Excess deaths from all causes and by COVID-19 in Brazil in 2020

10/08/2021

Supplementary Material

Methods

The Farrington algorithm is designed to detect outliers in univariate time series. To accomplish this, it considers an overdispersed Poisson generalized linear model (Quasi-Poisson) to determine a predictive distribution for the observed values of the series in a non-surge scenario. Considering the predictive distribution, a specific quantile is obtained, which will be used as a threshold to determine whether the observed value at time t is an outlier. If the observed value is above this threshold, then an alarm is triggered. [1]

For execution of the algorithm, the time series of the number of deaths in the period from 2010 to 2020 for each Brazilian state was partitioned into two parts. The first partition of the series was composed with the data from week 1 of 2010 (i.e., January 3, 2010) to the last week of 2014 (December 28, 2014), corresponding to 260 epidemiological weeks. These data were used for fitting the quasi-Poisson model. The data from the first week of 2015 (January 4, 2015) until week 52 of 2020 (December 13, 2020) were considered for monitoring, totaling 312 weeks. Thus, using only values from the period 2010 to 2014 for model fitting, prediction intervals are obtained for the observed values for 2015 to 2020.

For detection of outliers in the series from 2015 to 2020, the quantile 0.995 of the predictive distribution of the observed values of the series was adopted as the threshold. The Farrington algorithm is implemented in the surveillance package of the R program, and the function farrington should be used for its execution. [2]

Supplementary figures 46, 47, and 48 present the detected alarms for the death series for some brazilian states where specific patterns of alarms were observed in some weeks of 2016 - RN, PE, AL, PB, RJ, SP, PR and RS states. For comparison purposes, we fitted the model specified in equation (1), described in the methods section of the main article, with the series from 2015 to 2019 with the weeks that showed anomalies in the year 2016 and without the inclusion of these weeks. Although the differences were statistically significant, the relative differences between the estimates of the number of expected deaths for the epidemiological weeks of the year 2020 calculated based on the 2015-2019 series with and without those anomalies were small (<0.7%). Thus, we chose to consider the complete series of the year 2016 for the estimation of expected deaths.

References:

1. Farrington CP, Andrews NJ, Beale AD, Catchpole MA. A statistical algorithm for the early detection of outbreaks of infectious disease. J R Stat Soc Ser A Stat Soc. 1996; 159(3):547-63.

2. Höhle M. Surveillance: An R package for the monitoring of infectious diseases. Computational Statistics. 2007; 22(4):571-582.

Supplementary Tables

Supplementary Table 1. Number of expected deaths and its lower and upper 95% confidence limits by state, Brazil, 2020

state	expected	lower_limit_expected	upper_limit_expected
RO	8380	8118	8656
AC	4313	4122	4518
AM	18574	18097	19052
RR	3106	2944	3277
PA	42048	41224	42877
AP	3679	3507	3863
TO	8263	7990	8537
MA	35556	34794	36323
PI	21514	20838	22210
CE	58570	57326	59839
RN	22078	21500	22682
PB	27379	26717	28054
PE	63602	61886	65358
AL	20050	19531	20581
SE	13251	12913	13596
BA	93854	92469	95266
MG	141695	139184	144252
ES	24852	24312	25396
RJ	146253	143401	149165
SP	308807	303618	314077
PR	75237	73778	76723
SC	43261	42427	44112
RS	90237	88112	92417
MS	17135	16710	17572
MT	18779	18300	19267
GO	41265	40350	42199
DF	12816	12478	13170
Brazil	1364603	1350846	1378510

Supplementary Table 2. Number of expected deaths and its lower and upper 95% confidence limits by sex, age and race, Brazil, 2020

Category	expected	lower_limit_expected	upper_limit_expected
Male	752451	744860	760123
Female	611671	604904	618505
Age_00_to_19	63628	62720	64539
Age_20_to_39	102251	100011	104535
Age_40_to_59	242597	240052	245164
Age_60_to_79	528174	522349	534062
Age_80_or_older	418733	412727	424832
White	692066	683479	700760
Black	110258	108855	111680
Brown	524683	519541	529879
Others	12077	11787	12373
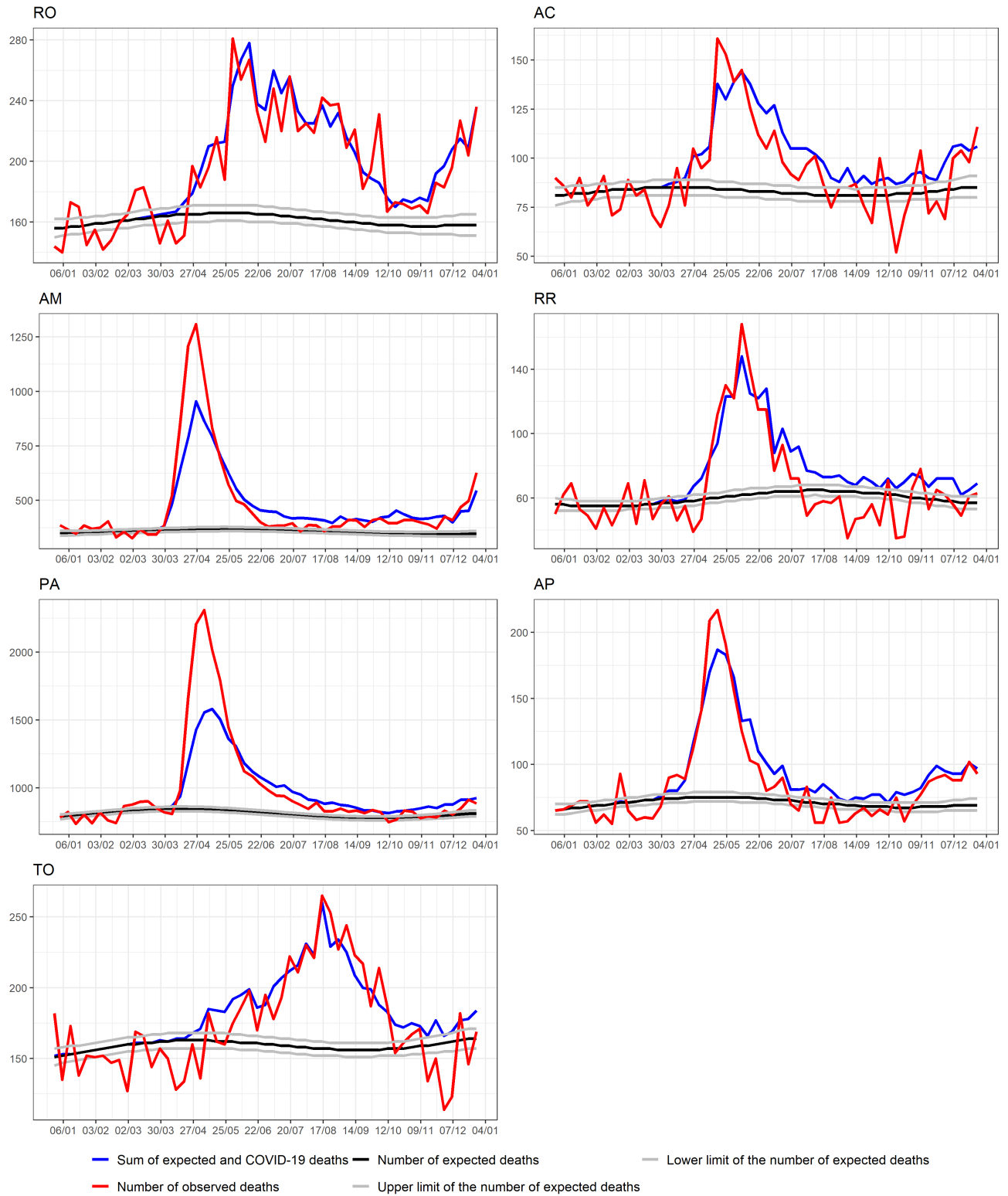
Supplementary Figures

Supplementary figure 1. Excess deaths by all causes and by COVID=19 by epidemiological week, North Region, Brazil, 2020
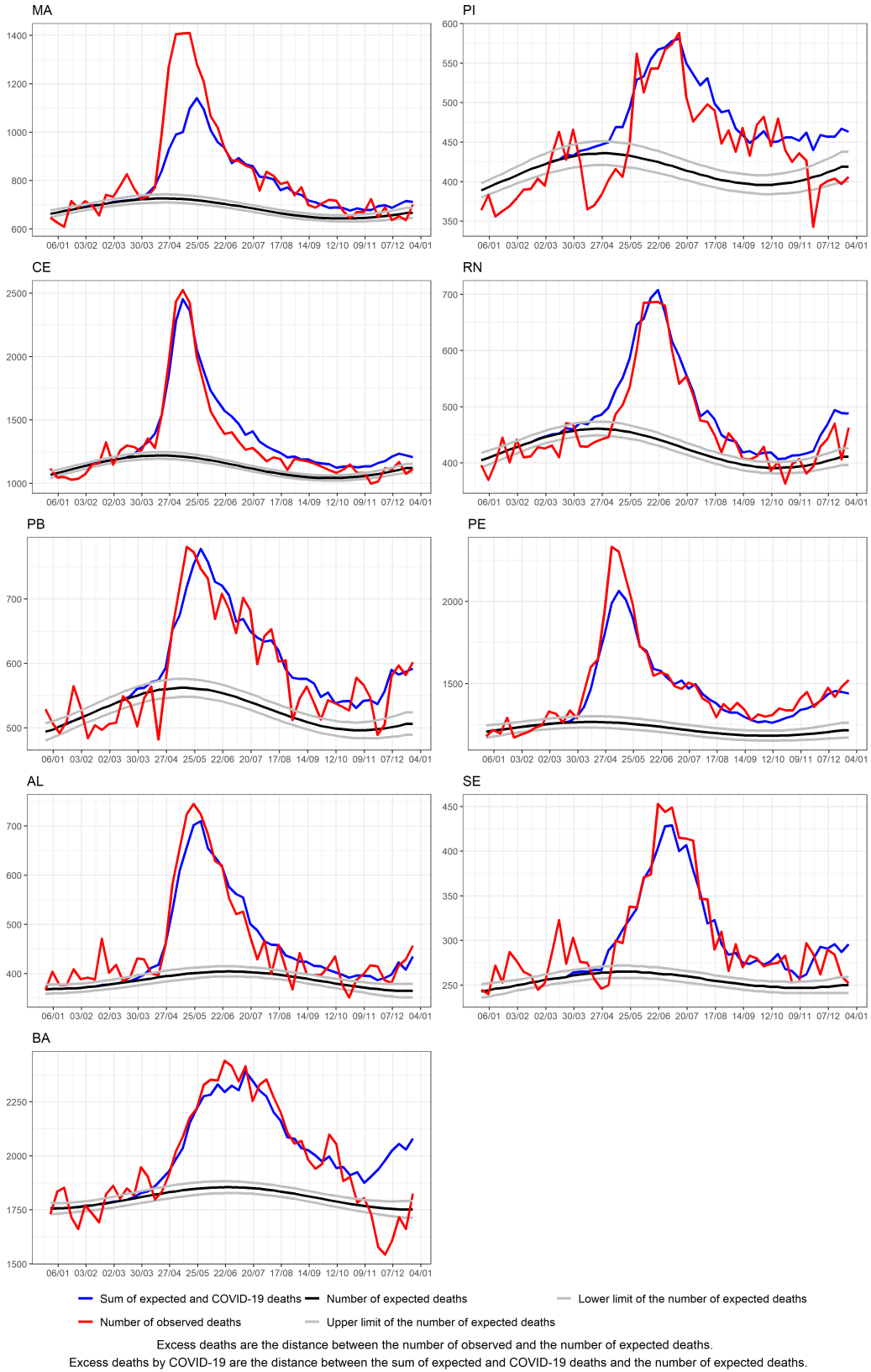
Supplementary figure 2. Excess deaths by all causes and by COVID=19 by epidemiological
week, Northeast Region, Brazil, 2020
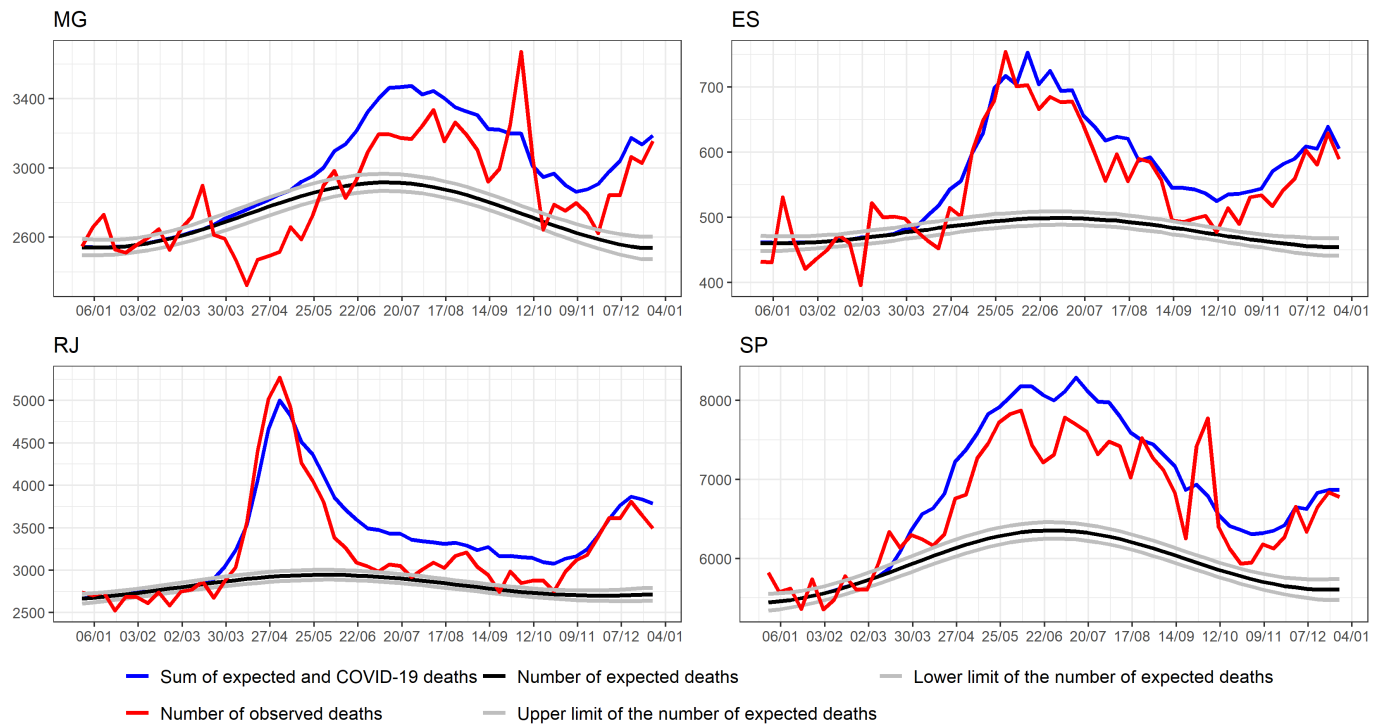
Excess deaths are the distance between the number of observed and the number of expected deaths.
Excess deaths by COVID-19 are the distance between the sum of expected and COVID-19 deaths and the number of expected deaths.

