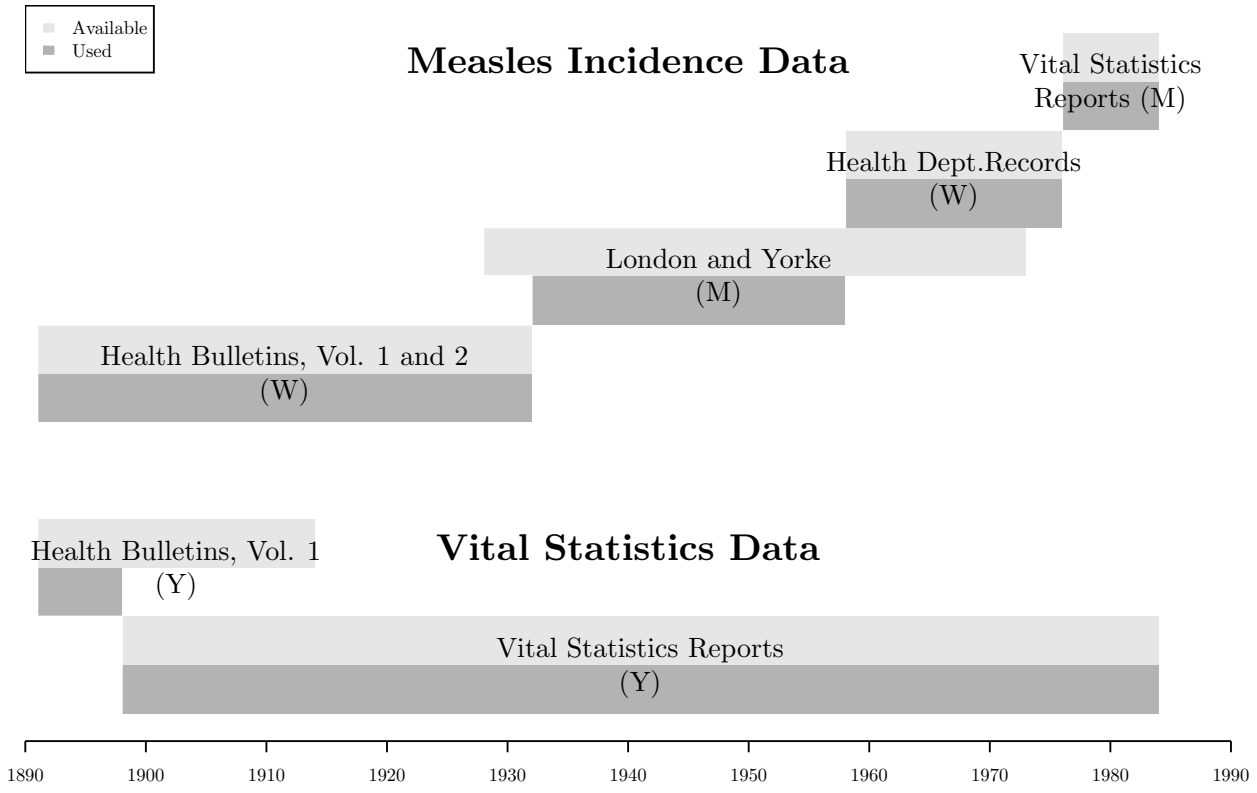


Figure S8: Summary of available and used data.

S1.7 Normalized Data

For our analysis of the disease incidence data, we need to control for changes in population size. To this end we have constructed a time series of yearly total population numbers, as detailed previously. Using the population data, we can normalize disease incidence data with respect to population size. This serves to remove elements of the dynamics which are simply artifacts of changes in population, and what remains is a more consistent representation of the dynamics of measles. See Figure S9 for a plot of total population with respect to time, which we use to normalize our data. Note in particular the high rate of population growth in the early 1900s; much of an apparent rise in measles incidence can be attributed to this. The sudden jump in the population data is attributed to a change in reporting area (see §S1.1)

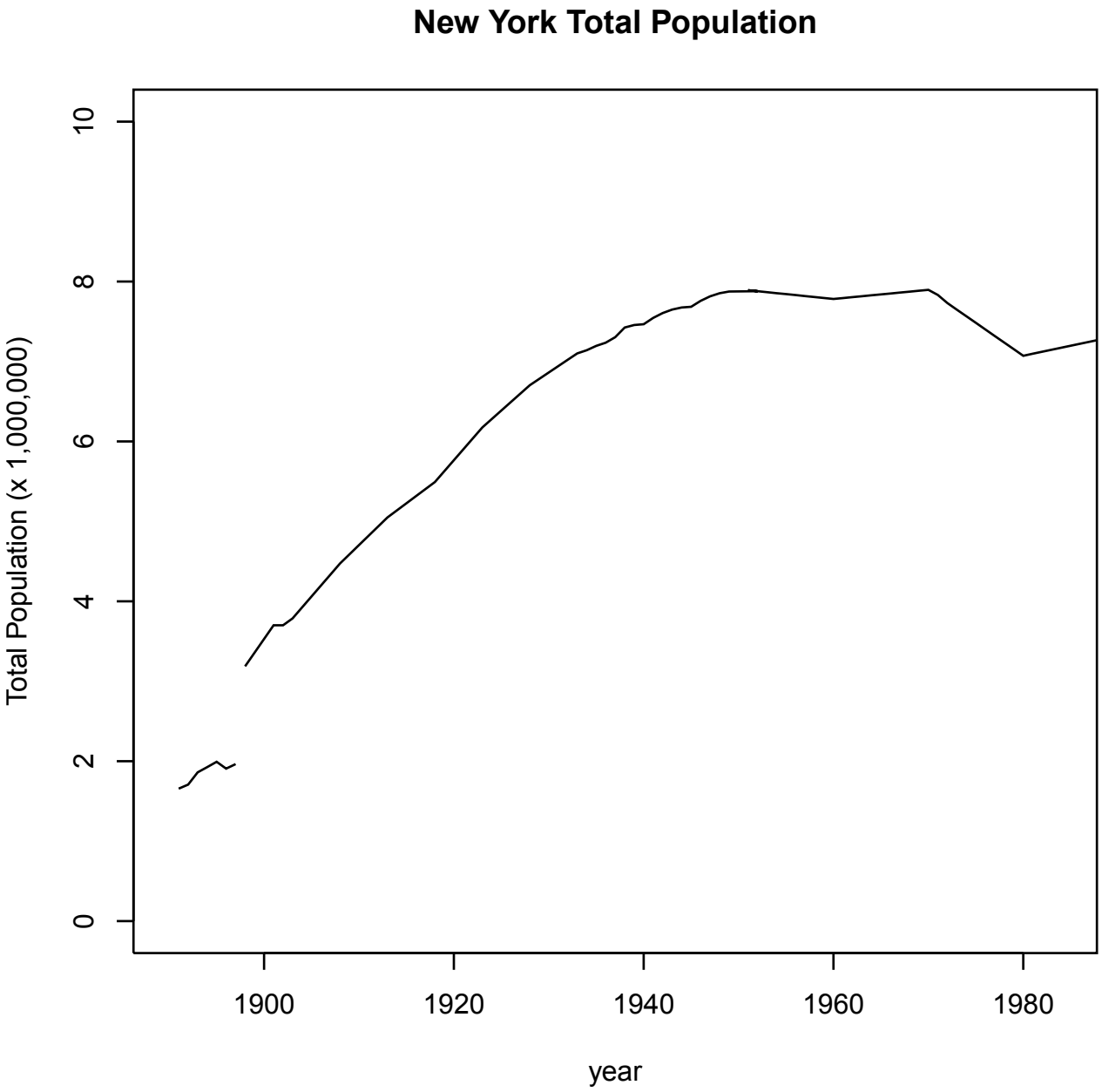


Figure S9: Time series plot of the total population of NYC from 1891–1984.

S1.8 Consistency Checks

Since much of the data we use is from original digitization, it is appropriate to conduct a number of checks on the data to ensure that its quality is acceptable for the analysis. We therefore cross-reference our new data with as much independent information as we can. To this end we perform the following three sanity checks on our new data:

1. The NYC Health Department Vital Statistics Reports [2] list yearly totals for disease incidence from 1911 to the present. Our first check takes yearly sums of our weekly data from the Health Bulletins

in the time-span of 1911–1932, and compares these yearly sums to data from the Health Department Vital Statistics Reports. See Figure S10 for this comparison. We conclude that, with the exception of the year 1915 (which we dealt with previously), the close match of these totals evidences reliability of the Health Bulletin data.

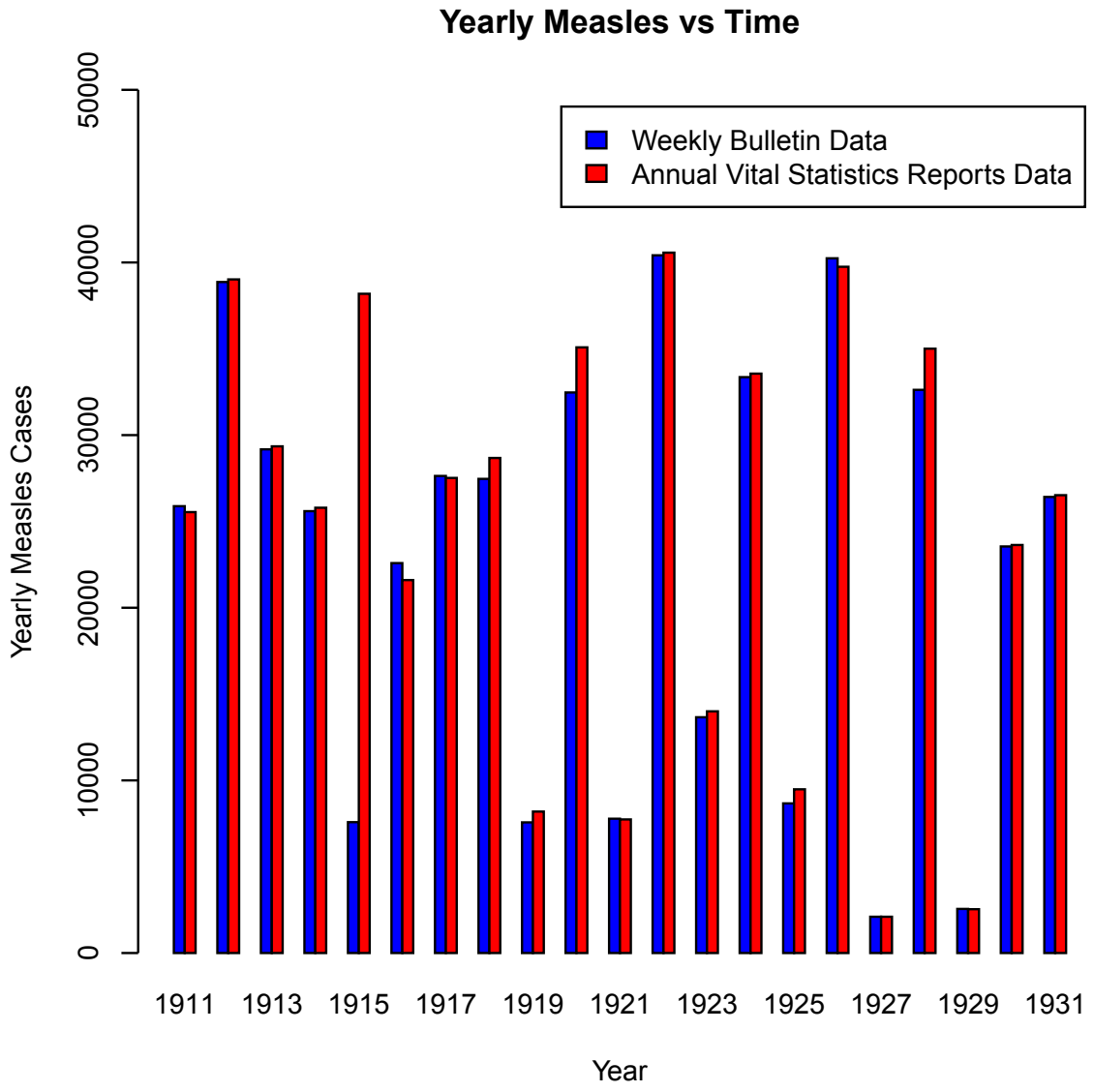


Figure S10: Overlapping time series plots of yearly measles incidence counts taken from the Health Bulletins and the Health Dept. Vital Statistics Reports.