Supplementary figure 3. Excess deaths by all causes and by COVID=19 by epidemiological week, Southeast Region, Brazil, 2020

Excess deaths are the distance between the number of observed and the number of expected deaths.
Excess deaths by COVID-19 are the distance between the sum of expected and COVID-19 deaths and the number of expected deaths.
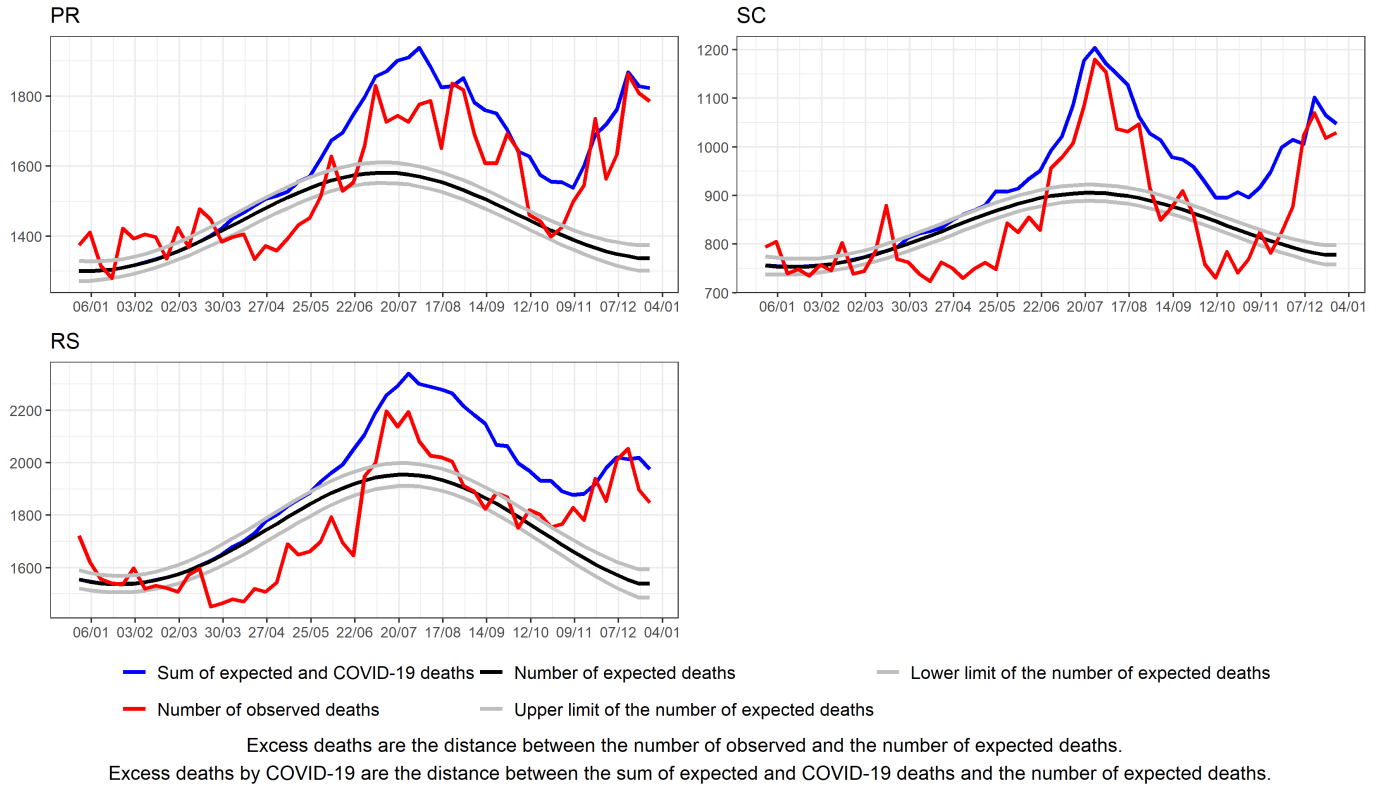
Supplementary figure 4. Excess deaths by all causes and by COVID=19 by epidemiological week, South Region, Brazil, 2020

Excess deaths are the distance between the number of observed and the number of expected deaths.

Excess deaths by COVID-19 are the distance between the sum of expected and COVID-19 deaths and the number of expected deaths.
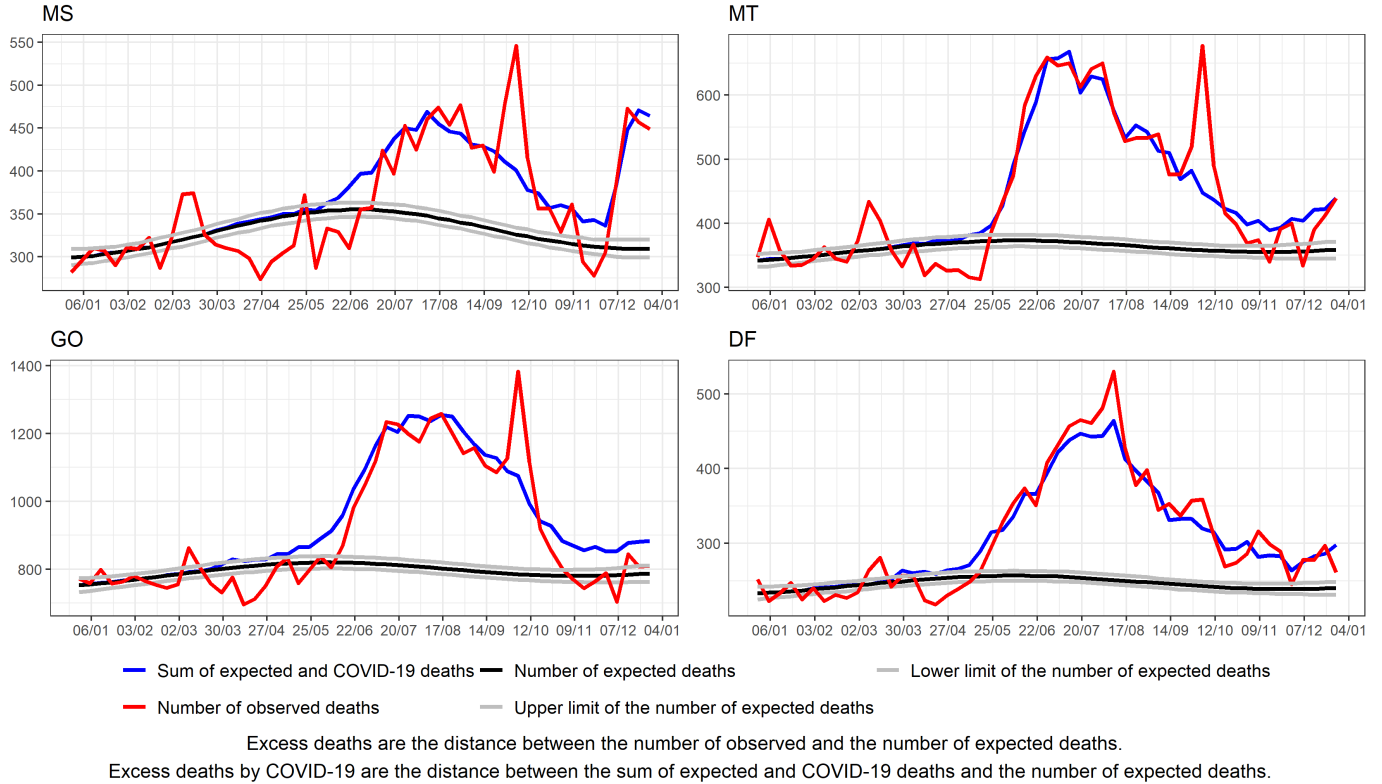
Supplementary figure 5. Excess deaths by all causes and by COVID=19 by epidemiological week, Center-West Region, Brazil, 2020

Excess deaths are the distance between the number of observed and the number of expected deaths.

Excess deaths by COVID-19 are the distance between the sum of expected and COVID-19 deaths and the number of expected deaths.
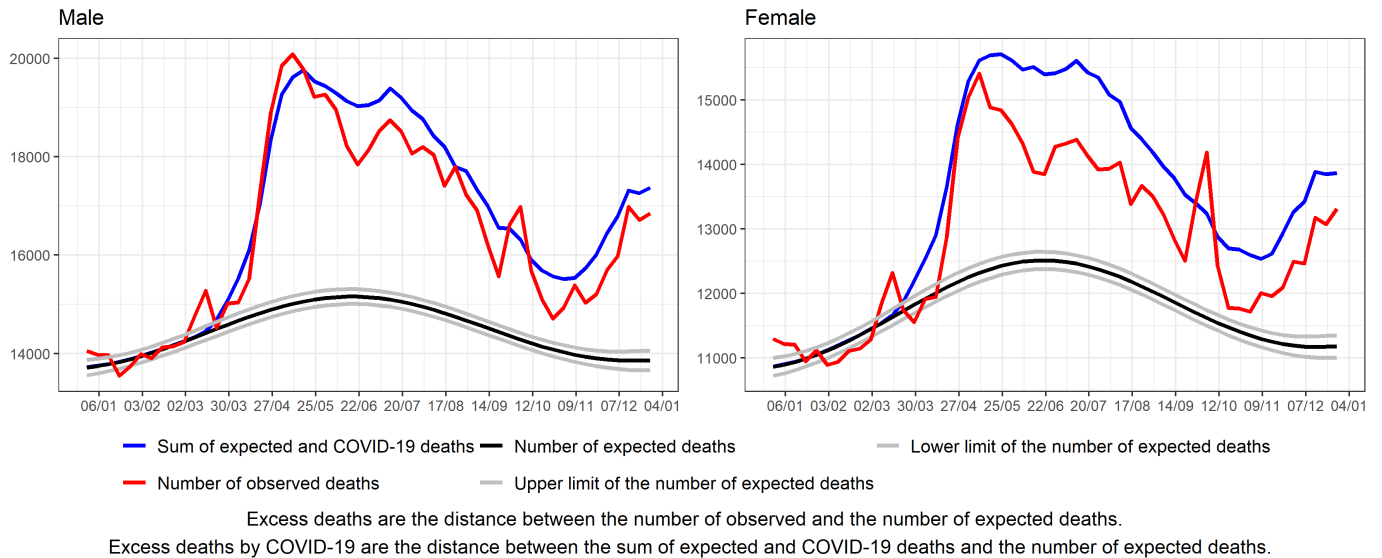
Supplementary figure 6. Excess deaths by all causes and by COVID=19 by epidemiological week according to sex, Brazil, 2020
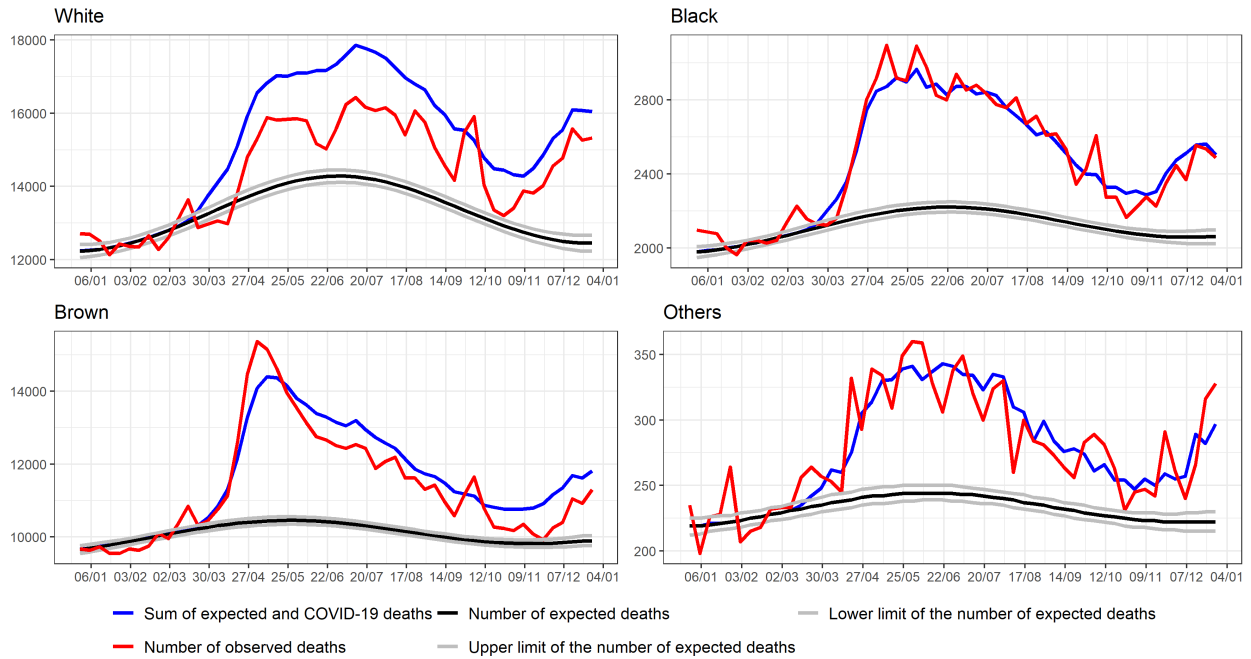
White · Black · Brown · Others

— Sum of expected and COVID-19 deaths   — Number of expected deaths   — Lower limit of the number of expected deaths
— Number of observed deaths   — Upper limit of the number of expected deaths

Excess deaths are the distance between the number of observed and the number of expected deaths.
Excess deaths by COVID-19 are the distance between the sum of expected and COVID-19 deaths and the number of expected deaths.

Supplementary figure 7. Excess deaths by all causes and by COVID=19 by epidemiological week according to race, Brazil, 2020
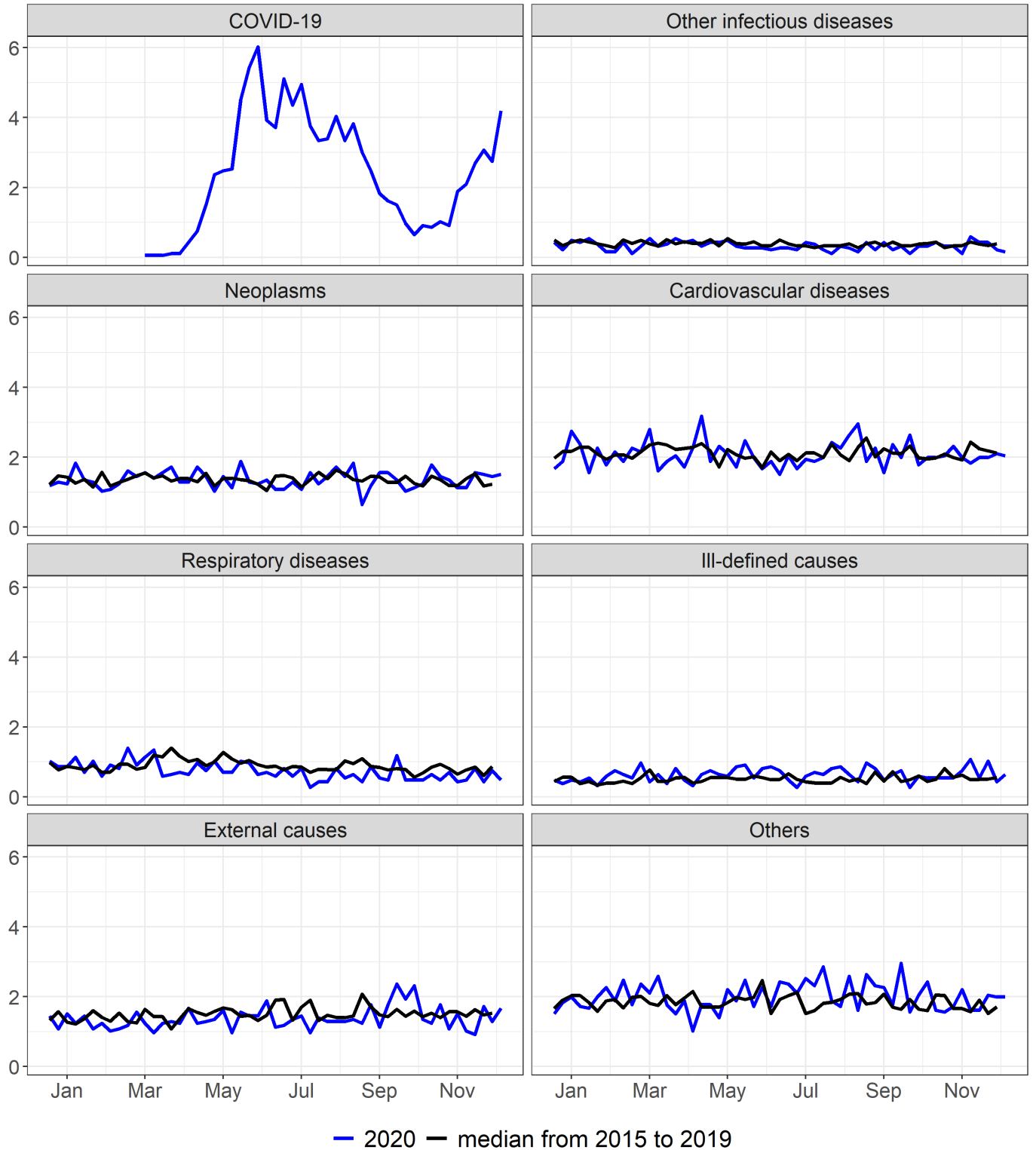
Supplementary figure 8. Mortality rate (per 100.000) by epidemiological week according to selected causes, RO, 2015 to 2020
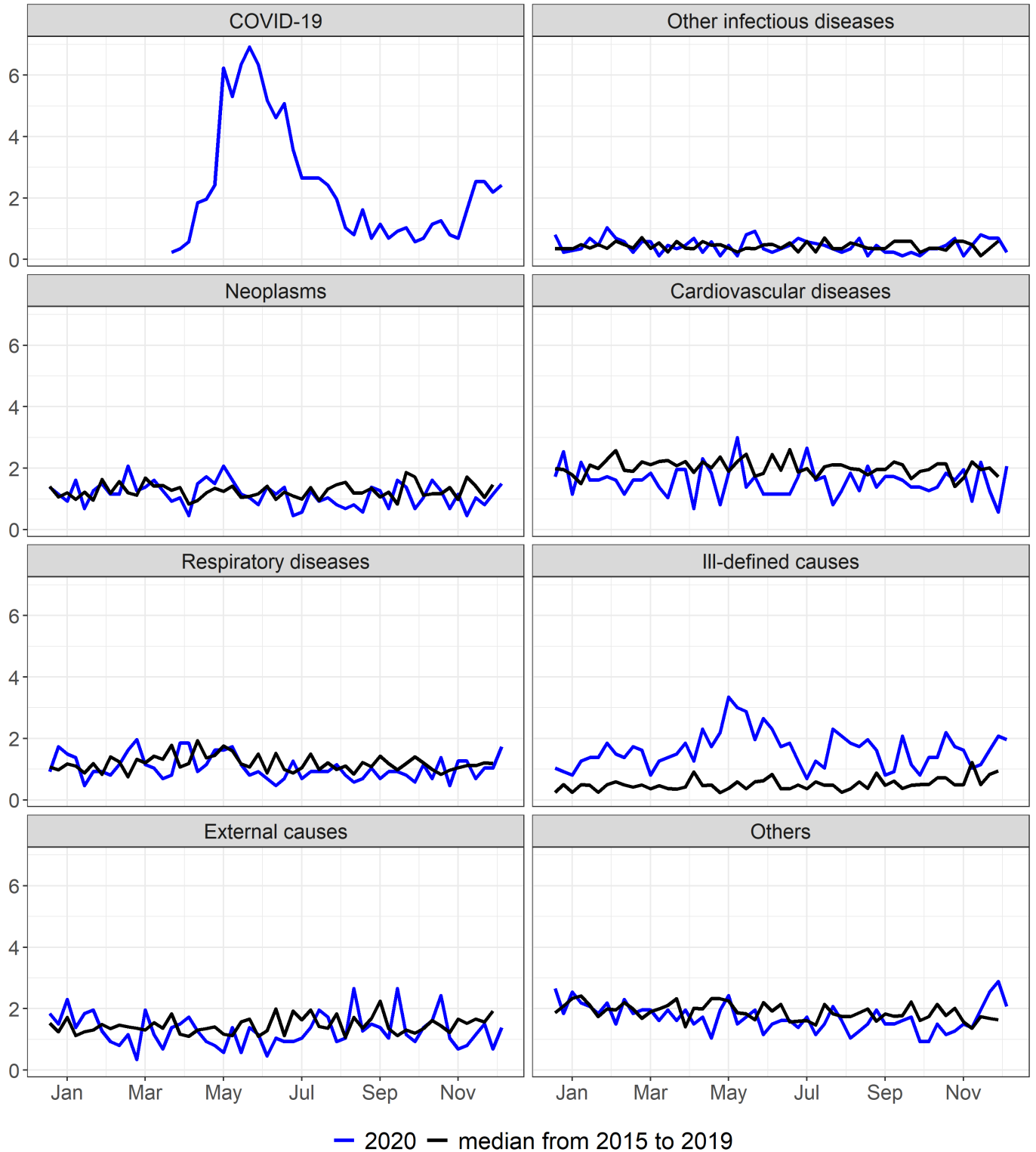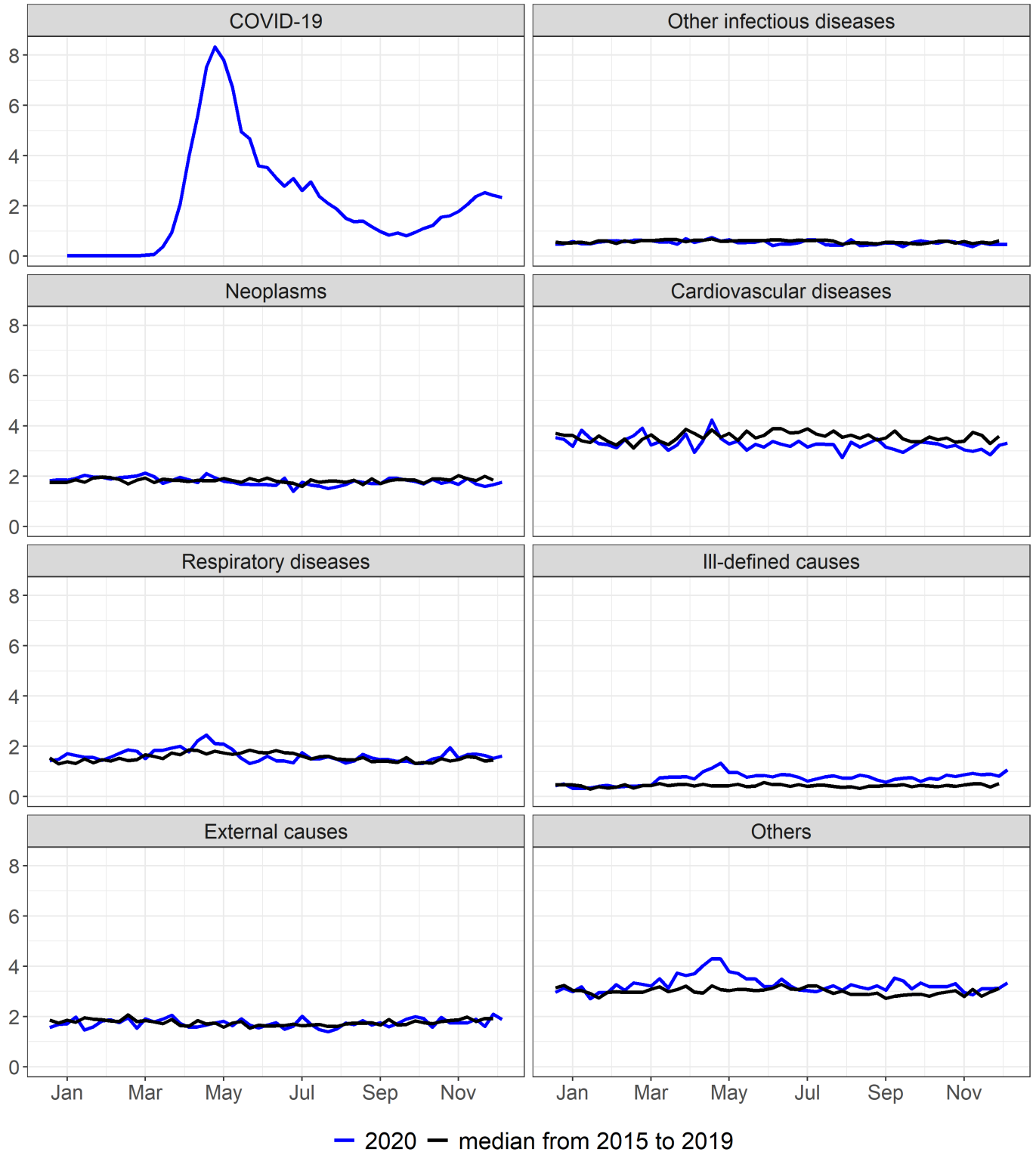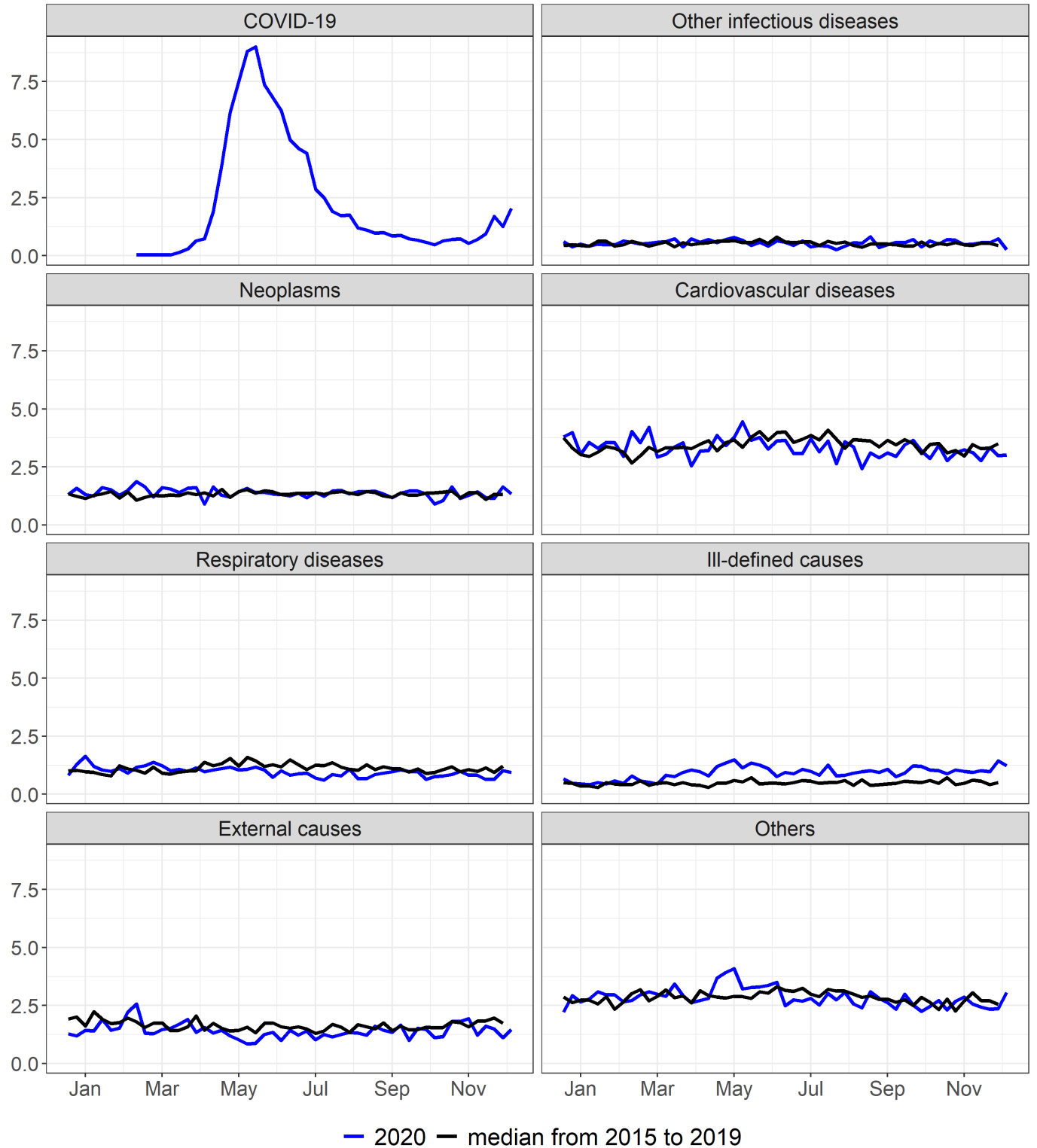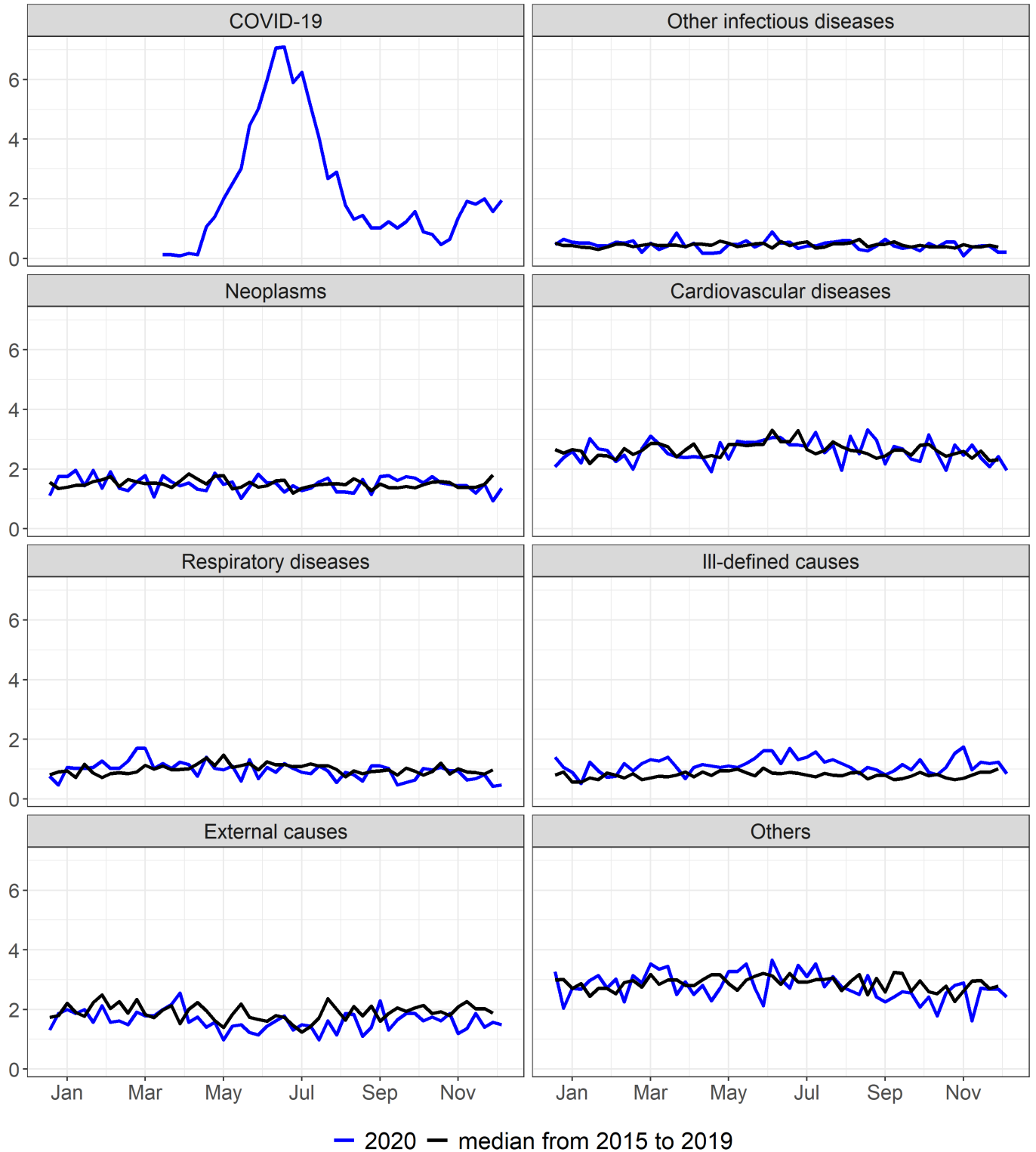