2. Much of the newly digitized data overlaps with monthly data previously published by London and Yorke [11]. We can therefore use monthly tabulated totals of our original weekly data in the overlapping periods and compare them to London and Yorke's data. The results of this second check are shown in Figures S11 and S12. Interestingly, these numbers do not match up perfectly, suggesting that adjustments were made by the NYC Health Department to the data we acquired (both from the Health Bulletins and the Health Department Records), prior to its tabulation in the paper published

in 1973 by London and Yorke [11].[2] The monthly sums of measles cases, however, match up closely enough in both overlapping time periods that we conclude our weekly data are reliable.

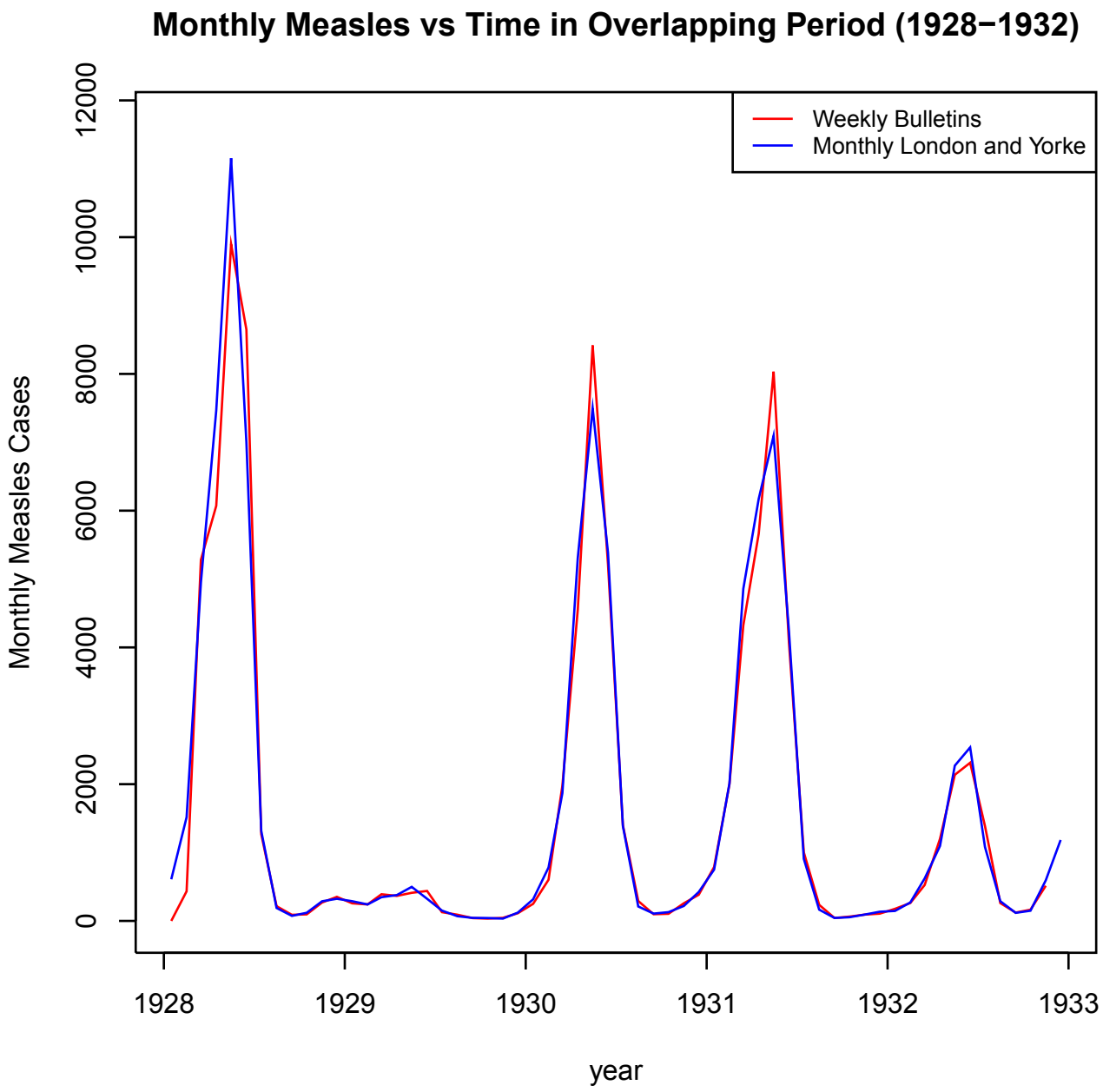


Figure S11: Overlapping time series plots of London and Yorke's monthly measles incidence rates, and the Health Dept. Bulletins weekly measles incidence rates, from 1928–1932. To compare these numbers, we have summed the weekly Bulletin data monthly, summing up the number of measles cases reported at the ends of weeks that fall in the same month.

[2]London and Yorke give very little information regarding the source of the data published their 1973 paper [11], only mentioning that the provider was the NYC Health Dept. Bureau of Infectious Disease Control (which no longer exists).

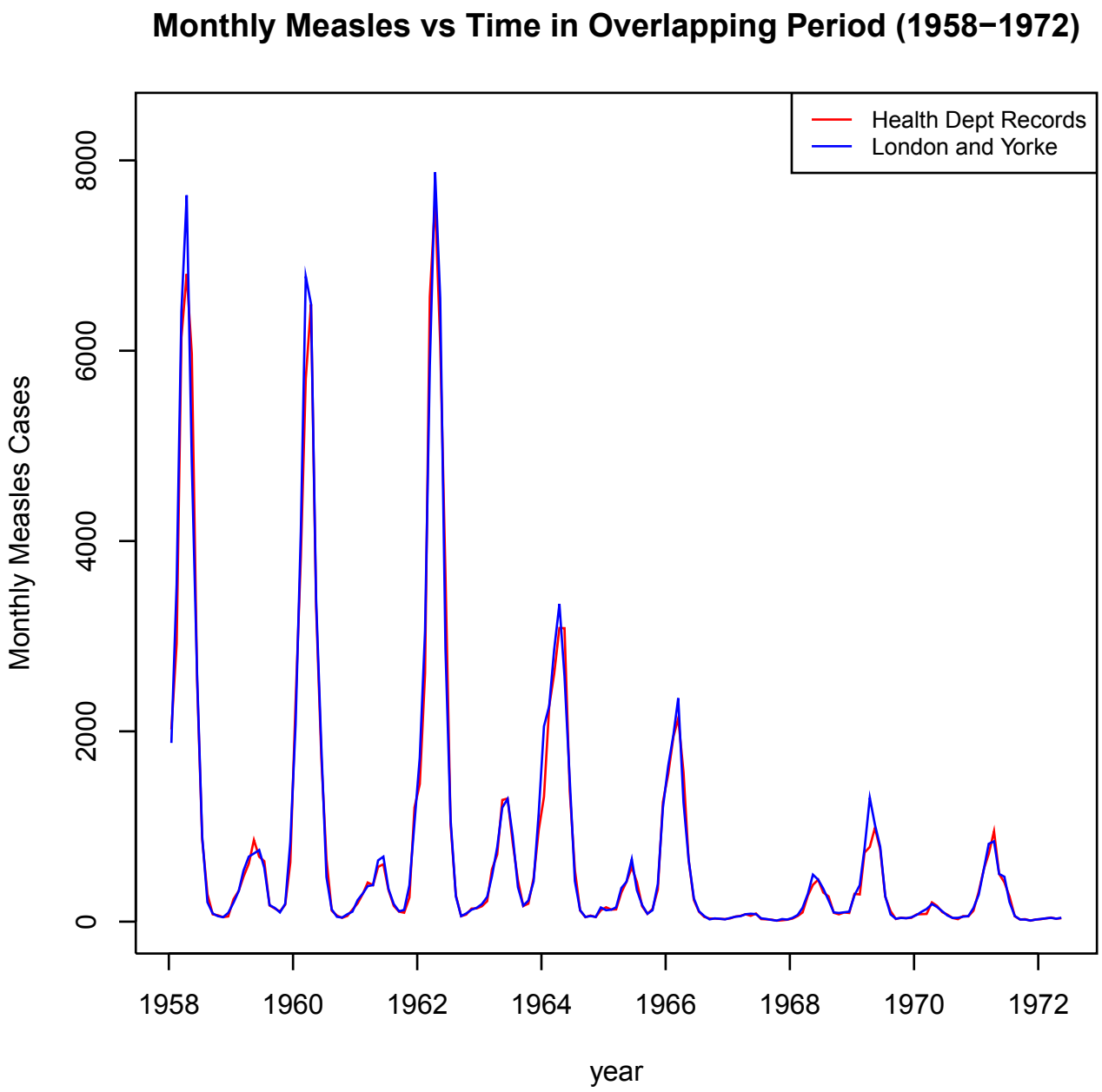
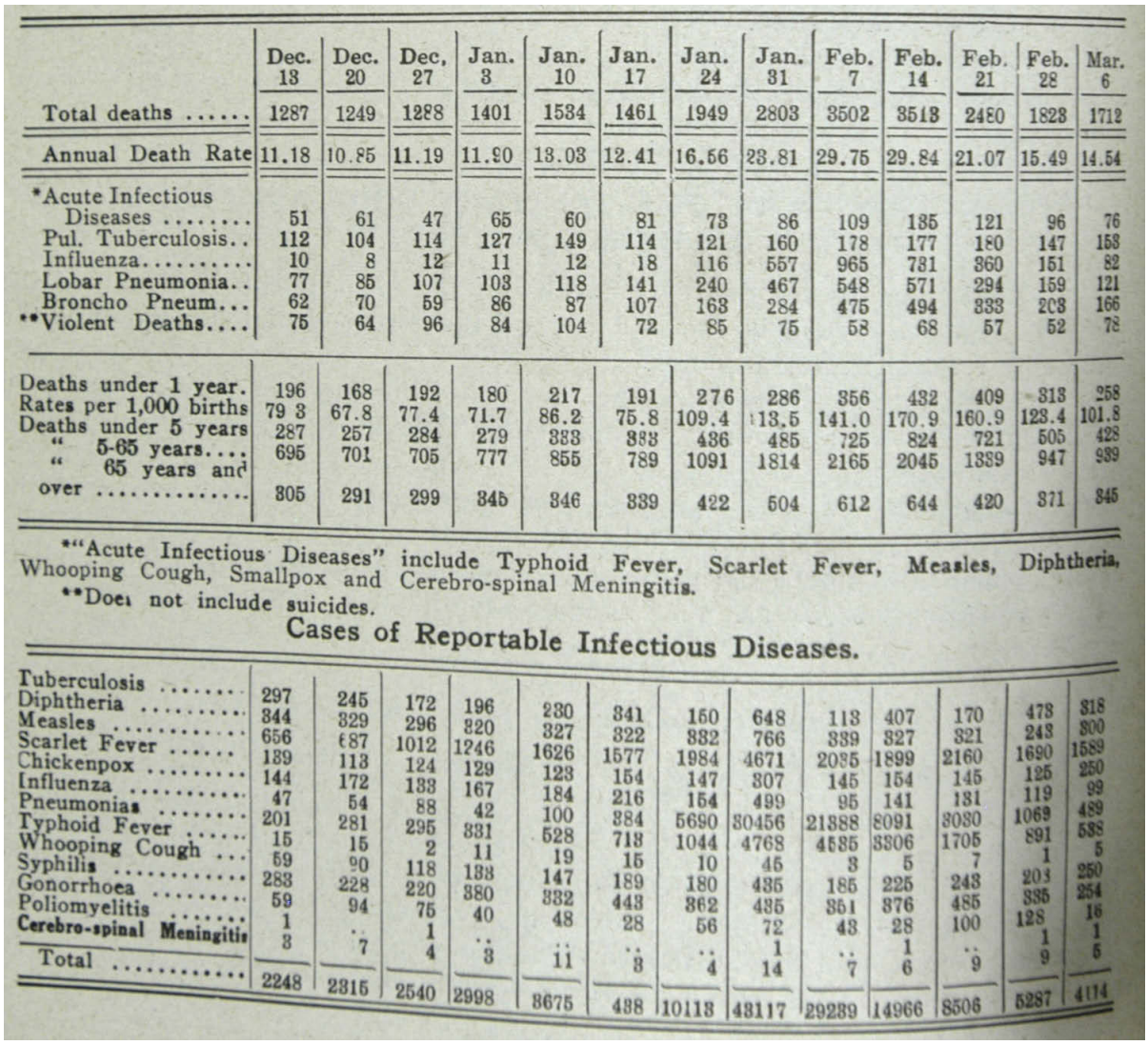


Figure S12: Overlapping time series plots of London and Yorke's monthly measles incidence rates, and the Health Dept. Records weekly incidence rates summed monthly, from 1958–1973.

Jan 31, 1920 In Figure S13, we show a page from the Weekly Bulletins in which an epidemic of influenza can be seen from the case reports, peaking on Jan 31, 1920 with a number of reported cases of 30456. For this same week, the cases of measles are reported as 4671, where the previous and following weeks were 1984 and 2035, respectively. Such a high number of reported measles cases seems unlikely, and possibly erroneously entered, but could otherwise have been misdiagnoses from the influenza outbreak.



	Dec. 13	Dec. 20	Dec. 27	Jan. 3	Jan. 10	Jan. 17	Jan. 24	Jan. 31	Feb. 7	Feb. 14	Feb. 21	Feb. 28	Mar. 6
Total deaths	1287	1249	1288	1401	1534	1461	1949	2803	3502	3513	2480	1828	1712
Annual Death Rate	11.18	10.85	11.19	11.90	13.03	12.41	16.56	23.81	29.75	29.84	21.07	15.49	14.54
*Acute Infectious Diseases	51	61	47	65	60	81	73	86	109	135	121	96	76
Pul. Tuberculosis..	112	104	114	127	149	114	121	160	178	177	180	147	153
Influenza.....	10	8	12	11	12	18	116	557	965	781	360	151	82
Lobar Pneumonia..	77	85	107	103	118	141	240	467	548	571	294	159	121
Broncho Pneum...	62	70	59	86	87	107	163	284	475	494	333	203	166
**Violent Deaths....	75	64	96	84	104	72	85	75	58	68	57	52	78
Deaths under 1 year.	196	168	192	180	217	191	276	286	356	432	409	313	258
Rates per 1,000 births	79 3	67.8	77.4	71.7	86.2	75.8	109.4	113.5	141.0	170.9	160.9	123.4	101.8
Deaths under 5 years	287	257	284	279	333	333	436	485	725	824	721	505	428
" 5-65 years....	695	701	705	777	855	789	1091	1814	2165	2045	1339	947	939
" 65 years and over	305	291	299	345	346	339	422	504	612	644	420	371	345

*"Acute Infectious Diseases" include Typhoid Fever, Scarlet Fever, Measles, Diphtheria, Whooping Cough, Smallpox and Cerebro-spinal Meningitis.

**Does not include suicides.

Cases of Reportable Infectious Diseases.

Tuberculosis	297	245	172	196	230	341	150	648	113	407	170	473	318
Diphtheria	344	329	296	320	327	322	332	766	339	327	321	243	300
Measles	656	687	1012	1246	1626	1577	1984	4671	2085	1899	2160	1690	1589
Scarlet Fever	139	113	124	129	123	154	147	307	145	154	145	125	250
Chickenpox	144	172	133	167	184	216	154	499	95	141	131	119	99
Influenza	47	54	88	42	100	384	5690	30456	21388	8091	3030	1069	489
Pneumonias	201	281	295	331	528	718	1044	4768	4585	3306	1705	891	538
Typhoid Fever	15	15	2	11	19	15	10	45	3	5	7	1	5
Whooping Cough ...	59	90	118	133	147	189	180	435	185	225	243	203	250
Syphilis	283	228	220	380	332	443	362	435	351	376	485	335	254
Gonorrhoea	59	94	75	40	48	28	56	72	43	28	100	128	16
Poliomyelitis	1	..	1	..	..	..	..	1	..	1	..	1	1
Cerebro-spinal Meningitis	3	7	4	3	11	3	4	14	7	6	9	9	5
Total	2248	2315	2540	2998	3675	438	10113	43117	29289	14966	8506	5287	4114

Figure S13: Weekly Bulletins pages showing weekly reported cases for infectious diseases from 13 December 1919 to 6 March 1920. The reported number of cases of measles for the week of 31 January is unusually high (no other weekly count exceeds 2500 until the year 1941). Concurrent with an apparent measles epidemic is an influenza epidemic, which suggests that the 31 January reported number—and possibly others— could result from misdiagnoses. It is also possible that the unusually high number, if it is incorrect, resulted from a clerical error.

S2 Transient Periods in Wavelet Spectra

A wavelet spectrum of an epidemic time series typically has peaks at the periodicities of attractors that the system visits. However, transient periods do not reveal themselves as consistently as attractor periods, since they depend on demographic stochasticity to be maintained [3,4,7]. The distance of the system from a periodic attractor is influenced by random stochastic perturbations, and the spectral power of transient periods in the time series depends on this distance. As a result, we should expect significant lack of homogeneity in the spectral power of transient periods in disease time series.

To verify this intuition, we simulated many realizations of the stochatic SIR model, and we show wavelet spectra [5, 6, 9, 10, 12] of a subset of these simulated time series in Figures S14 to S19. In order to produce simulated time series comparable to our NYC measles time series, we produced simulations of the same length as the measles time series. We produced 10 stochastic SIR realizations for each of 6 different parameter sets. Three parameter sets fixed $\mu = \nu = 0.02/\text{year}$, and the other three parameter sets were defined using birth and death rates derived from NYC vital statistics. In both groups of parameter sets, we considered three $\mathcal{R}_0$ values ($\mathcal{R}_0 \in \{12, 14.5, 17\}$). The mean infectious period was set to 13 days in all simulations, and the initial total population was fixed at the NYC population in 1891 (the beginning of the time series). For each parameter set, we show one of the 10 realizations in Figures S14 to S19.

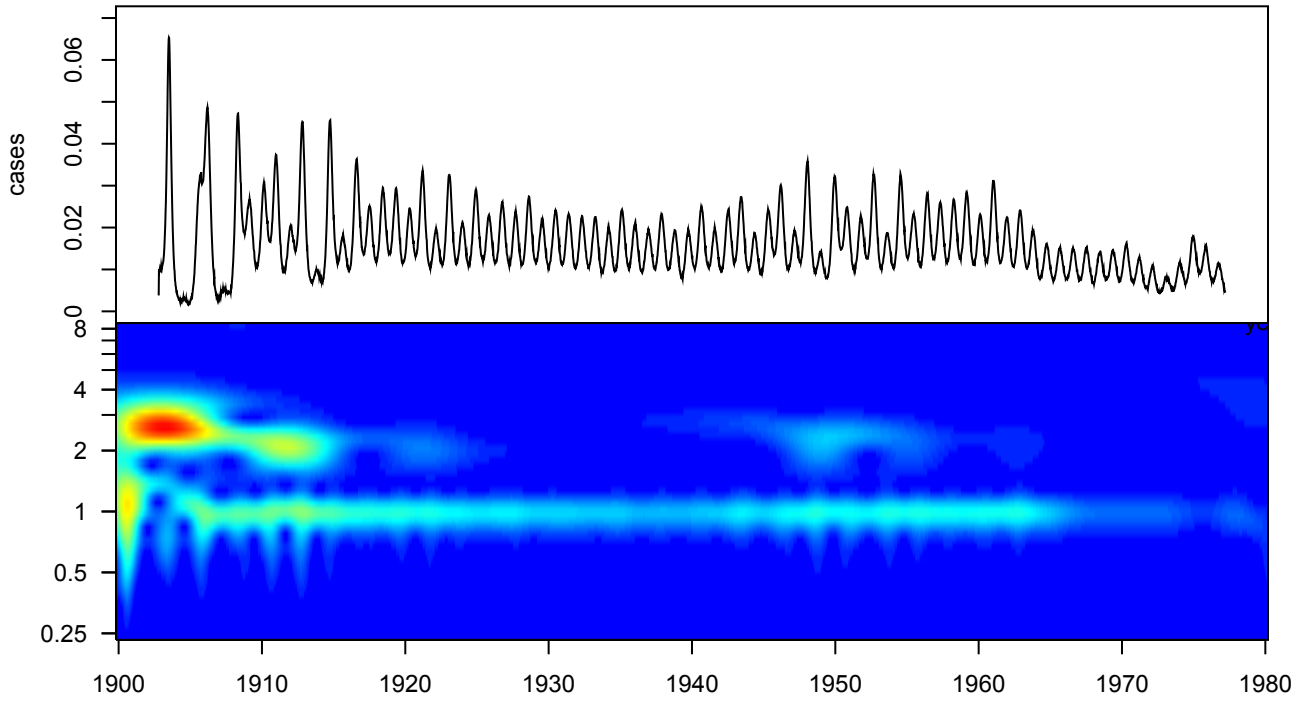


Figure S14: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 12$, $1/\gamma = 13$ days, $\mu = \nu = 0.02\,\mathrm{yr}^{-1}$.

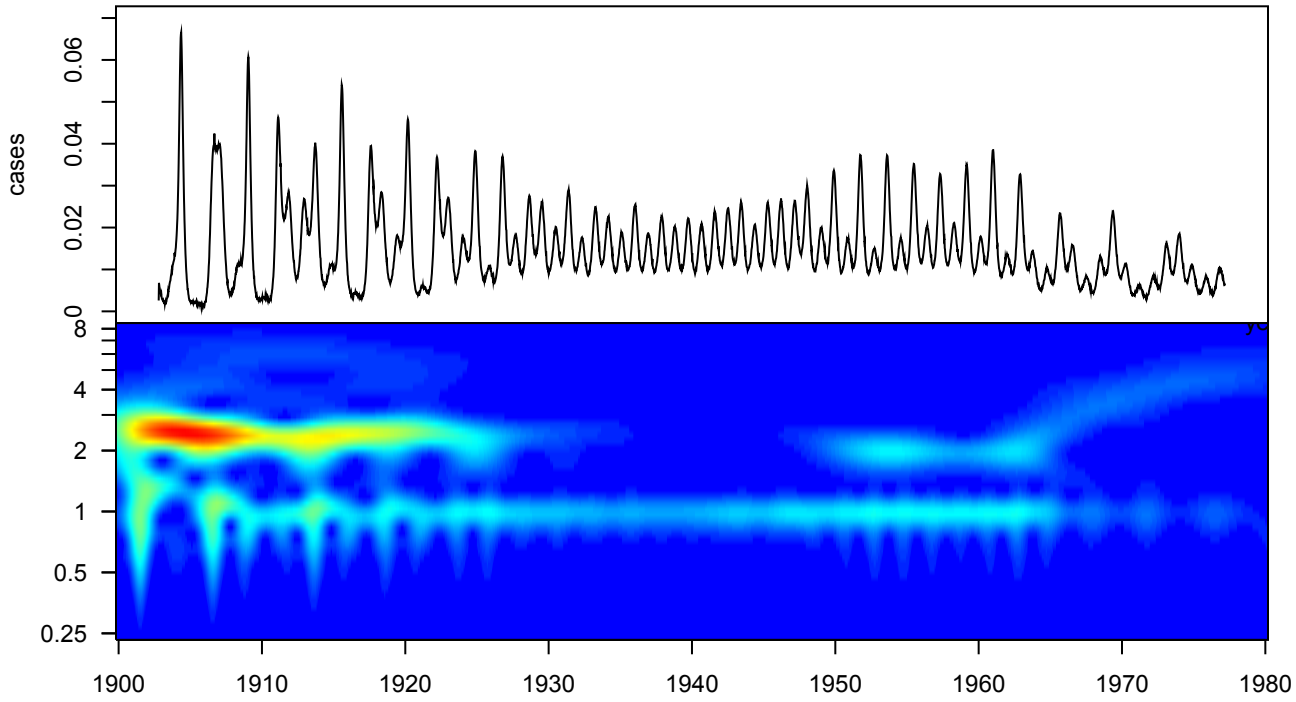


Figure S15: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 14.5$, $1/\gamma = 13$ days, $\mu = \nu = 0.02\,\mathrm{yr}^{-1}$.