Supplementary figure 9. Mortality rate (per 100.000) by epidemiological week
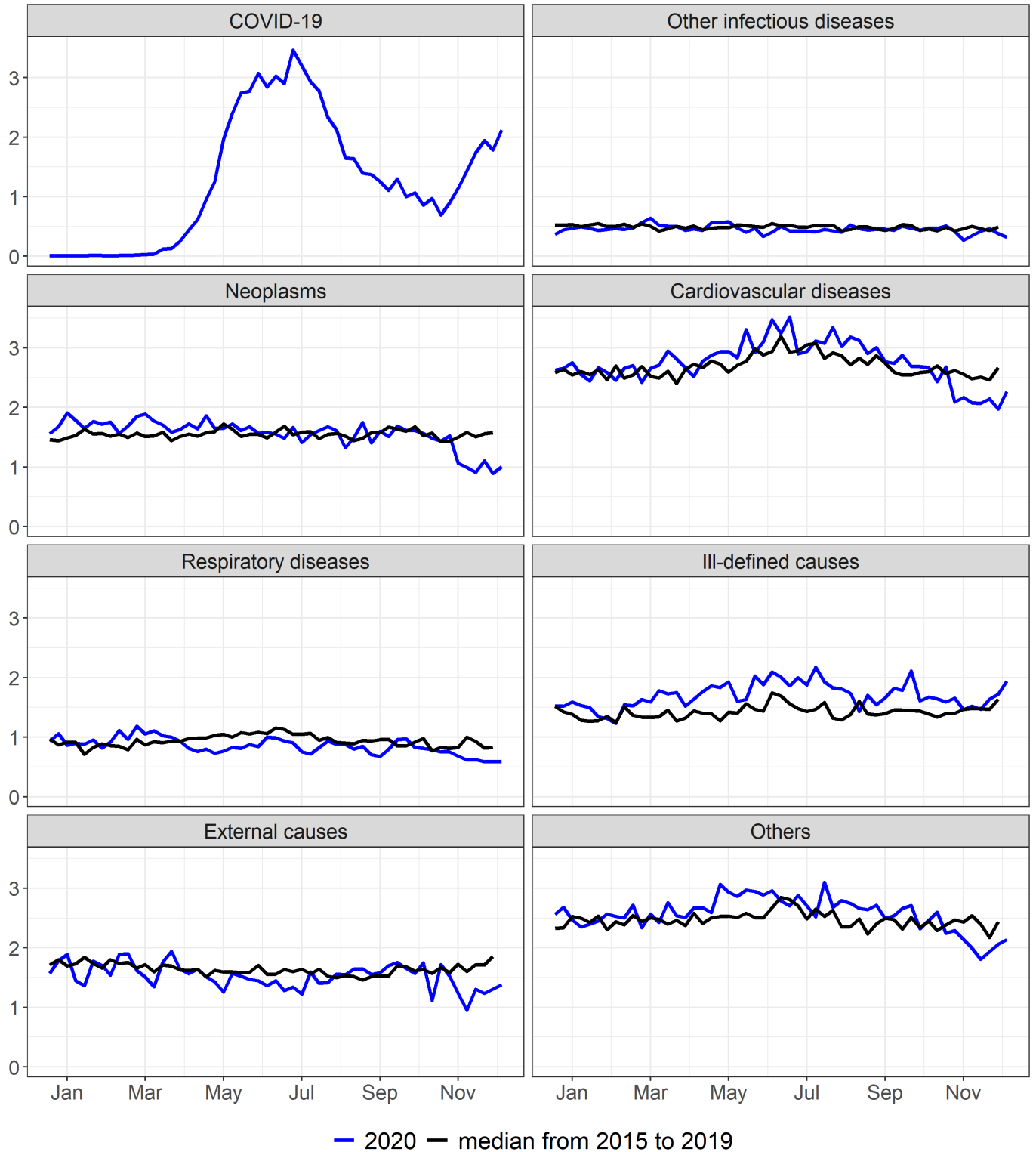according to selected causes, AC, 2015 to 2020
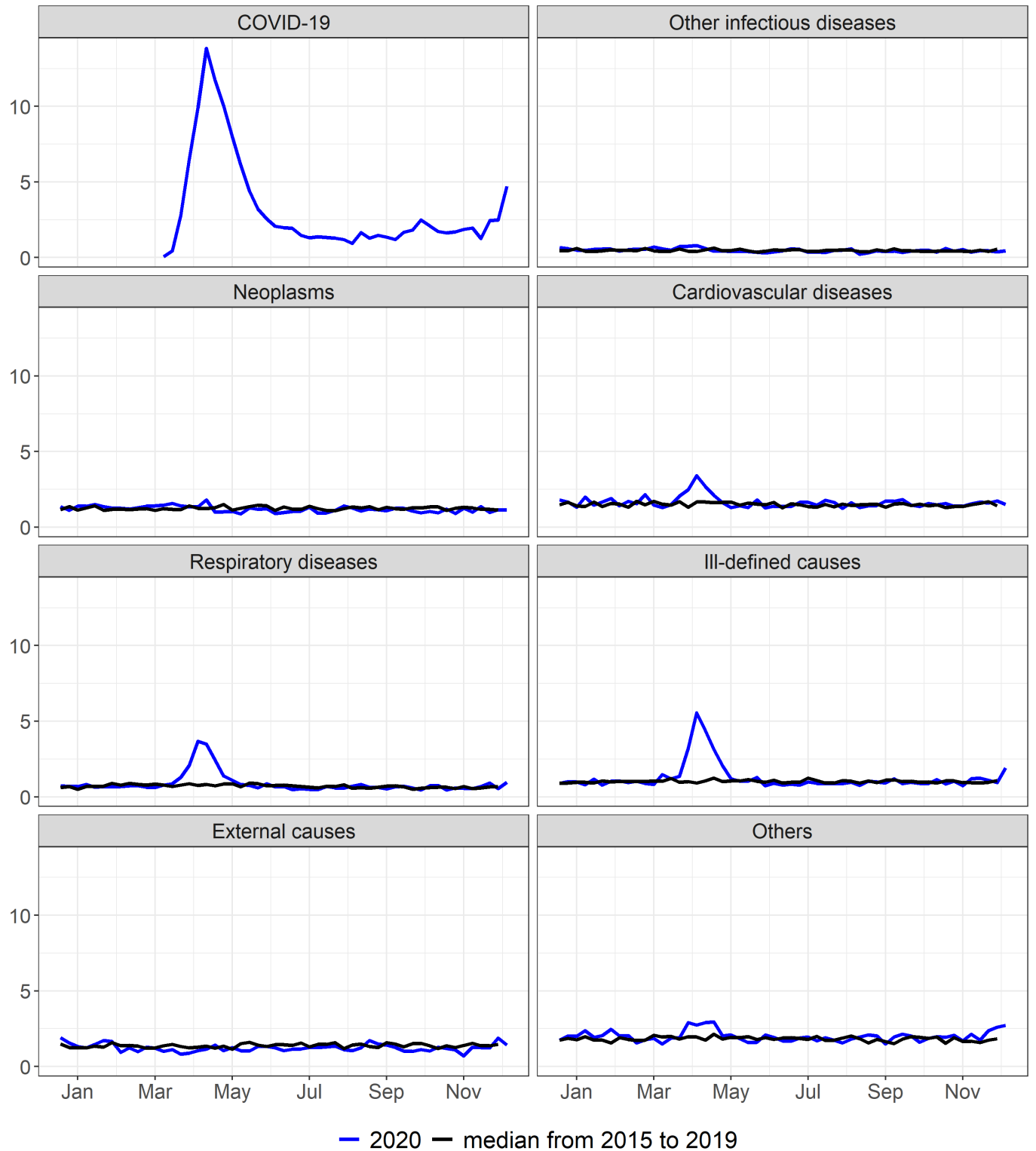
Supplementary figure 10. Mortality rate (per 100.000) by epidemiological week according to selected causes, AM, 2015 to 2020
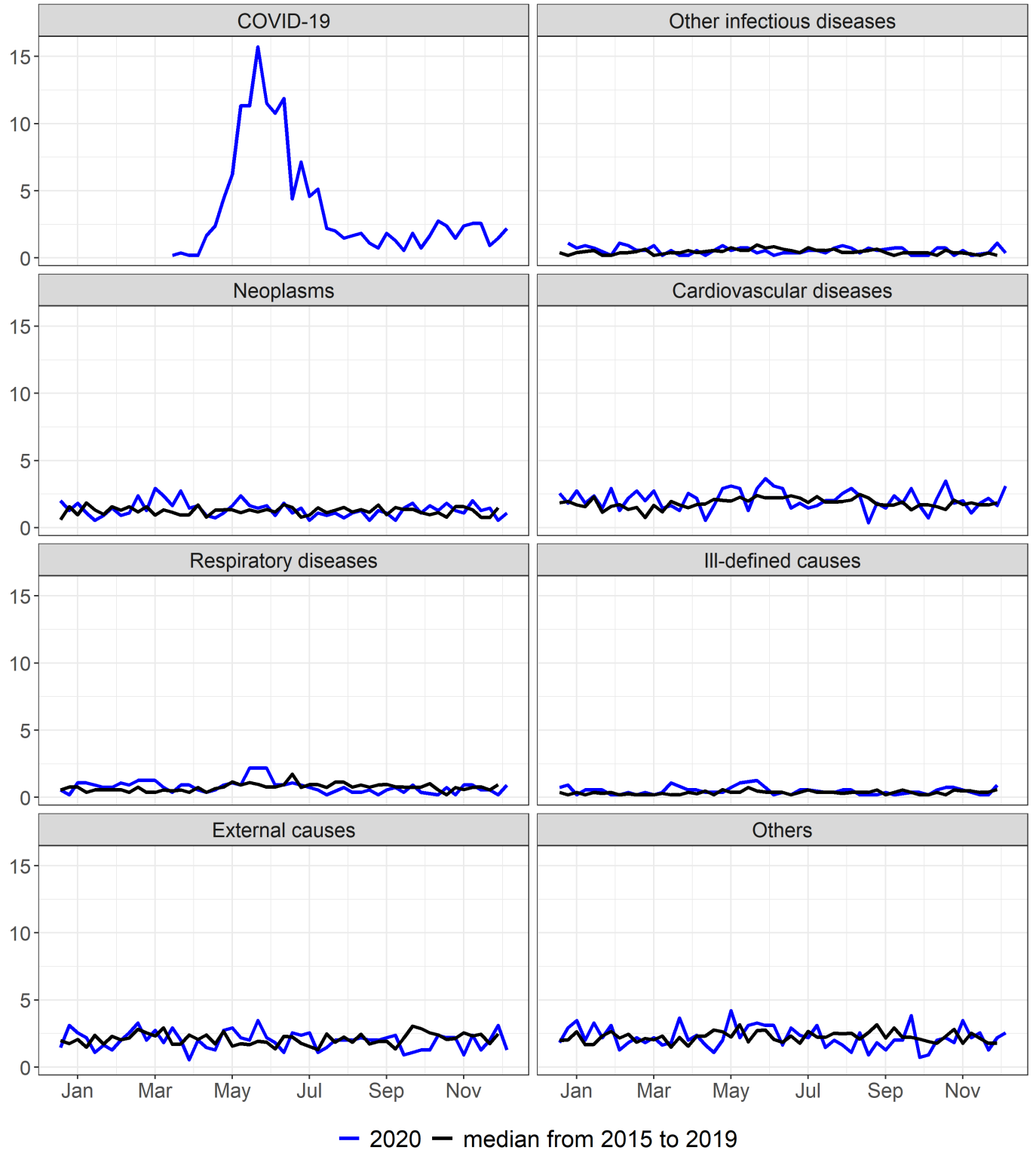
Supplementary figure 11. Mortality rate (per 100.000) by epidemiological week according to selected causes, RR, 2015 to 2020
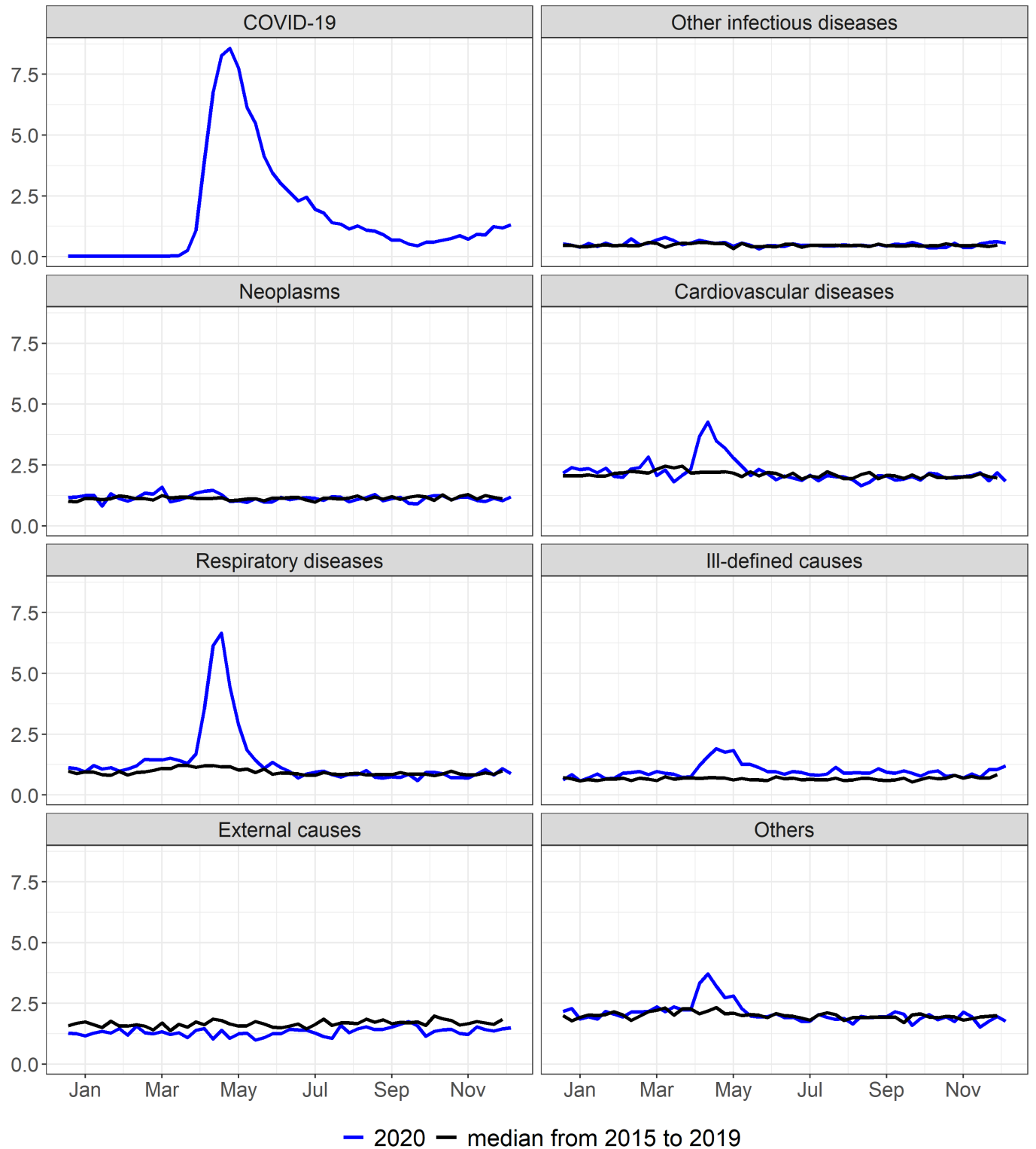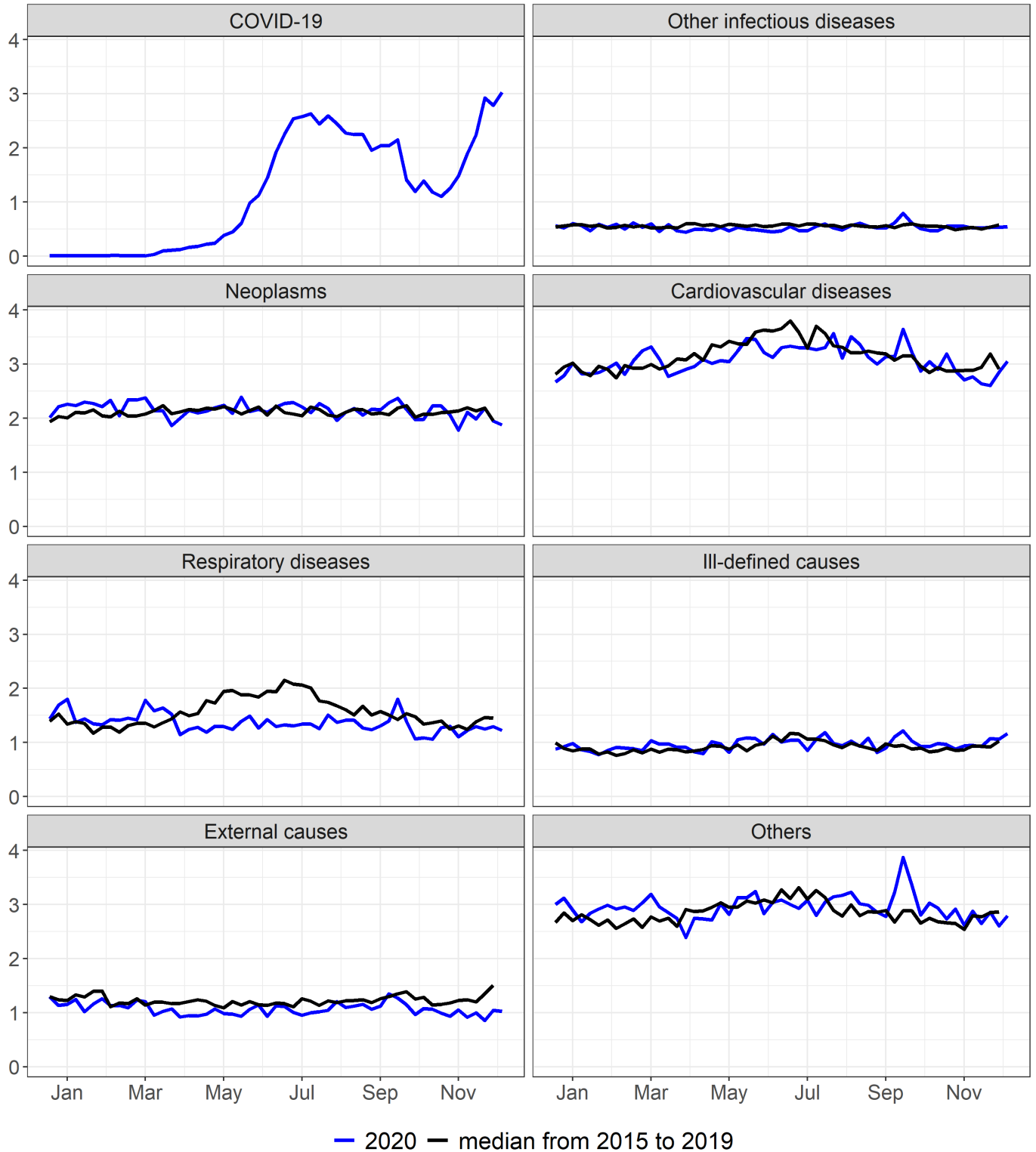
Supplementary figure 12. Mortality rate (per 100.000) by epidemiological week according to selected causes, PA, 2015 to 2020
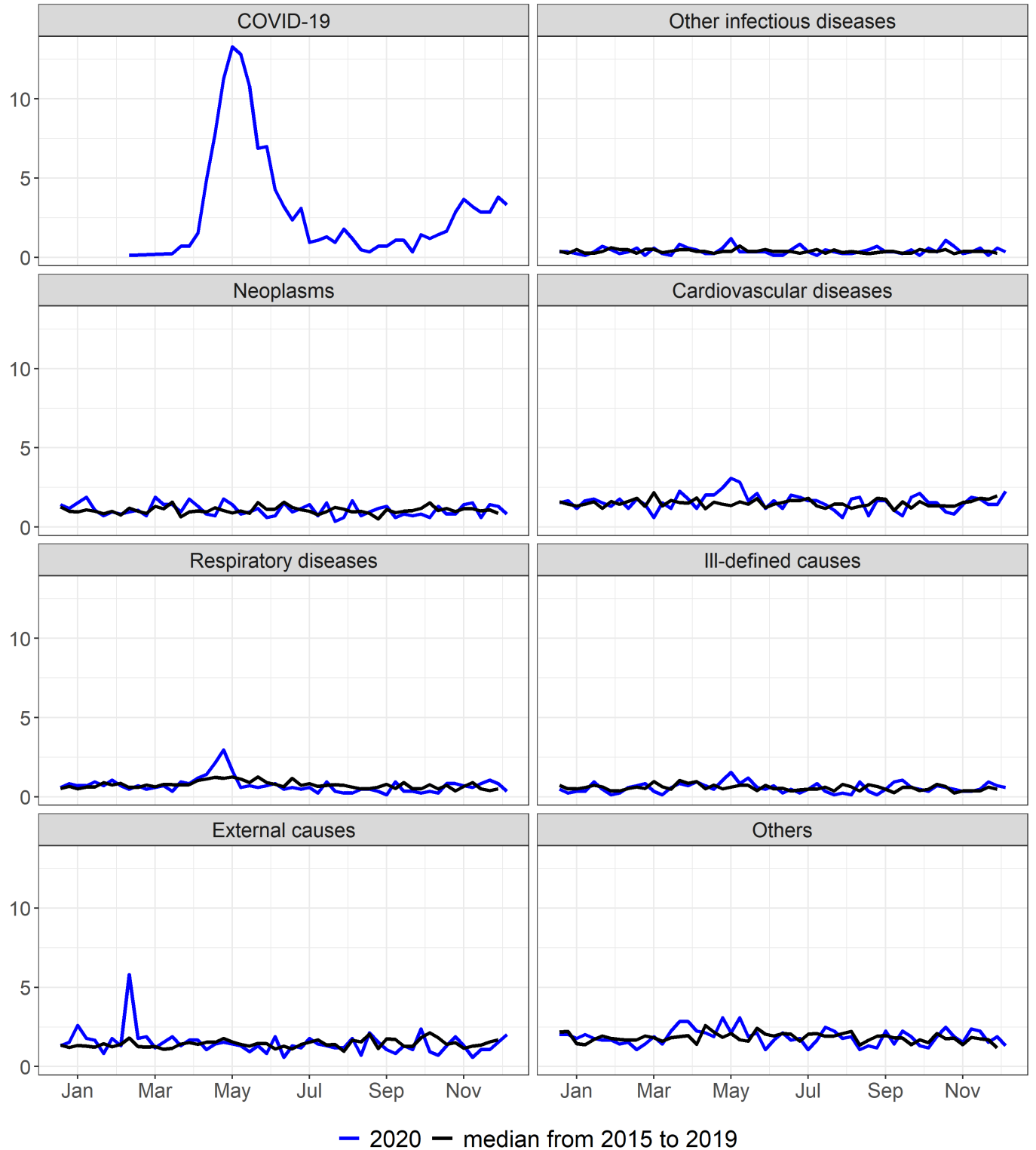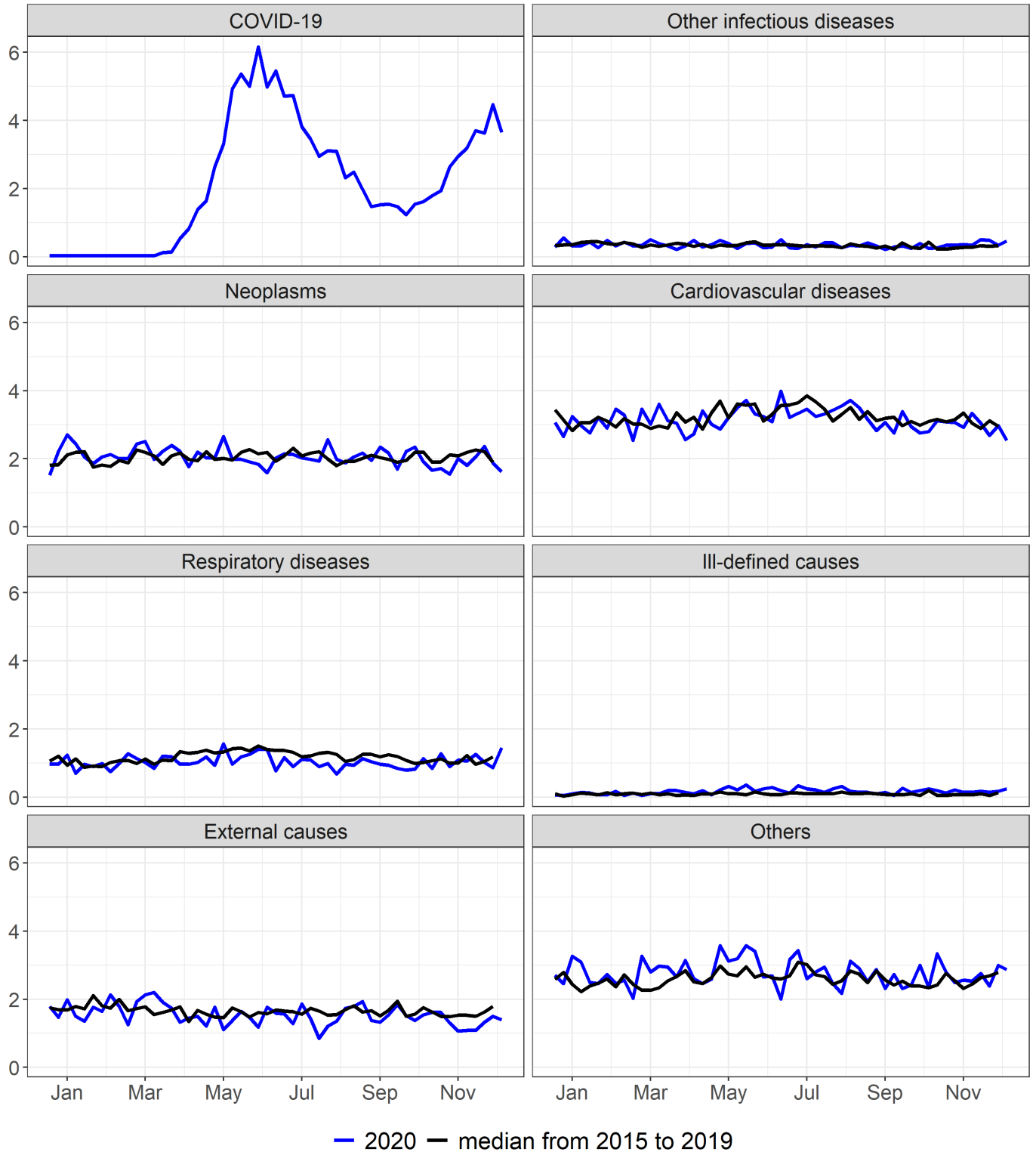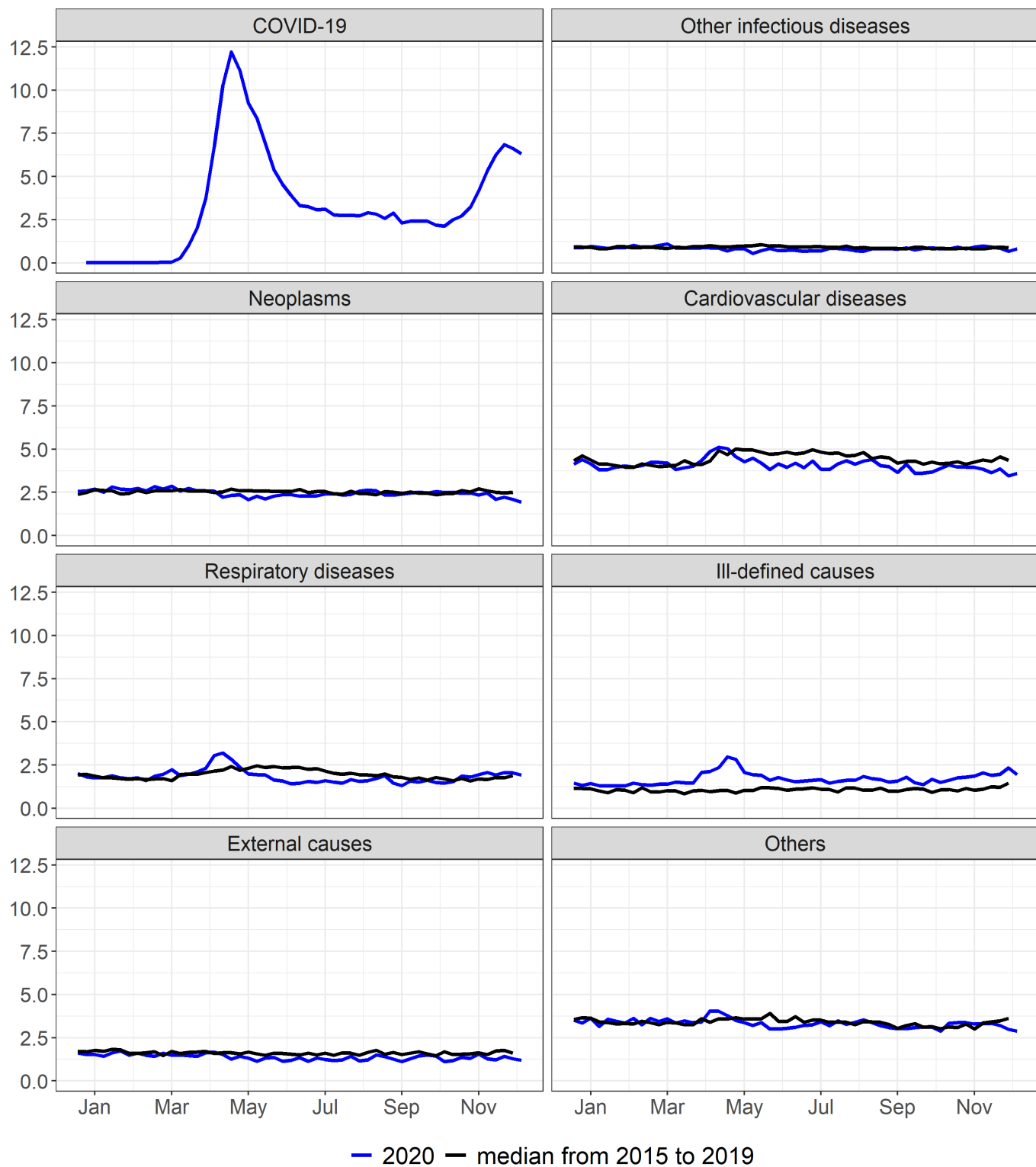
Supplementary figure 13. Mortality rate (per 100.000) by epidemiological week according to selected causes, AP, 2015 to 2020