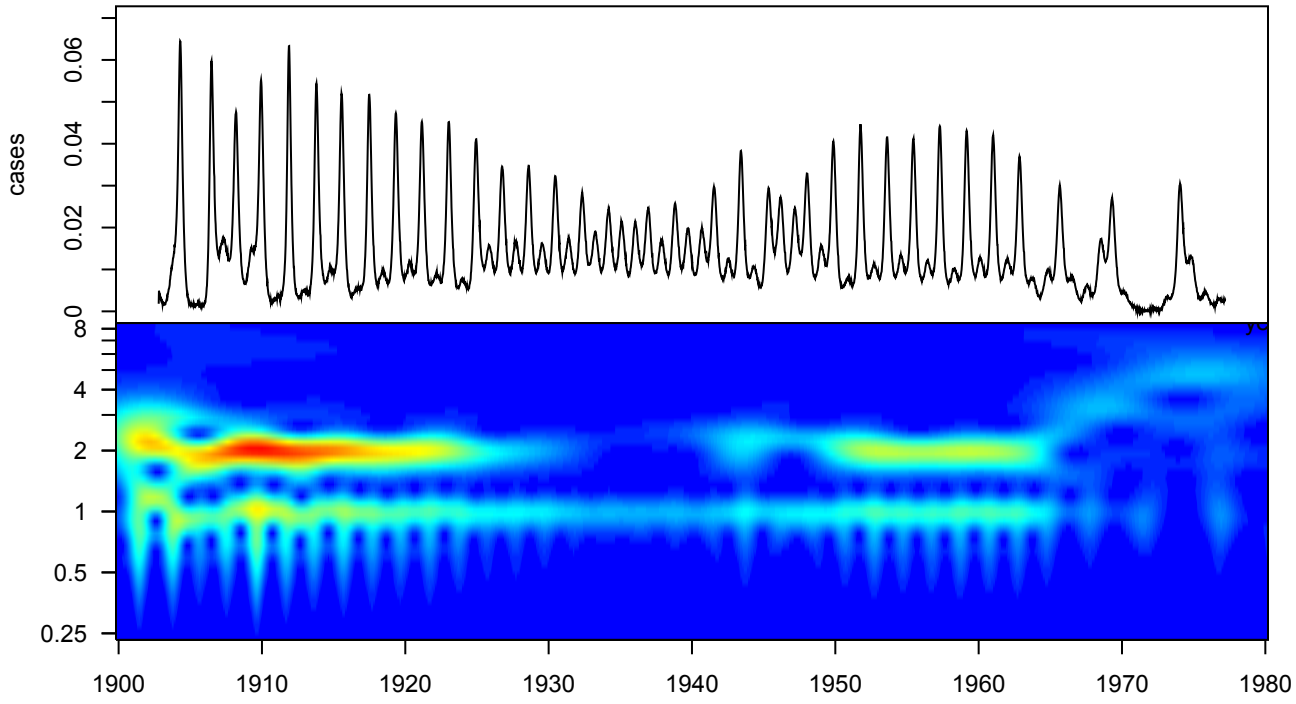


Figure S16: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 17$, $1/\gamma = 13$ days, $\mu = \nu = 0.02\,\mathrm{yr}^{-1}$.

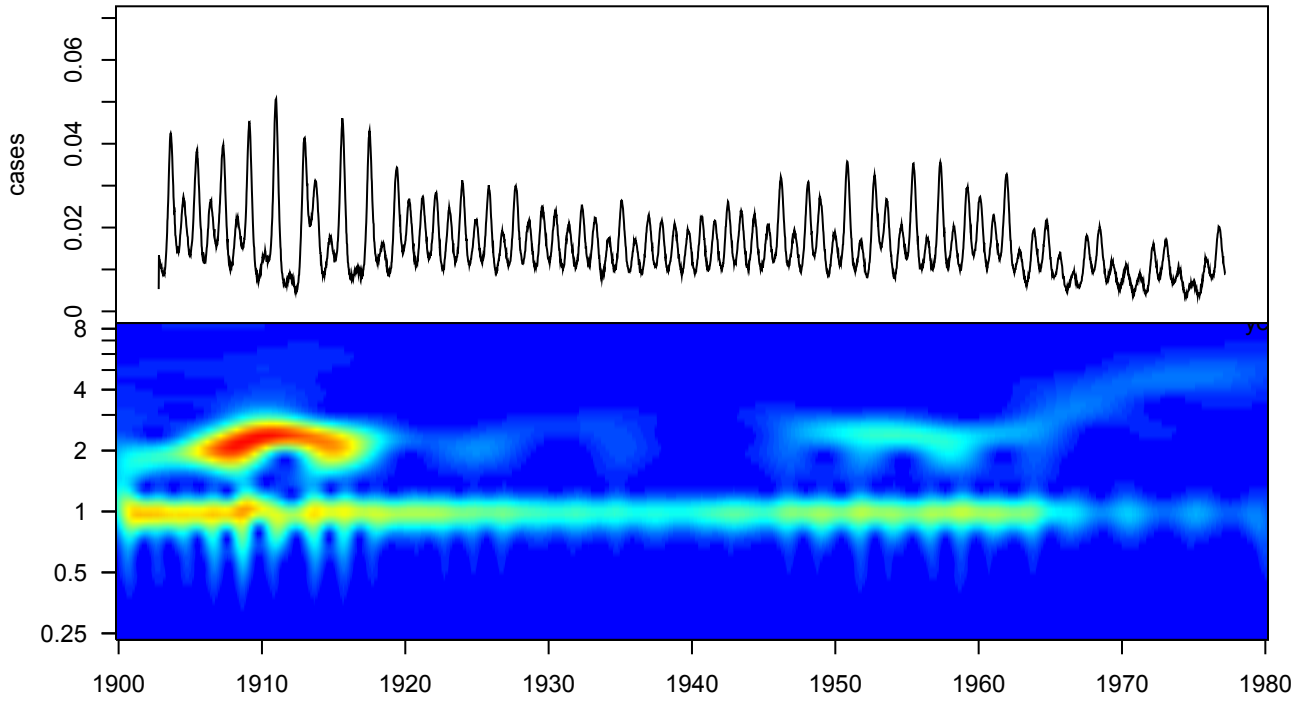


Figure S17: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 12$, $1/\gamma = 13$ days, $\mu(t)$ and $\nu(t)$ are realistic NYC values changing with time.

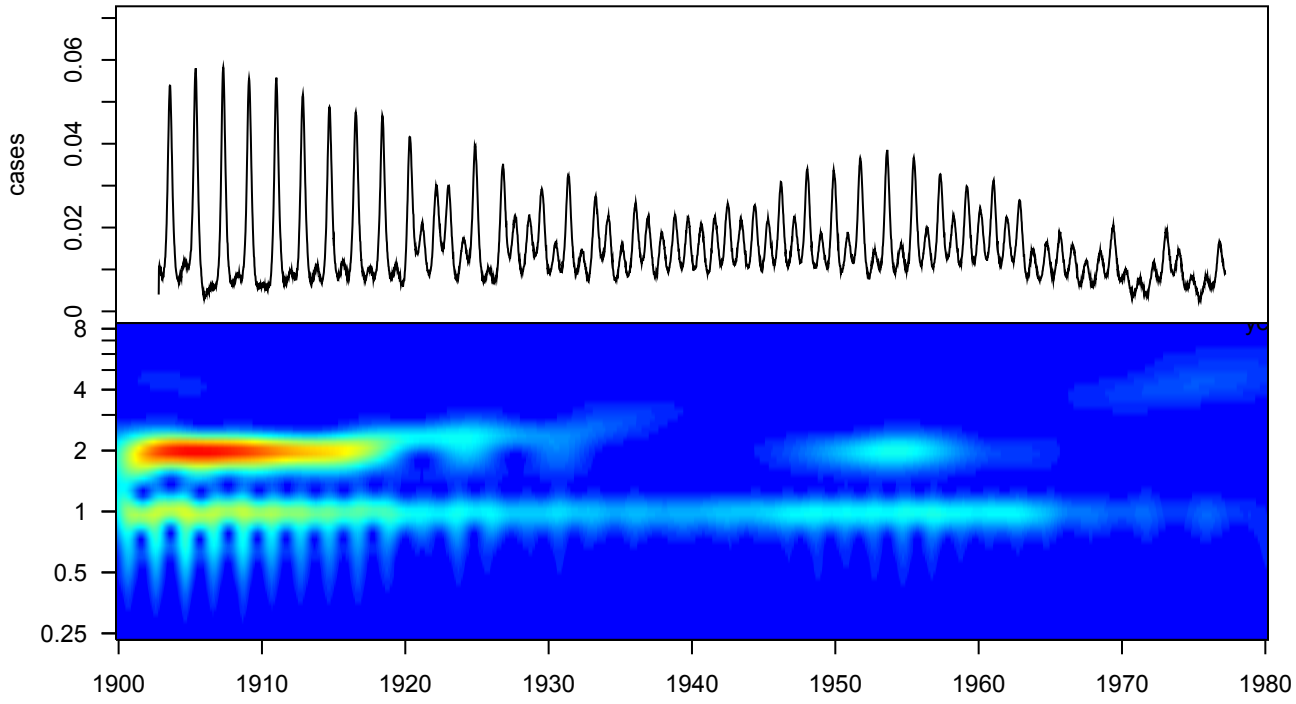


Figure S18: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 14.5$, $1/\gamma = 13$ days, $\mu(t)$ and $\nu(t)$ are realistic NYC values changing with time.

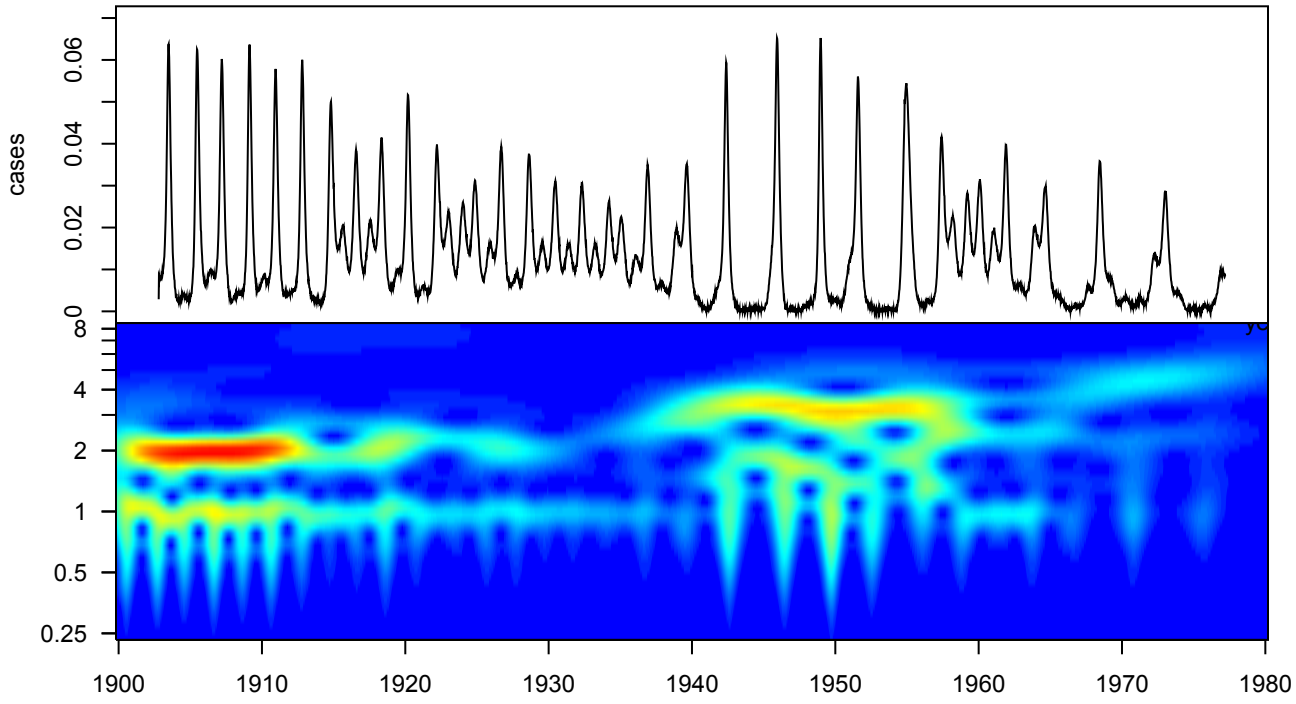
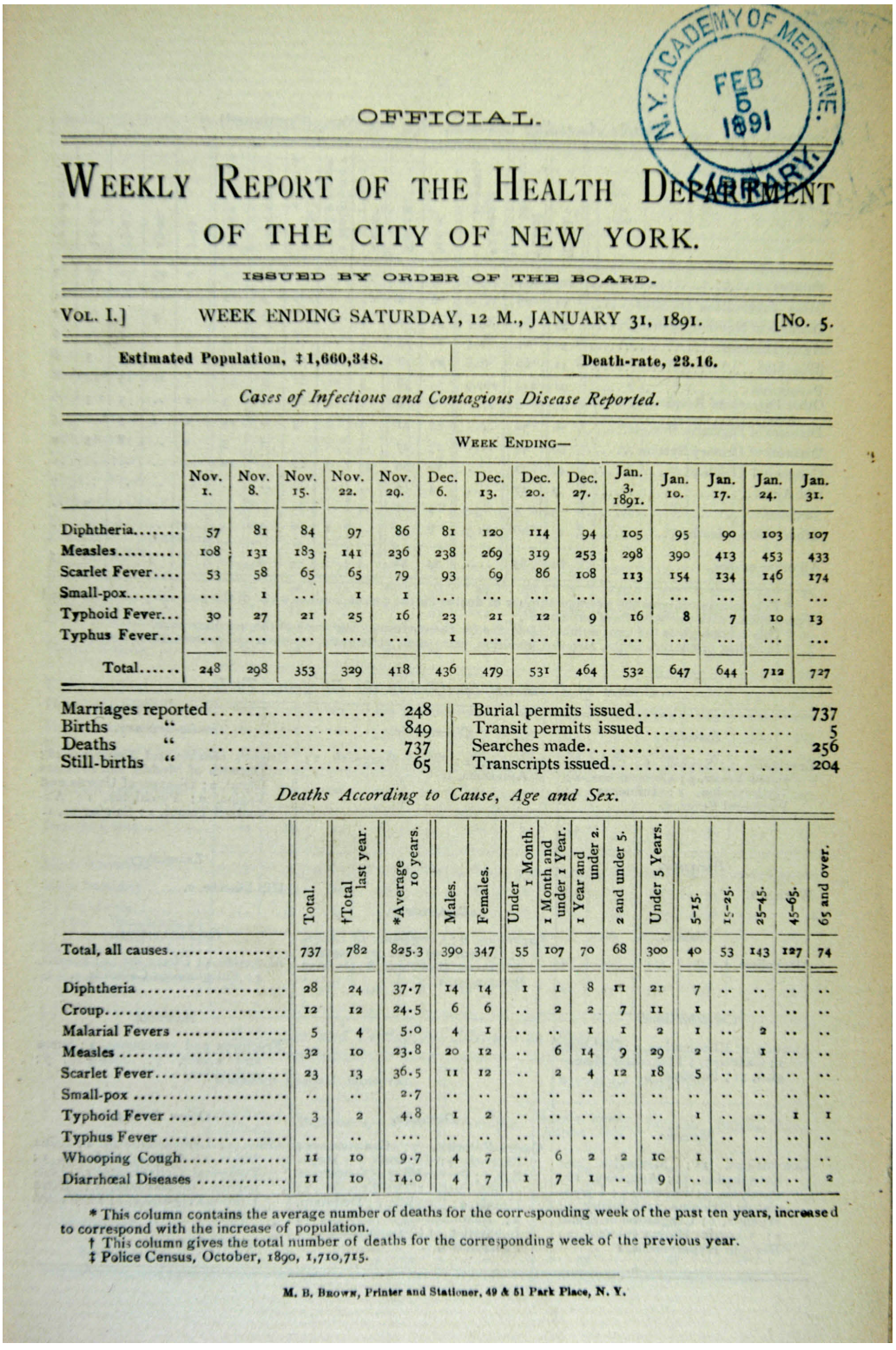


Figure S19: Stochastic SIR simulation emulating NYC. *Top panel:* cases time series. *Bottom panel:* wavelet spectrum. *Parameter values:* $\mathcal{R}_0 = 17$, $1/\gamma = 13$ days, $\mu(t)$ and $\nu(t)$ are realistic NYC values changing with time.

S3 Sample Photographs from Data Sources



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WEEKLY REPORT OF THE HEALTH DEPARTMENT OF THE CITY OF NEW YORK.

ISSUED BY ORDER OF THE BOARD.

VOL. I.] WEEK ENDING SATURDAY, 12 M., JANUARY 31, 1891. [No. 5.

Estimated Population, ‡1,660,348. | **Death-rate, 23.16.**

Cases of Infectious and Contagious Disease Reported.

	Week Ending—													
	Nov. 1.	Nov. 8.	Nov. 15.	Nov. 22.	Nov. 29.	Dec. 6.	Dec. 13.	Dec. 20.	Dec. 27.	Jan. 3, 1891.	Jan. 10.	Jan. 17.	Jan. 24.	Jan. 31.
Diphtheria	57	81	84	97	86	81	120	114	94	105	95	90	103	107
Measles	108	131	183	141	236	238	269	319	253	298	390	413	453	433
Scarlet Fever	53	58	65	65	79	93	69	86	108	113	154	134	146	174
Small-pox	...	1	...	1	1	...	...	...	...	...	...	...	...	...
Typhoid Fever	30	27	21	25	16	23	21	12	9	16	8	7	10	13
Typhus Fever	...	...	...	...	...	1	...	...	...	...	...	...	...	...
Total	248	298	353	329	418	436	479	531	464	532	647	644	712	727

Marriages reported	248	Burial permits issued	737
Births "	849	Transit permits issued	5
Deaths "	737	Searches made	256
Still-births "	65	Transcripts issued	204

Deaths According to Cause, Age and Sex.

	Total.	†Total last year.	*Average 10 years.	Males.	Females.	Under 1 Month.	1 Month and under 1 Year.	1 Year and under 2.	2 and under 5.	Under 5 Years.	5–15.	15–25.	25–45.	45–65.	65 and over.
Total, all causes	737	782	825.3	390	347	55	107	70	68	300	40	53	143	127	74
Diphtheria	28	24	37.7	14	14	1	1	8	11	21	7	..	..	..	..
Croup	12	12	24.5	6	6	..	2	2	7	11	1	..	..	..	..
Malarial Fevers	5	4	5.0	4	1	..	..	1	1	2	1	..	2	..	..
Measles	32	10	23.8	20	12	..	6	14	9	29	2	..	1	..	..
Scarlet Fever	23	13	36.5	11	12	..	2	4	12	18	5	..	..	..	..
Small-pox	..	..	2.7	..	..	..	..	..	..	..	..	..	..	..	..
Typhoid Fever	3	2	4.8	1	2	..	..	..	..	..	1	..	..	1	1
Typhus Fever	..	..	....	..	..	..	..	..	..	..	..	..	..	..	..
Whooping Cough	11	10	9.7	4	7	..	6	2	2	10	1	..	..	..	..
Diarrhœal Diseases	11	10	14.0	4	7	1	7	1	..	9	..	..	..	..	2

* This column contains the average number of deaths for the corresponding week of the past ten years, increased to correspond with the increase of population.
† This column gives the total number of deaths for the corresponding week of the previous year.
‡ Police Census, October, 1890, 1,710,715.

M. B. Brown, Printer and Stationer, 49 & 51 Park Place, N. Y.

Figure S20: Weekly Bulletins Vol 1: Page 1

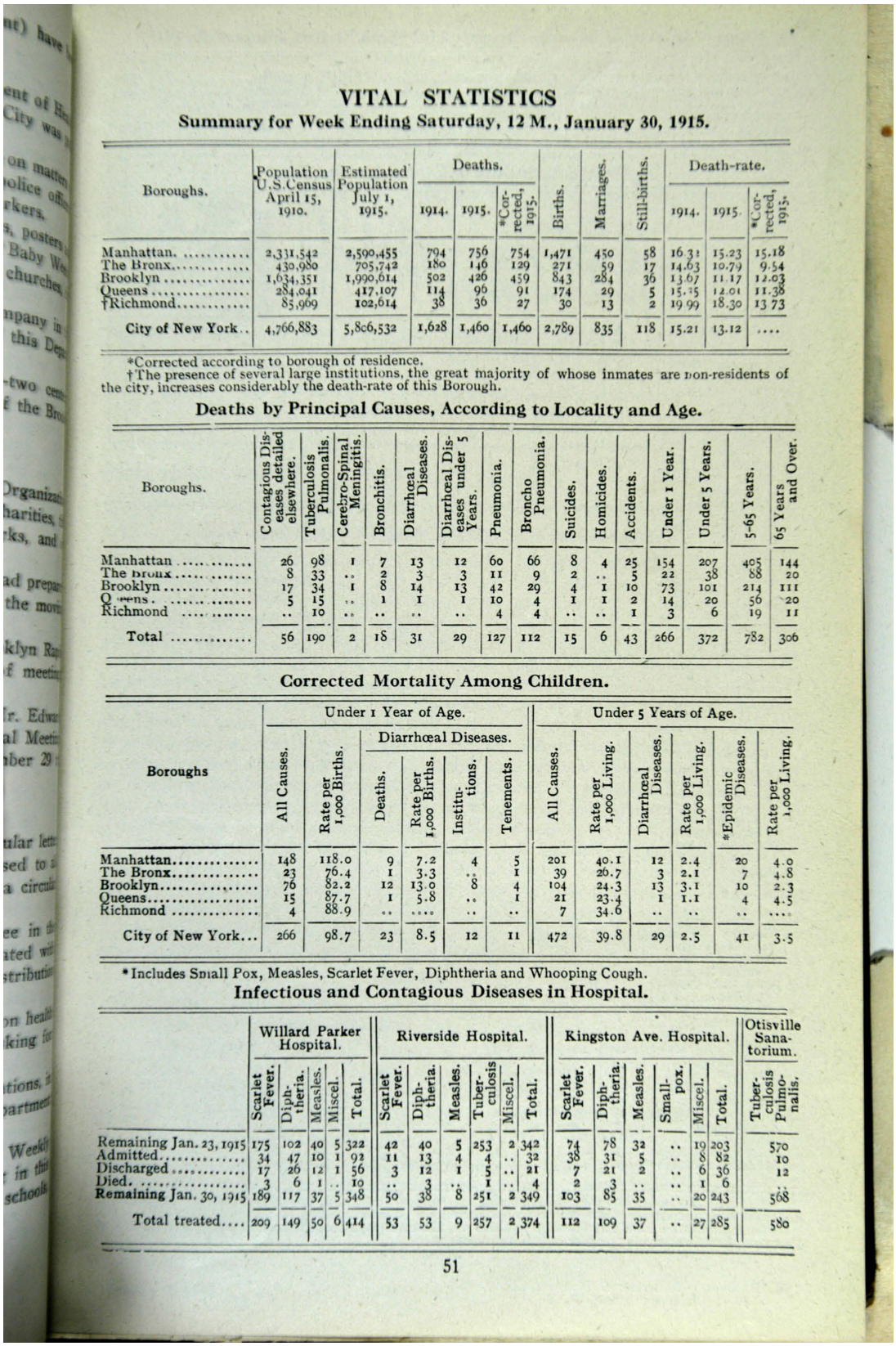
Deaths According to Cause, Annual Rate per 1,000 and Age, with Meteorology, and Number of Deaths in Public Institutions for 13 weeks.

Week Ending	Nov. 8.	Nov. 15.	Nov. 22.	Nov. 29.	Dec. 6.	Dec. 13.	Dec. 20.	Dec. 27.	Jan. 3, 1891.	Jan. 10.	Jan. 17.	Jan. 24.	Jan. 31.
Total deaths	671	643	583	654	672	704	731	705	764	744	786	748	737
Annual death-rate	21.23	20.33	18.43	20.66	21.21	22.21	23.05	22.22	24.06	23.42	24.73	23.52	23.16
Diphtheria	19	27	29	22	31	31	37	31	28	14	19	22	28
Croup	5	17	6	20	14	11	11	14	11	16	22	11	12
Malarial Fevers	5	3	3	1	1	5	3	6	4	2	3	4	5
Measles	13	11	12	12	12	15	15	19	22	15	18	33	32
Scarlet Fever	11	7	10	10	5	10	11	11	21	16	22	20	23
Small-pox	..	..	..	..	..	..	..	..	..	..	..	..	..
Typhoid Fever	10	10	7	5	8	11	3	5	7	3	3	3	3
Typhus Fever	..	..	..	..	..	..	..	..	..	..	..	..	..
Whooping Cough	10	7	7	3	5	7	5	8	9	8	12	17	11
Diarrhœal Diseases	20	11	8	8	10	9	11	9	10	10	9	13	11
Diarrhœal Diseases under 5 years	17	8	3	7	6	6	7	7	6	7	4	8	9
Phthisis	110	85	78	98	94	102	98	96	105	110	98	111	105
Bronchitis	30	40	32	25	35	29	38	22	49	27	38	44	41
Pneumonia	90	72	85	87	95	115	117	126	134	123	136	105	91
Other Diseases of Respiratory Organs	15	23	18	15	24	21	29	18	29	21	28	25	16
Violent Deaths	30	36	25	36	21	28	33	20	31	37	27	21	18
Under one year	140	134	109	133	120	126	142	130	152	140	165	157	162
Under five years	226	225	204	225	212	240	260	247	290	253	285	284	300
Five to sixty-five	369	352	320	355	371	375	393	374	390	406	403	384	363
Sixty-five years and over	76	66	59	74	89	89	78	84	84	85	98	80	74
In Public Institutions	134	138	128	141	133	133	170	150	140	161	179	136	166
Inquest Cases	73	89	76	85	73	89	87	80	91	110	87	70	83
Mean barometer	29.931	30.103	29.833	29.901	29.850	29.819	29.995	29.904	29.866	30.077	29.823	29.879	29.919
Mean humidity	73	80	68	68	67	60	61	61	57	55	59	65	62
Inches of rain	....	.39	.32	....	1.00	.05	1.87	.77	.80	.07	2.38	1.42	1.46
Mean temperature (Fahrenheit)	48.9	47.2	45.9	35.2	32.0	29.7	32.0	31.5	29.0	25.7	34.6	36.5	38.9
Maximum temperature (Fahrenheit)	69°	60°	64°	59°	49°	47°	43°	47°	54°	41°	51°	53°	48°
Minimum temperature (Fahrenheit)	36°	37°	31°	19°	18°	16°	16°	15°	13°	17°	25°	23°	28°

Infectious and Contagious Diseases in Hospital.