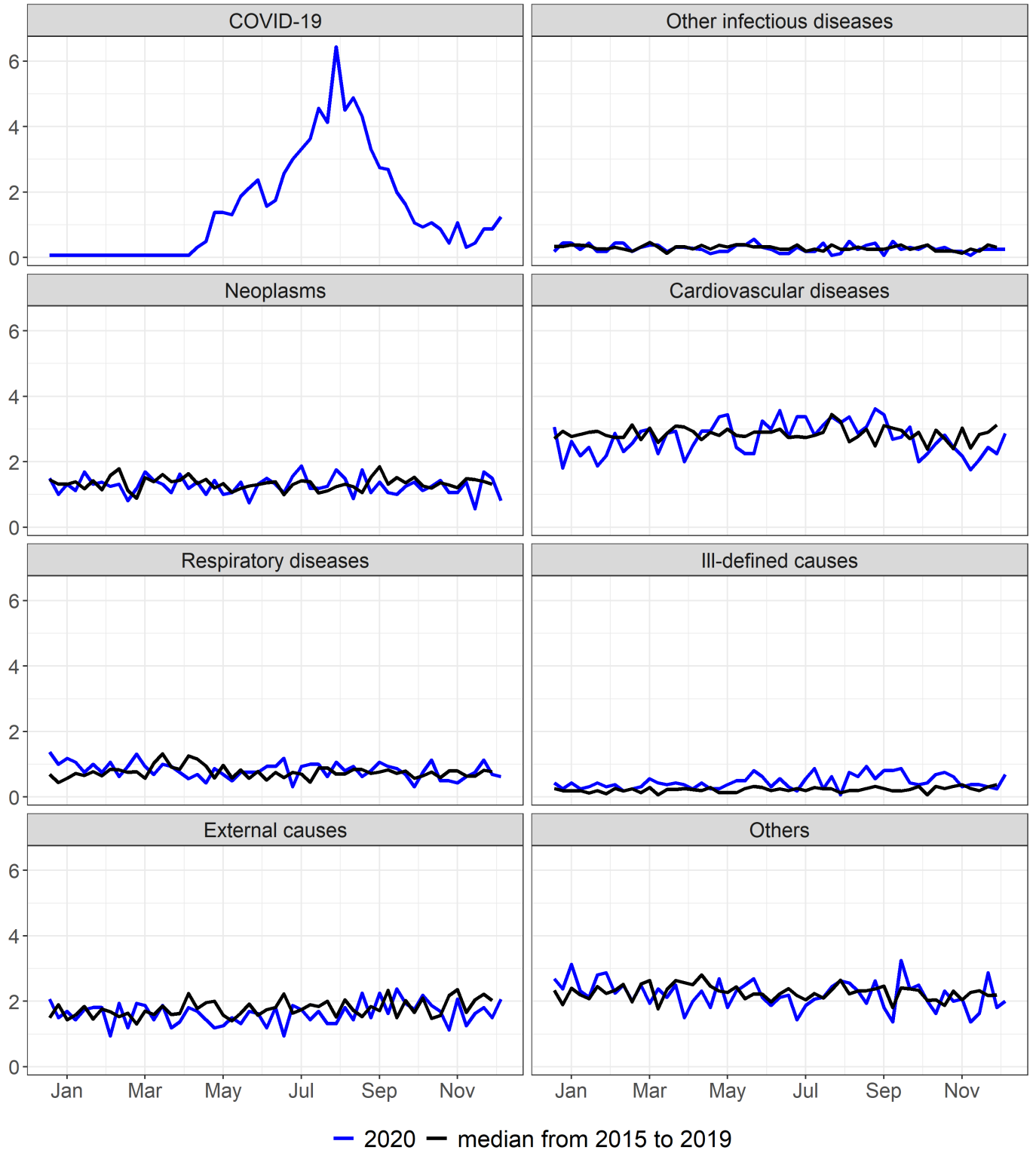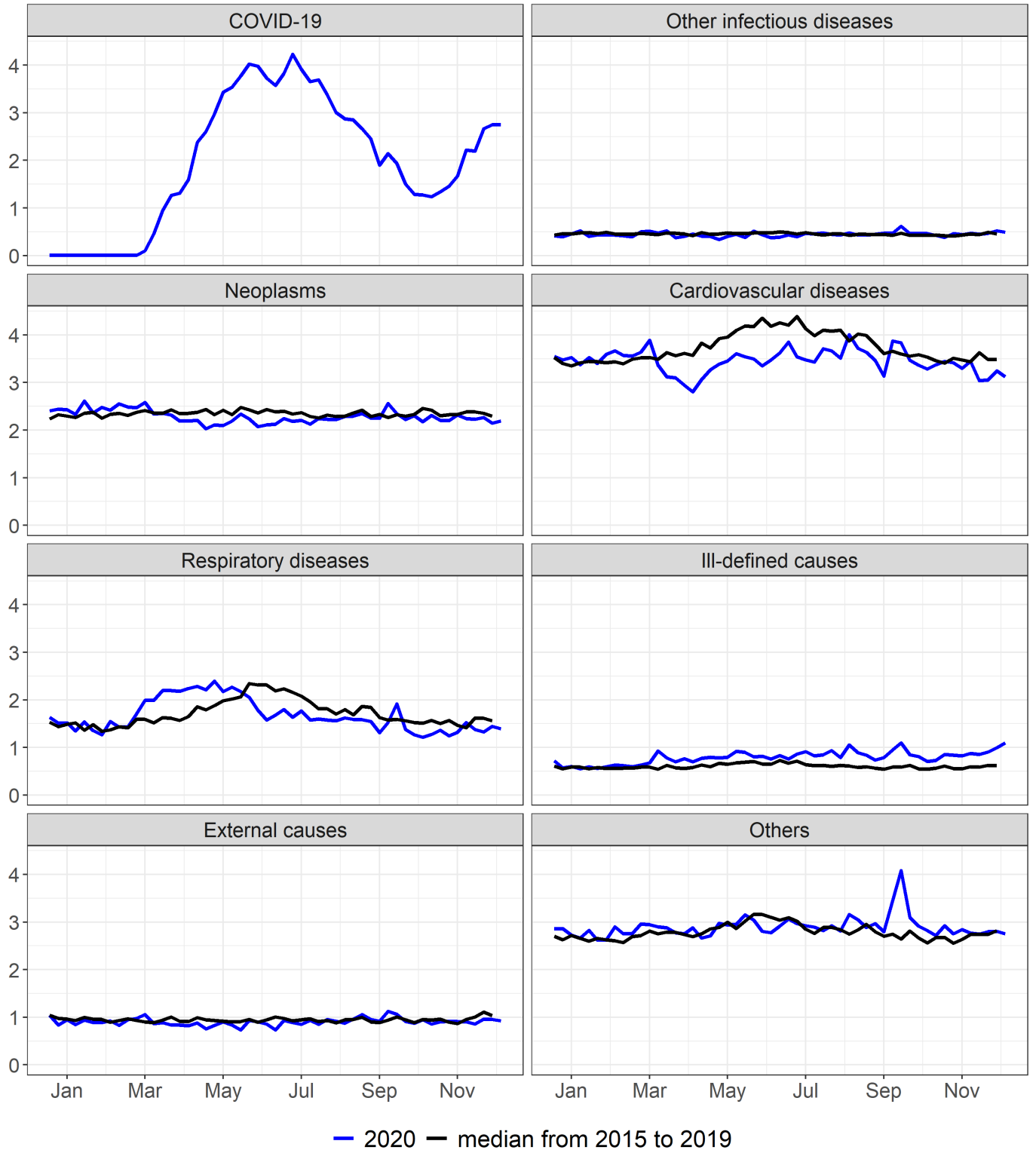
Supplementary figure 14. Mortality rate (per 100.000) by epidemiological week according to selected causes, TO, 2015 to 2020
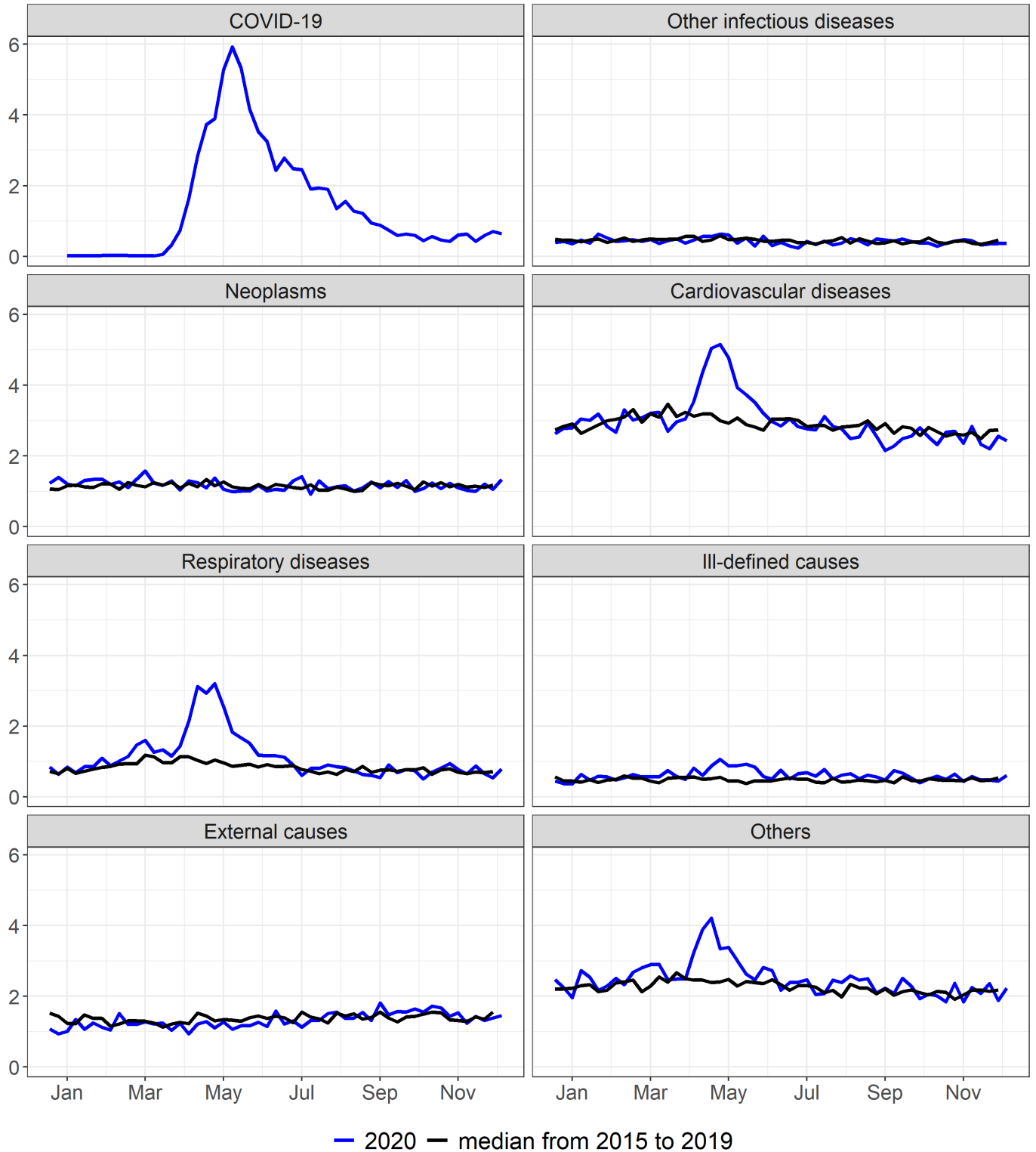
Supplementary figure 15. Mortality rate (per 100.000) by epidemiological week
according to selected causes, MA, 2015 to 2020
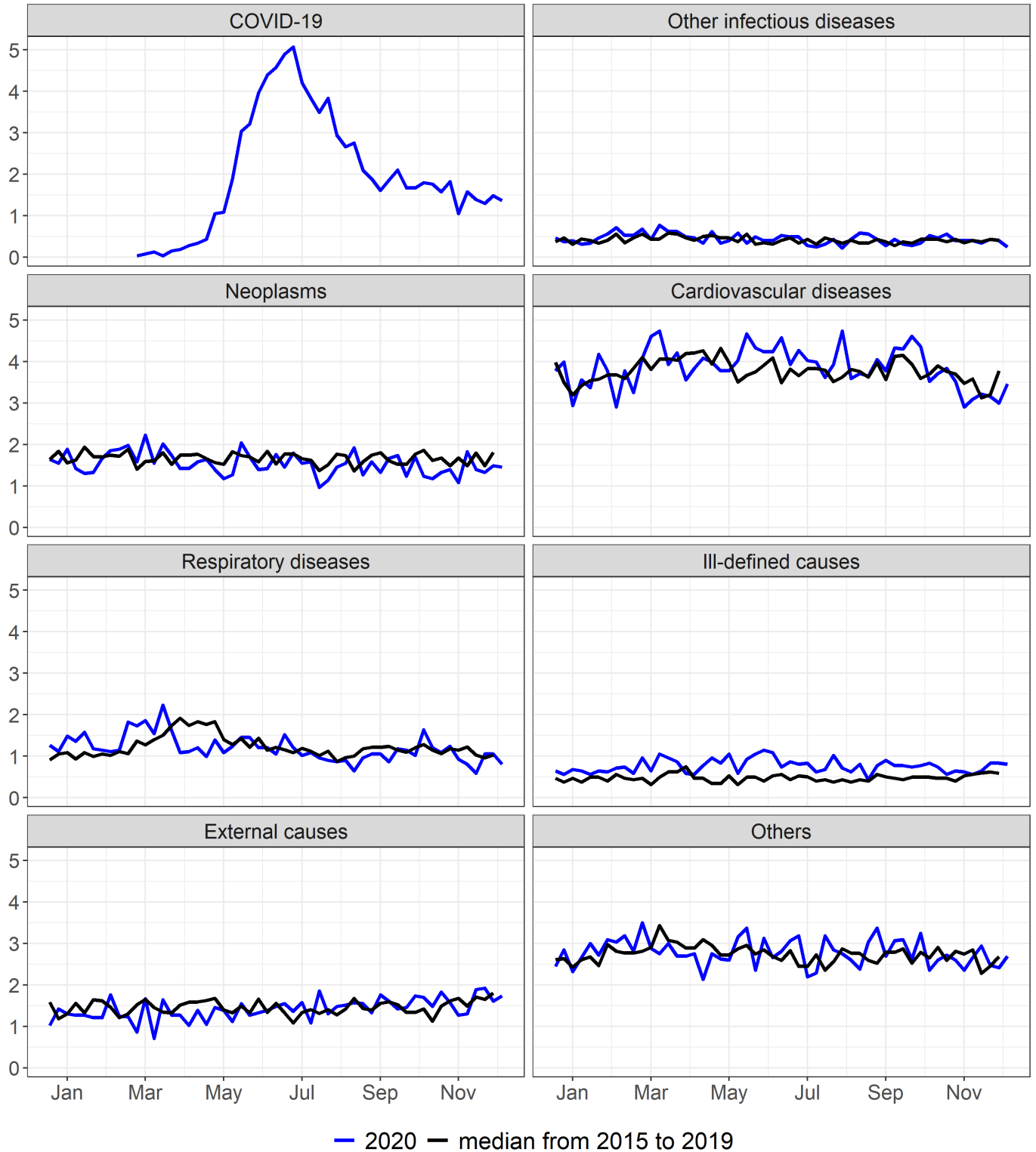