	Willard Parker Hospital.			Riverside Hospital.				
	Scarlet Fever (Children).	Diphtheria.	Total.	Small-pox.	Scarlet Fever. (Adults Only.)	Measles.	Others.	Total.
Remaining Jan. 24	26	3	29	..	19	22	4	45
Admitted	10	6	16	..	4	10	3	17
Discharged	3	4	7	..	3	12	1	16
Died	3	..	3	..	..	2	..	2
Remaining Jan. 31	30	5	35	..	20	18	6	44
Total treated	36	9	45	..	23	32	7	62

Figure S21: Weekly Bulletins Vol 1: Page 2



VITAL STATISTICS

Summary for Week Ending Saturday, 12 M., January 30, 1915.

Boroughs.	Population U.S.Census April 15, 1910.	Estimated Population July 1, 1915.	Deaths. 1914.	Deaths. 1915.	Deaths. *Corrected, 1915.	Births.	Marriages.	Still-births.	Death-rate. 1914.	Death-rate. 1915.	Death-rate. *Corrected, 1915.
Manhattan	2,331,542	2,590,455	794	756	754	1,471	450	58	16.31	15.23	15.18
The Bronx	430,980	705,742	180	146	129	271	59	17	14.63	10.79	9.54
Brooklyn	1,634,351	1,990,614	502	426	459	843	284	36	13.67	11.17	12.03
Queens	284,041	417,107	114	96	91	174	29	5	15.75	12.01	11.38
†Richmond	85,969	102,614	38	36	27	30	13	2	19.99	18.30	13.73
City of New York	4,766,883	5,806,532	1,628	1,460	1,460	2,789	835	118	15.21	13.12	....

*Corrected according to borough of residence.

†The presence of several large institutions, the great majority of whose inmates are non-residents of the city, increases considerably the death-rate of this Borough.

Deaths by Principal Causes, According to Locality and Age.

Boroughs.	Contagious Diseases detailed elsewhere.	Tuberculosis Pulmonalis.	Cerebro-Spinal Meningitis.	Bronchitis.	Diarrhœal Diseases.	Diarrhœal Diseases under 5 Years.	Pneumonia.	Broncho Pneumonia.	Suicides.	Homicides.	Accidents.	Under 1 Year.	Under 5 Years.	5-65 Years.	65 Years and Over.
Manhattan	26	98	1	7	13	12	60	66	8	4	25	154	207	405	144
The Bronx	8	33	..	2	3	3	11	9	2	..	5	22	38	88	20
Brooklyn	17	34	1	8	14	13	42	29	4	1	10	73	101	214	111
Queens	5	15	..	1	1	1	10	4	1	1	2	14	20	56	20
Richmond	..	10	..	..	..	..	4	4	..	..	1	3	6	19	11
Total	56	190	2	18	31	29	127	112	15	6	43	266	372	782	306

Corrected Mortality Among Children.

Boroughs	Under 1 Year of Age. All Causes.	Under 1 Year of Age. Rate per 1,000 Births.	Under 1 Year of Age. Diarrhœal Diseases. Deaths.	Under 1 Year of Age. Diarrhœal Diseases. Rate per 1,000 Births.	Under 1 Year of Age. Diarrhœal Diseases. Institutions.	Under 1 Year of Age. Diarrhœal Diseases. Tenements.	Under 5 Years of Age. All Causes.	Under 5 Years of Age. Rate per 1,000 Living.	Under 5 Years of Age. Diarrhœal Diseases.	Under 5 Years of Age. Rate per 1,000 Living.	Under 5 Years of Age. *Epidemic Diseases.	Under 5 Years of Age. Rate per 1,000 Living.
Manhattan	148	118.0	9	7.2	4	5	201	40.1	12	2.4	20	4.0
The Bronx	23	76.4	1	3.3	..	1	39	26.7	3	2.1	7	4.8
Brooklyn	76	82.2	12	13.0	8	4	104	24.3	13	3.1	10	2.3
Queens	15	87.7	1	5.8	..	1	21	23.4	1	1.1	4	4.5
Richmond	4	88.9	..	....	..	..	7	34.6	..	..	..	....
City of New York	266	98.7	23	8.5	12	11	472	39.8	29	2.5	41	3.5

*Includes Small Pox, Measles, Scarlet Fever, Diphtheria and Whooping Cough.

Infectious and Contagious Diseases in Hospital.

	Willard Parker Hospital. Scarlet Fever.	Diphtheria.	Measles.	Miscel.	Total.	Riverside Hospital. Scarlet Fever.	Diphtheria.	Measles.	Tuberculosis	Miscel.	Total.	Kingston Ave. Hospital. Scarlet Fever.	Diphtheria.	Measles.	Small-pox.	Miscel.	Total.	Otisville Sanatorium. Tuberculosis Pulmonalis.
Remaining Jan. 23, 1915	175	102	40	5	322	42	40	5	253	2	342	74	78	32	..	19	203	570
Admitted	34	47	10	1	92	11	13	4	4	..	32	38	31	5	..	8	82	10
Discharged	17	26	12	1	56	3	12	1	5	..	21	7	21	2	..	6	36	12
Died	3	6	1	..	10	..	..	..	1	..	4	2	..	..	..	1	6	..
Remaining Jan. 30, 1915	189	117	37	5	348	50	38	8	251	2	349	103	85	35	..	20	243	568
Total treated	209	149	50	6	414	53	53	9	257	2	374	112	109	37	..	27	285	580

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Figure S22: Weekly Bulletins Vol 1: Sample Page from 1915.

THE HEALTH DEPARTMENT'S BABY SAVING WORK.

In 1876, owing to an unusually high mortality occurring in infants, the Department of Health obtained a special appropriation for the employment of a staff of physicians during the months of July and August. This staff was known as the "Summer Corps," and the physicians were required to canvass the tenements in the most congested quarters of the City. They treated all sick babies found whose parents were otherwise unable to obtain medical care. This plan was followed each summer for many years.

That it achieved results in the reduction of infant mortality is shown by the decrease in the number of infant deaths during this period, but its efficiency was limited in that the system was directed toward treating sick babies and not primarily toward the prevention of illness.

In 1902 seventeen trained nurses were added to the staff, and were assigned to duty in the work of school medical inspection during the school term, assisting the inspectors of the summer corps during July and August. These nurses instructed mothers in the methods of preparing food for babies, as well as demonstrating proper methods of bathing, clothing, and airing. They also nursed sick babies under the care of the medical inspectors.

With the formation of the Division of Child Hygiene, under the direction of Dr. S. Josephine Baker, in the fall of 1908, a definite and constructive change was made in the department's attitude with regard to the best means to be used in effecting a definite reduction in the infant death rate. The appointment of a staff of 141 nurses for the medical inspection of school children afforded an opportunity of employing these nurses to instruct mothers in proper baby care, not only during the summer months, but also in connection with their school duties during the early spring.

Milk Stations Established in 1911.

In 1911 the desire to treat infant mortality as a year-round problem, and to carry out more effectively the policy of preventing disease among babies, was made practically possible by an added appropriation of $40,000 for the purpose of establishing fifteen infants' milk stations. In addition, the Bureau changed its system of home visiting of babies so as to insure more revisits in each case.

Owing to the successful results obtained in the reduction of infant mortality during 1911, the Department of Health received an added appropriation for 1912 sufficient to establish forty (40) additional infants' milk stations.

For 1916 the Department received an additional appropriation allowing for the establishment of four more stations, making a total of fifty-nine now maintained under its supervision. Some idea of the magnitude of the work performed by the milk stations may be gained from the fact that during 1915 over 46,000 new cases were registered at the Health Department's Stations, the mothers making a total of 1,182,286 visits to the stations. In addition to these, 273,000 home visits were made by physicians, nurses and nurses' assistants.

Cases of Infectious and Contagious Diseases Reported.

Week Ending	Feb. 5	Feb. 12	Feb. 19	Feb. 26	Mar. 4	Mar. 11	Mar. 18	Mar. 25	Apr. 1	Apr. 8	Apr. 15	Apr. 22	Apr. 29
Tuberculosis	428	388	428	378	546	456	351	364	385	415	466	409	450
Diphtheria and Croup	372	328	391	300	316	342	264	347	312	304	373	313	302
Measles	345	308	559	503	527	576	696	772	939	932	1,045	1,019	1,095
Scarlet Fever	188	154	175	173	179	190	208	226	234	194	214	224	177
Chickenpox	171	220	194	208	273	259	304	320	398	430	440	279	404
Typhus Fever	...	...	...	...	..	...	...	1	...	1	...	...	...
Typhoid Fever	18	13	21	10	18	12	17	17	20	20	34	32	13
Whooping Cough	104	121	112	143	166	180	169	203	245	268	270	259	280
Syphilis	382	309	350	363	425	305	350	330	547	391	373	372	439
Gonorrhoea	134	100	141	90	178	64	76	73	330	65	108	93	249

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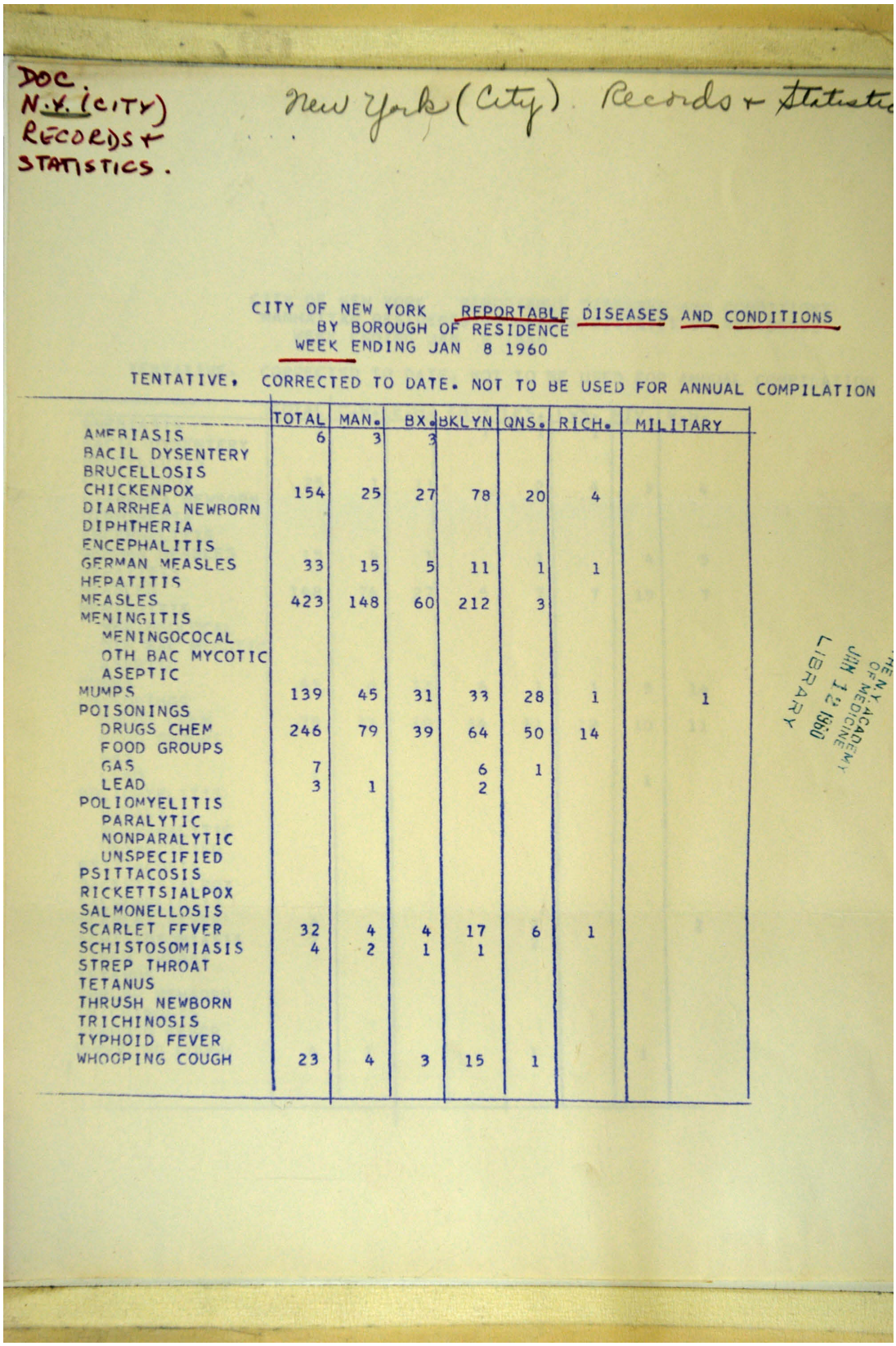
Figure S23: Weekly Bulletins Vol 2: Only Relevant Data Page



DOC
N.Y. (CITY)
RECORDS +
STATISTICS.

New York (City). Records + Statistic

CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
BY BOROUGH OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE, CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	MAN.	BX.	BKLYN	QNS.	RICH.	MILITARY
AMEBIASIS	6	3	3				
BACIL DYSENTERY							
BRUCELLOSIS							
CHICKENPOX	154	25	27	78	20	4	
DIARRHEA NEWBORN							
DIPHTHERIA							
ENCEPHALITIS							
GERMAN MEASLES	33	15	5	11	1	1	
HEPATITIS							
MEASLES	423	148	60	212	3		
MENINGITIS							
MENINGOCOCAL							
OTH BAC MYCOTIC							
ASEPTIC							
MUMPS	139	45	31	33	28	1	1
POISONINGS							
DRUGS CHEM	246	79	39	64	50	14	
FOOD GROUPS							
GAS	7			6	1		
LEAD	3	1		2			
POLIOMYELITIS							
PARALYTIC							
NONPARALYTIC							
UNSPECIFIED							
PSITTACOSIS							
RICKETTSIALPOX							
SALMONELLOSIS							
SCARLET FEVER	32	4	4	17	6	1	
SCHISTOSOMIASIS	4	2	1	1			
STREP THROAT							
TETANUS							
THRUSH NEWBORN							
TRICHINOSIS							
TYPHOID FEVER							
WHOOPING COUGH	23	4	3	15	1		

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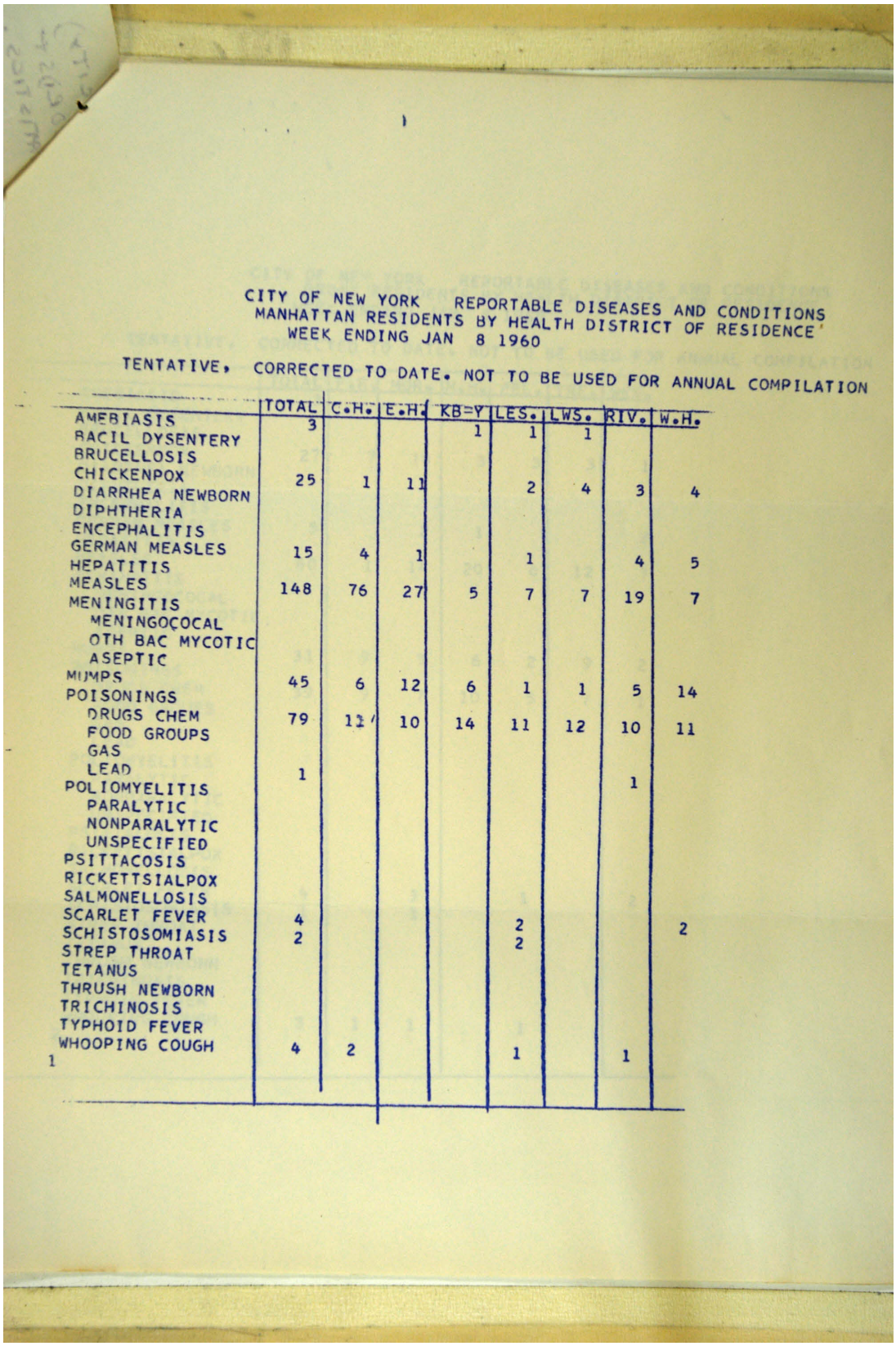
Figure S24: Health Department Records: Page 1

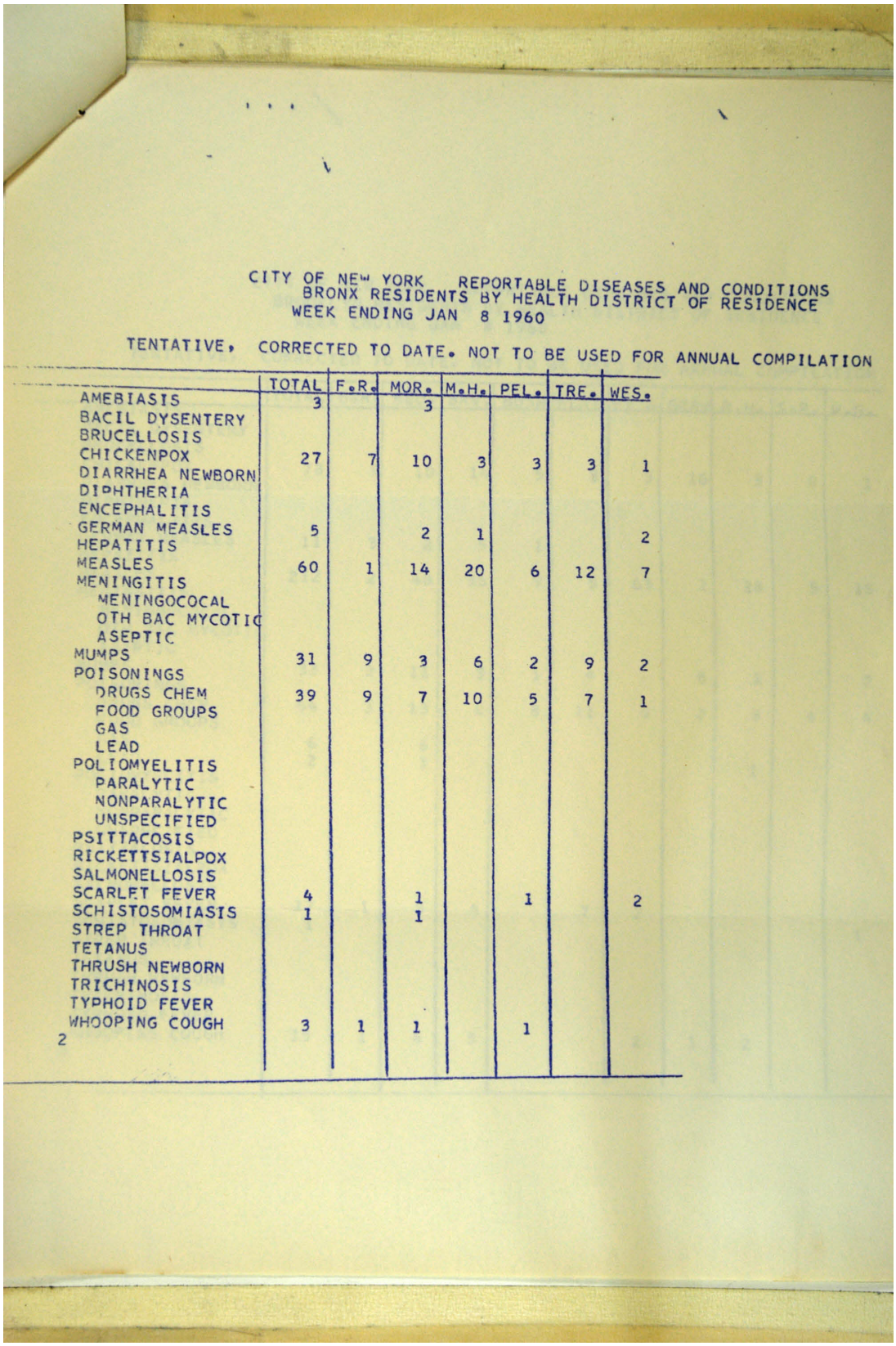


CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
MANHATTAN RESIDENTS BY HEALTH DISTRICT OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE. CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	C.H.	E.H.	KB=Y	LES.	LWS.	RIV.	W.H.
AMEBIASIS	3			1	1	1		
BACIL DYSENTERY								
BRUCELLOSIS								
CHICKENPOX	25	1	11		2	4	3	4
DIARRHEA NEWBORN								
DIPHTHERIA								
ENCEPHALITIS								
GERMAN MEASLES	15	4	1		1		4	5
HEPATITIS								
MEASLES	148	76	27	5	7	7	19	7
MENINGITIS								
MENINGOCOCAL								
OTH BAC MYCOTIC								
ASEPTIC								
MUMPS	45	6	12	6	1	1	5	14
POISONINGS								
DRUGS CHEM	79	11	10	14	11	12	10	11
FOOD GROUPS								
GAS								
LEAD	1						1	
POLIOMYELITIS								
PARALYTIC								
NONPARALYTIC								
UNSPECIFIED								
PSITTACOSIS								
RICKETTSIALPOX								
SALMONELLOSIS								
SCARLET FEVER	4				2			2
SCHISTOSOMIASIS	2				2			
STREP THROAT								
TETANUS								
THRUSH NEWBORN								
TRICHINOSIS								
TYPHOID FEVER								
WHOOPING COUGH	4	2			1		1	