Supplementary figure 16. Mortality rate (per 100.000) by epidemiological week according to selected causes, PI, 2015 to 2020
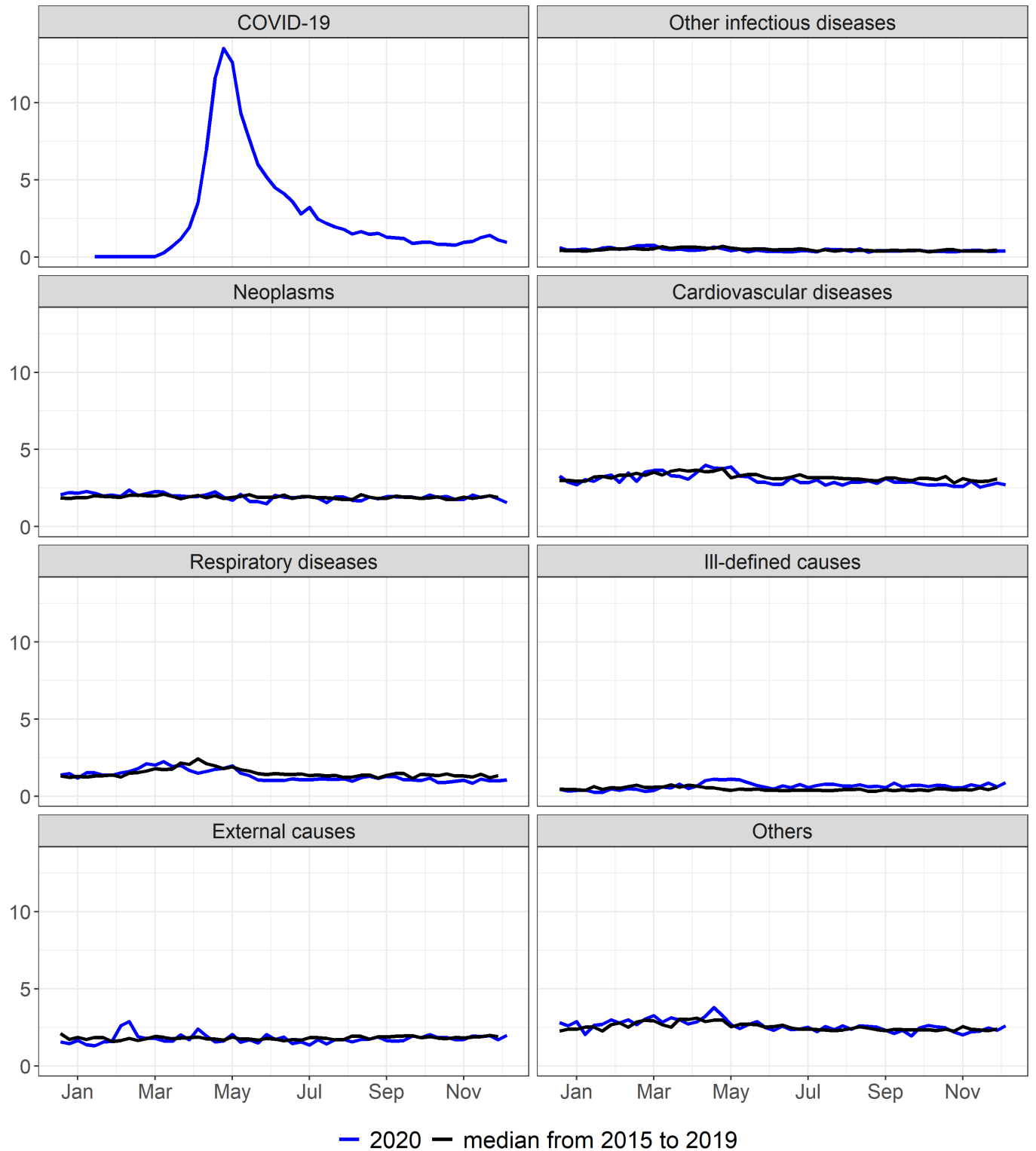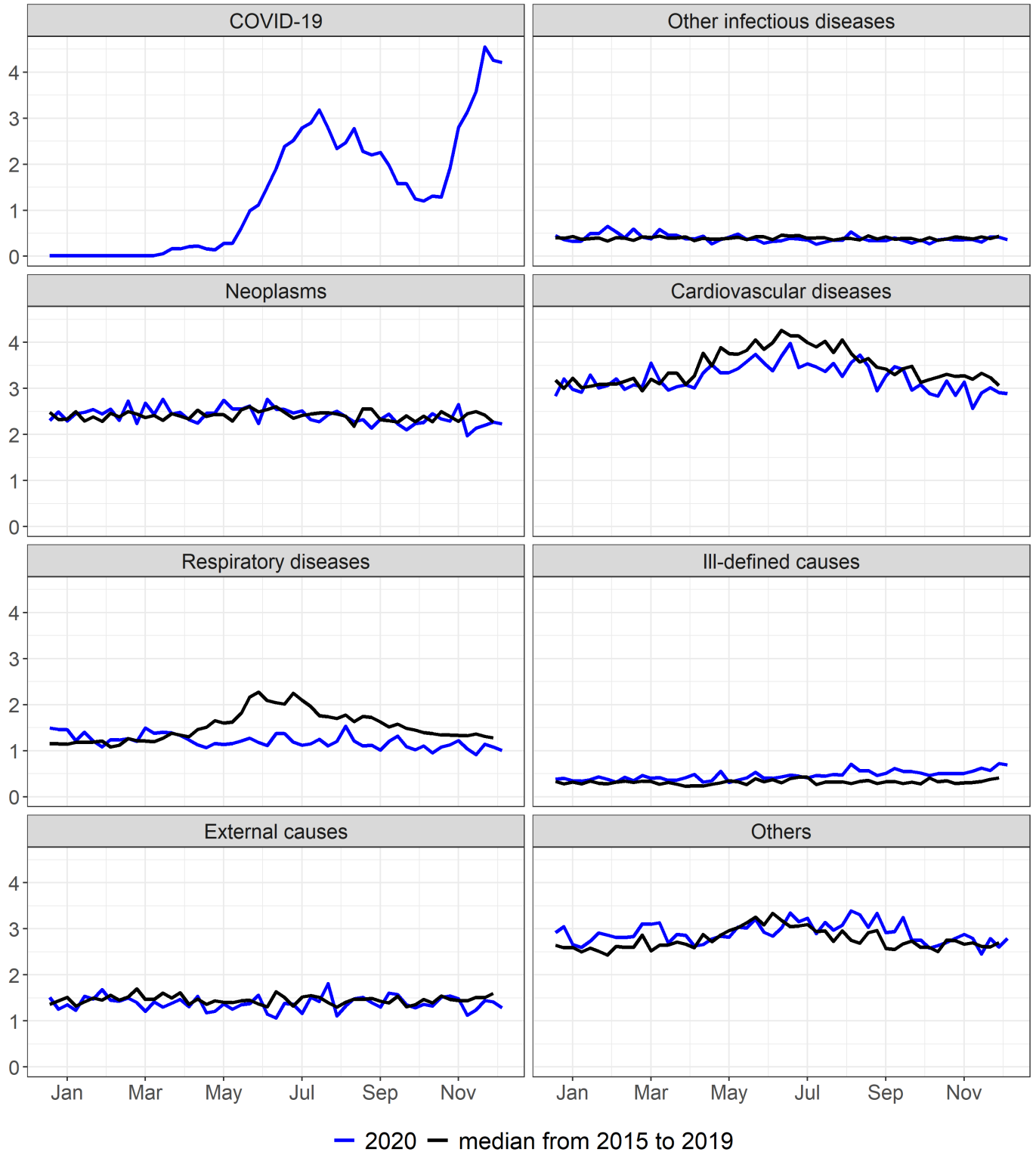
Supplementary figure 17. Mortality rate (per 100.000) by epidemiological week according to selected causes, CE, 2015 to 2020
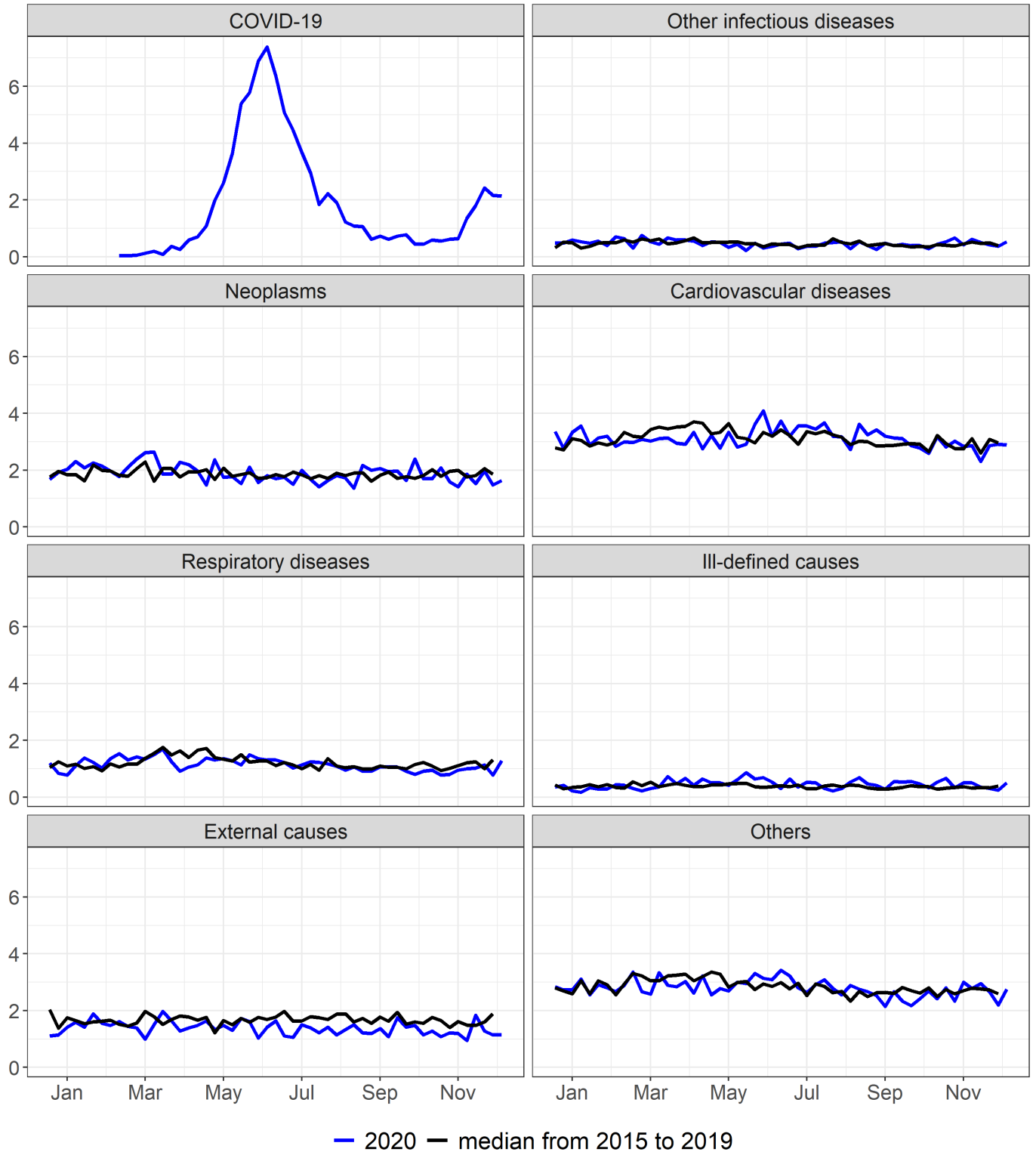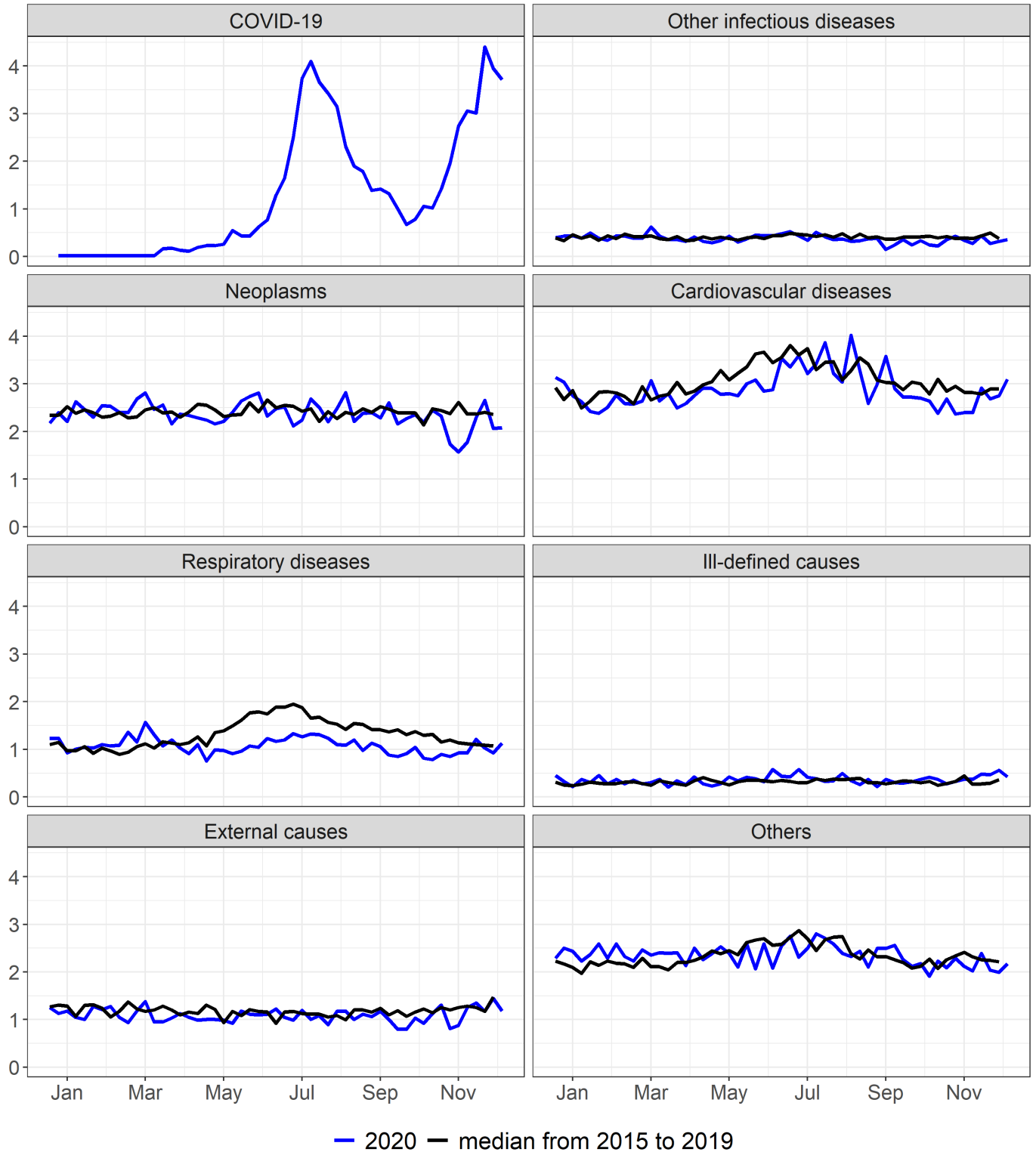
Supplementary figure 18. Mortality rate (per 100.000) by epidemiological week according to selected causes, RN, 2015 to 2020