Figure S25: Health Department Records: Page 2



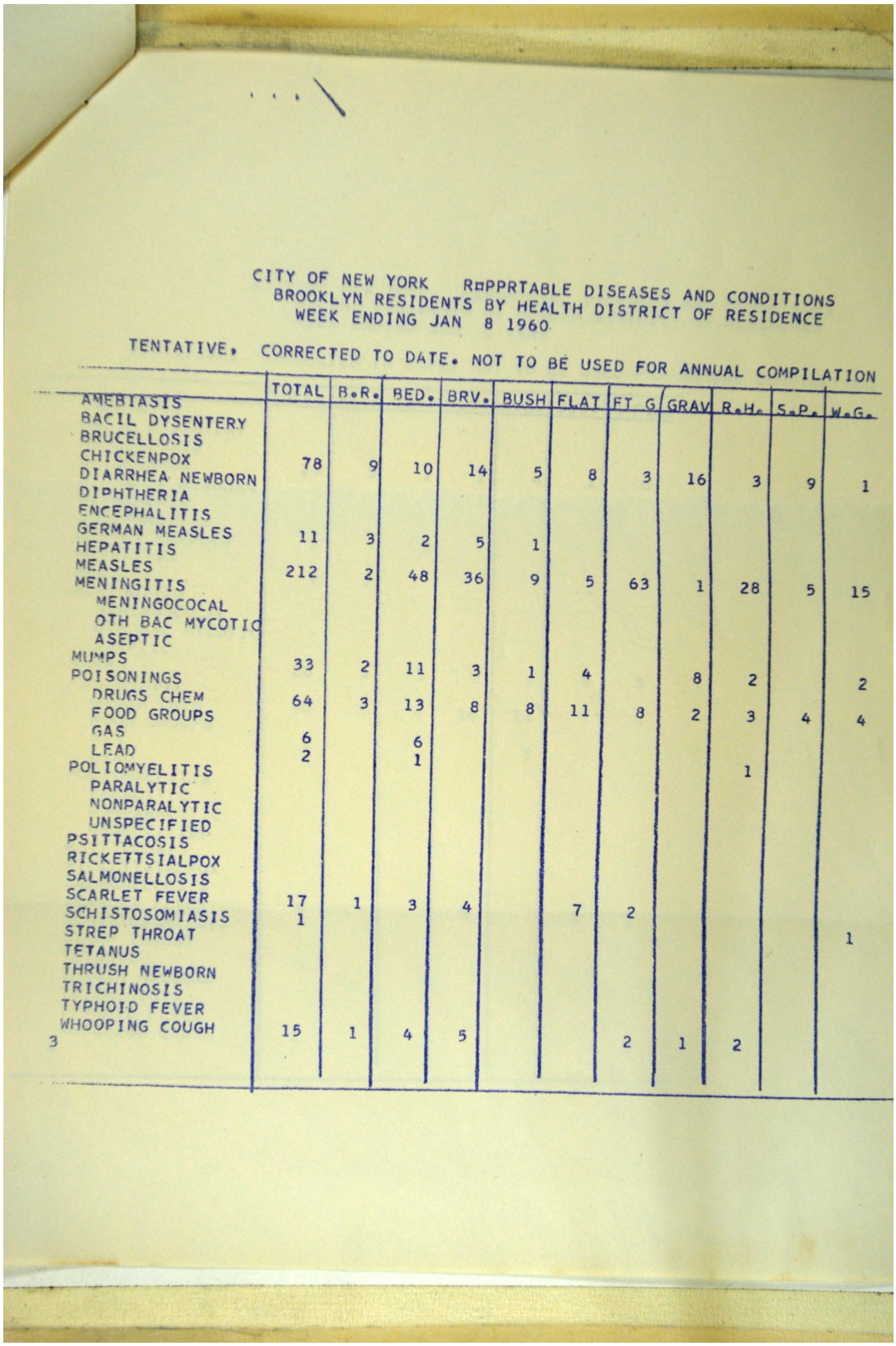
CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
BRONX RESIDENTS BY HEALTH DISTRICT OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE, CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	F.R.	MOR.	M.H.	PEL.	TRE.	WES.
AMEBIASIS	3		3				
BACIL DYSENTERY							
BRUCELLOSIS							
CHICKENPOX	27	7	10	3	3	3	1
DIARRHEA NEWBORN							
DIPHTHERIA							
ENCEPHALITIS							
GERMAN MEASLES	5		2	1			2
HEPATITIS							
MEASLES	60	1	14	20	6	12	7
MENINGITIS							
MENINGOCOCAL							
OTH BAC MYCOTIC							
ASEPTIC							
MUMPS	31	9	3	6	2	9	2
POISONINGS							
DRUGS CHEM	39	9	7	10	5	7	1
FOOD GROUPS							
GAS							
LEAD							
POLIOMYELITIS							
PARALYTIC							
NONPARALYTIC							
UNSPECIFIED							
PSITTACOSIS							
RICKETTSIALPOX							
SALMONELLOSIS							
SCARLET FEVER	4		1		1		2
SCHISTOSOMIASIS	1		1				
STREP THROAT							
TETANUS							
THRUSH NEWBORN							
TRICHINOSIS							
TYPHOID FEVER							
WHOOPING COUGH	3	1	1		1		

2

Figure S26: Health Department Records: Page 3



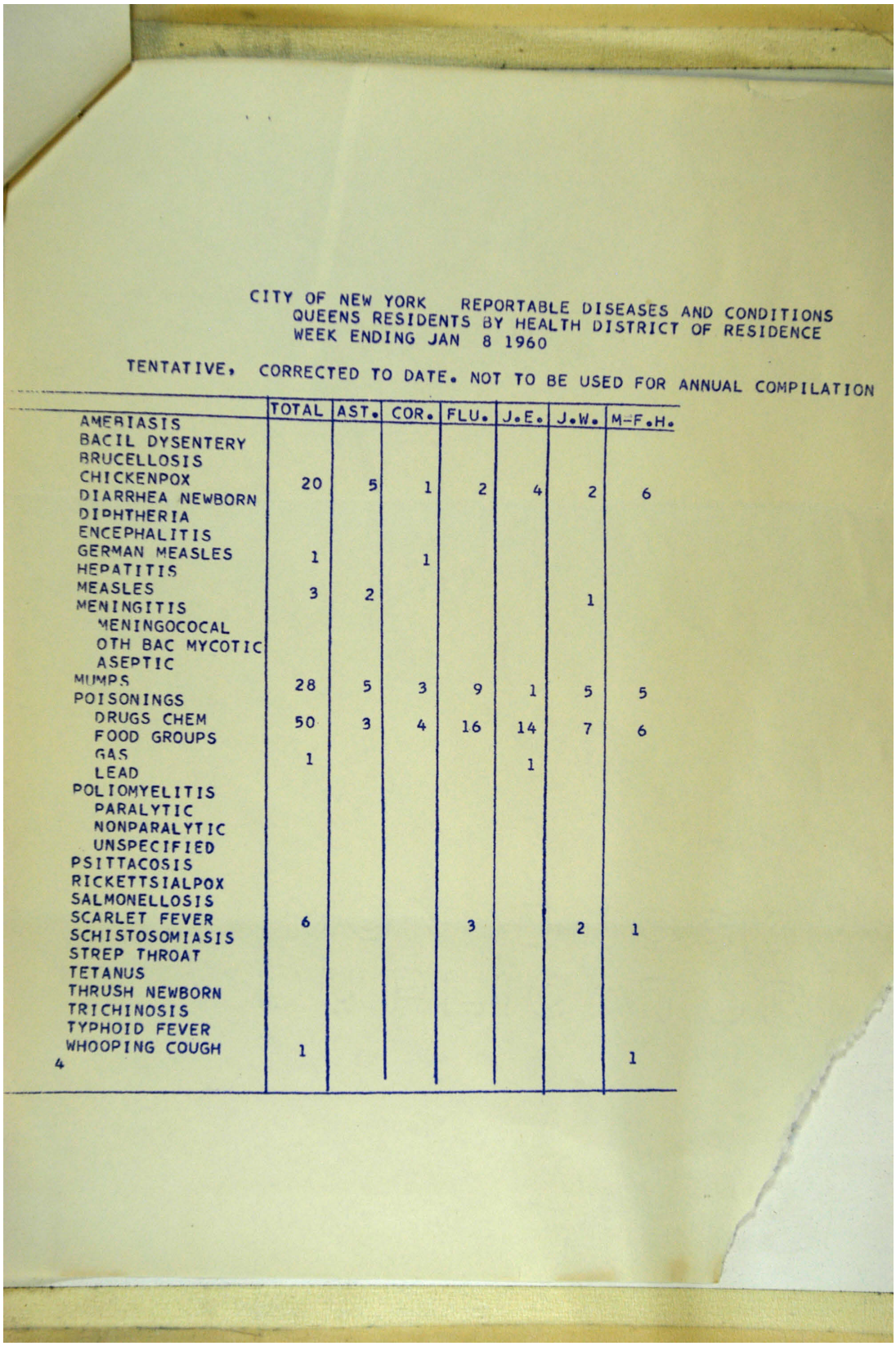
CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
BROOKLYN RESIDENTS BY HEALTH DISTRICT OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE, CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	B.R.	BED.	BRV.	BUSH	FLAT	FT G	GRAV	R.H.	S.P.	W.G.
AMEBIASIS											
BACIL DYSENTERY											
BRUCELLOSIS											
CHICKENPOX	78	9	10	14	5	8	3	16	3	9	1
DIARRHEA NEWBORN											
DIPHTHERIA											
ENCEPHALITIS											
GERMAN MEASLES	11	3	2	5	1						
HEPATITIS											
MEASLES	212	2	48	36	9	5	63	1	28	5	15
MENINGITIS											
MENINGOCOCAL											
OTH BAC MYCOTIC											
ASEPTIC											
MUMPS	33	2	11	3	1	4		8	2		2
POISONINGS											
DRUGS CHEM	64	3	13	8	8	11	8	2	3	4	4
FOOD GROUPS											
GAS	6		6								
LEAD	2		1						1		
POLIOMYELITIS											
PARALYTIC											
NONPARALYTIC											
UNSPECIFIED											
PSITTACOSIS											
RICKETTSIALPOX											
SALMONELLOSIS											
SCARLET FEVER	17	1	3	4		7	2				
SCHISTOSOMIASIS	1										
STREP THROAT											1
TETANUS											
THRUSH NEWBORN											
TRICHINOSIS											
TYPHOID FEVER											
WHOOPING COUGH	15	1	4	5			2	1	2		

3

Figure S27: Health Department Records: Page 4



CITY OF NEW YORK REPORTABLE DISEASES AND CONDITIONS
QUEENS RESIDENTS BY HEALTH DISTRICT OF RESIDENCE
WEEK ENDING JAN 8 1960

TENTATIVE, CORRECTED TO DATE. NOT TO BE USED FOR ANNUAL COMPILATION

	TOTAL	AST.	COR.	FLU.	J.E.	J.W.	M-F.H.
AMEBIASIS							
BACIL DYSENTERY							
BRUCELLOSIS							
CHICKENPOX	20	5	1	2	4	2	6
DIARRHEA NEWBORN							
DIPHTHERIA							
ENCEPHALITIS							
GERMAN MEASLES	1		1				
HEPATITIS							
MEASLES	3	2				1	
MENINGITIS							
MENINGOCOCAL							
OTH BAC MYCOTIC							
ASEPTIC							
MUMPS	28	5	3	9	1	5	5
POISONINGS							
DRUGS CHEM	50	3	4	16	14	7	6
FOOD GROUPS							
GAS	1				1		
LEAD							
POLIOMYELITIS							
PARALYTIC							
NONPARALYTIC							
UNSPECIFIED							
PSITTACOSIS							
RICKETTSIALPOX							
SALMONELLOSIS							
SCARLET FEVER	6			3		2	1
SCHISTOSOMIASIS							
STREP THROAT							
TETANUS							
THRUSH NEWBORN							
TRICHINOSIS							
TYPHOID FEVER							
WHOOPING COUGH	1						1

4

Figure S28: Health Department Records: Page 5

References

1 New York Academy of Medicine. 1216 5th Avenue, New York, NY 10029, United States. www.nyam.org.

2 New York City Department of Health and Mental Hygiene, Office of Vital Records. Summary of Vital Statistcs, 1961-2007 Archived Reports. Available from: http://www.nyc.gov/html/doh/html/vr/vr-archives.shtml.

3 C. T. Bauch and D. J. D. Earn. Transients and attractors in epidemics. *Proceedings of the Royal Society of London, Series* B, 270(1524):1573–1578, 2003.

4 Peter H Baxendale and Priscilla E Greenwood. Sustained oscillations for density dependent Markov processes. *Journal of Mathematical Biology*, 63(3):433–457, 2011.

5 B. Cazelles, M. Chavez, G. C. de Magny, J. F. Guegan, and S. Hales. Time-dependent spectral analysis of epidemiological time-series with wavelets. *Journal Of The Royal Society Interface*, 4(15):625–636, 2007.

6 Bernard Cazelles, Mario Chavez, Dominique Berteaux, Frédéric Ménard, Jon Olav Vik, Stéphanie Jenouvrier, and Nils C Stenseth. Wavelet analysis of ecological time series. *Oecologia*, 156(2):287–304, 2008.

7 D. J. D. Earn. Mathematical epidemiology of infectious diseases. In M. A. Lewis, M. A. J. Chaplain, J. P. Keener, and P. K. Maini, editors, *Mathematical Biology*, volume 14 of *IAS/ Park City Mathematics Series*, pages 151–186. American Mathematical Society, 2009.

8 D. He and D. J. D. Earn. Epidemiological effects of seasonal oscillations in birth rates. *Theoretical Population Biology*, 72:274–291, 2007.

9 A. M. Holdsworth, N. K. R. Kevlahan, and D. J. D. Earn. Multifractal signatures of infectious diseases. *Journal of the Royal Society Interface*, 9(74):2167–2180, 2012.

10 Michael A Johansson, Derek A T Cummings, and Gregory E Glass. Multiyear climate variability and dengue—el nino southern oscillation, weather, and dengue incidence in puerto rico, mexico, and thailand: a longitudinal data analysis. *PLoS Medicine*, 6(11):e1000168, 2009.

11 W. London and J. A. Yorke. Recurrent outbreaks of measles, chickenpox and mumps. I. seasonal variation in contact rates. *American Journal of Epidemiology*, 98(6):453–468, 1973.

12 C. Torrence and G. P. Compo. A practical guide to wavelet analysis. *Bulletin of American Meteorological Society*, 79(1):61–78. http://atoc.colorado.edu/research/wavelets/, 1998.