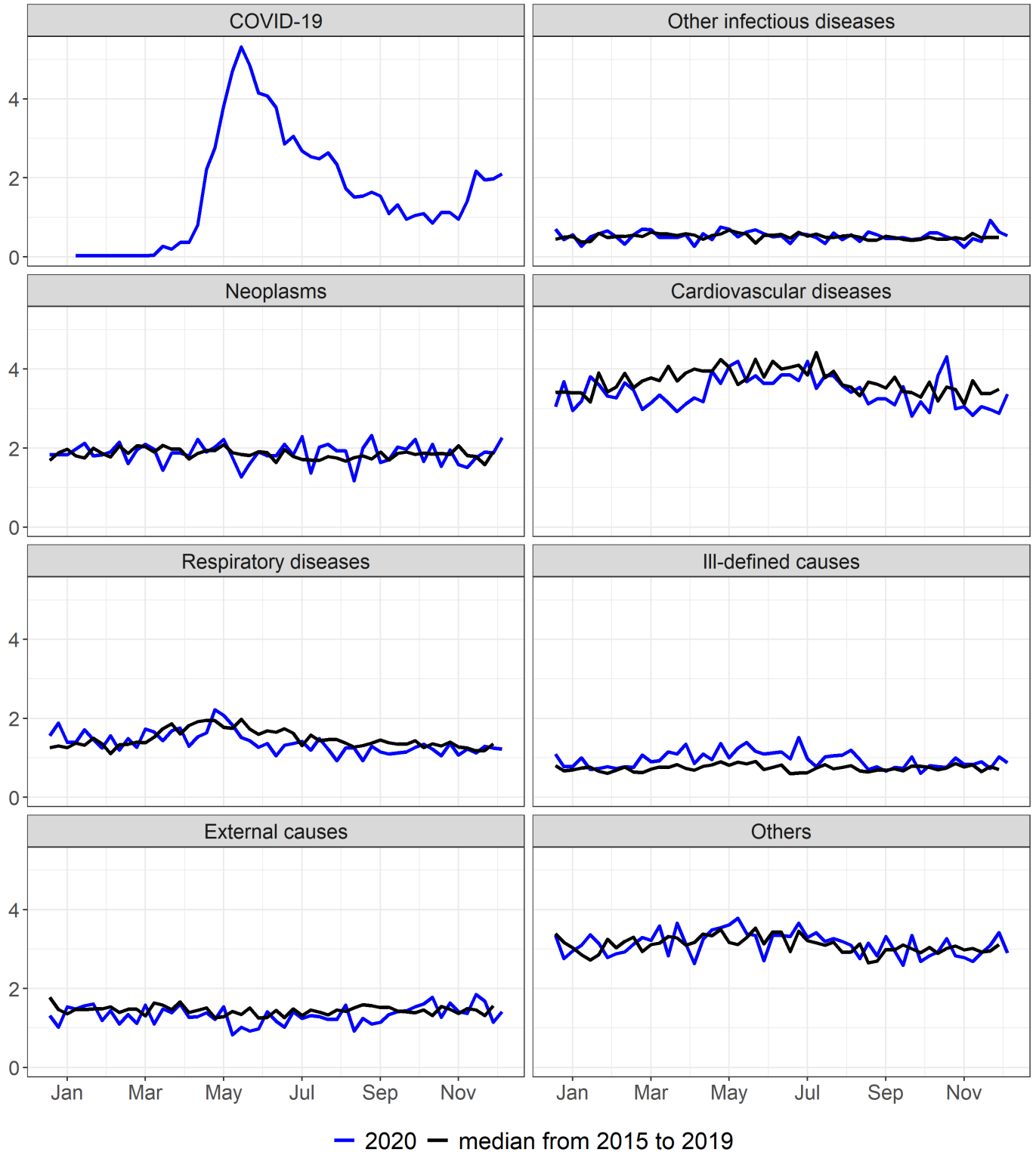
Supplementary figure 19. Mortality rate (per 100.000) by epidemiological week according to selected causes, PB, 2015 to 2020
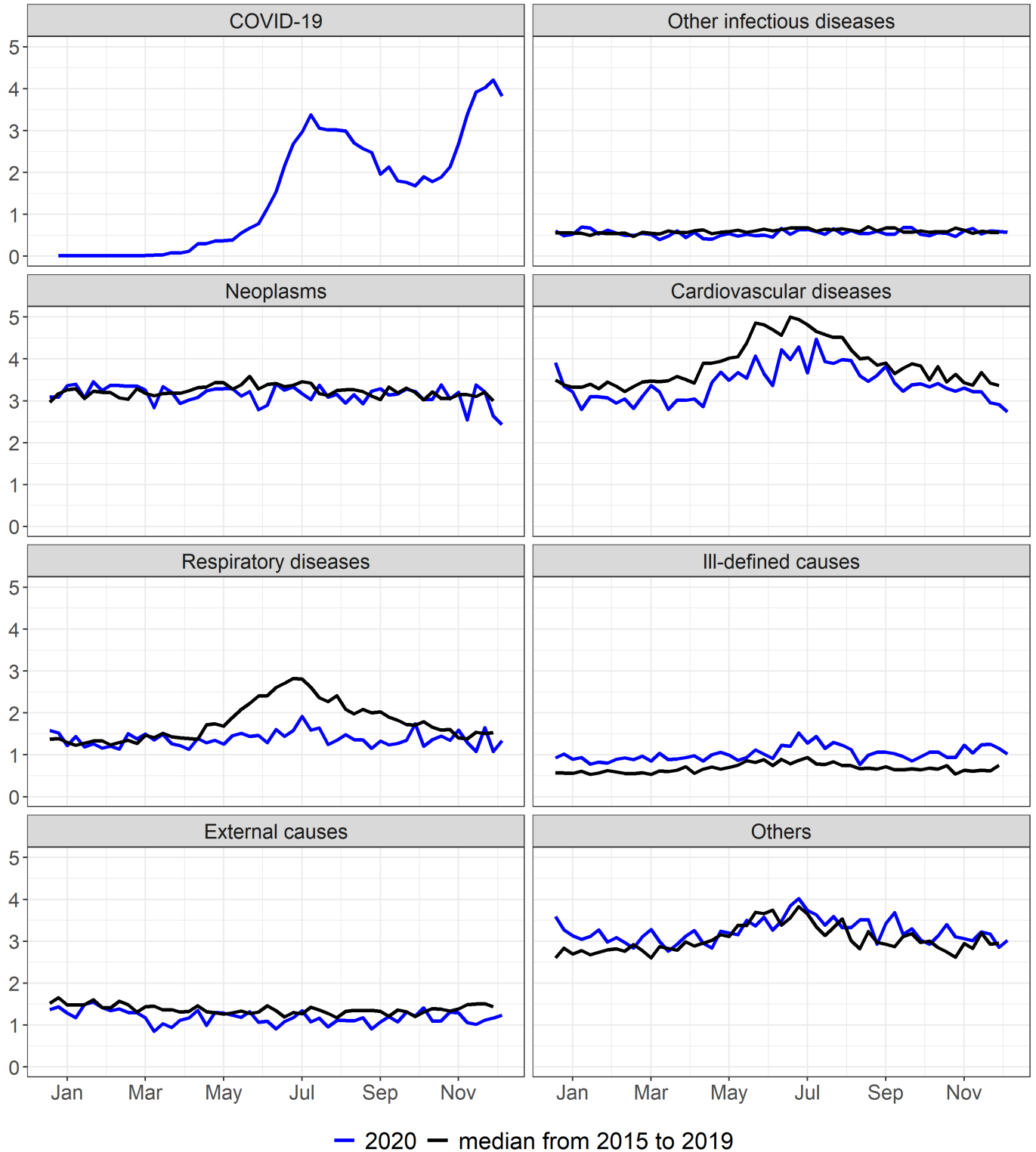
Supplementary figure 20. Mortality rate (per 100.000) by epidemiological week according to selected causes, PE, 2015 to 2020

Supplementary figure 21. Mortality rate (per 100.000) by epidemiological week according to selected causes, AL, 2015 to 2020
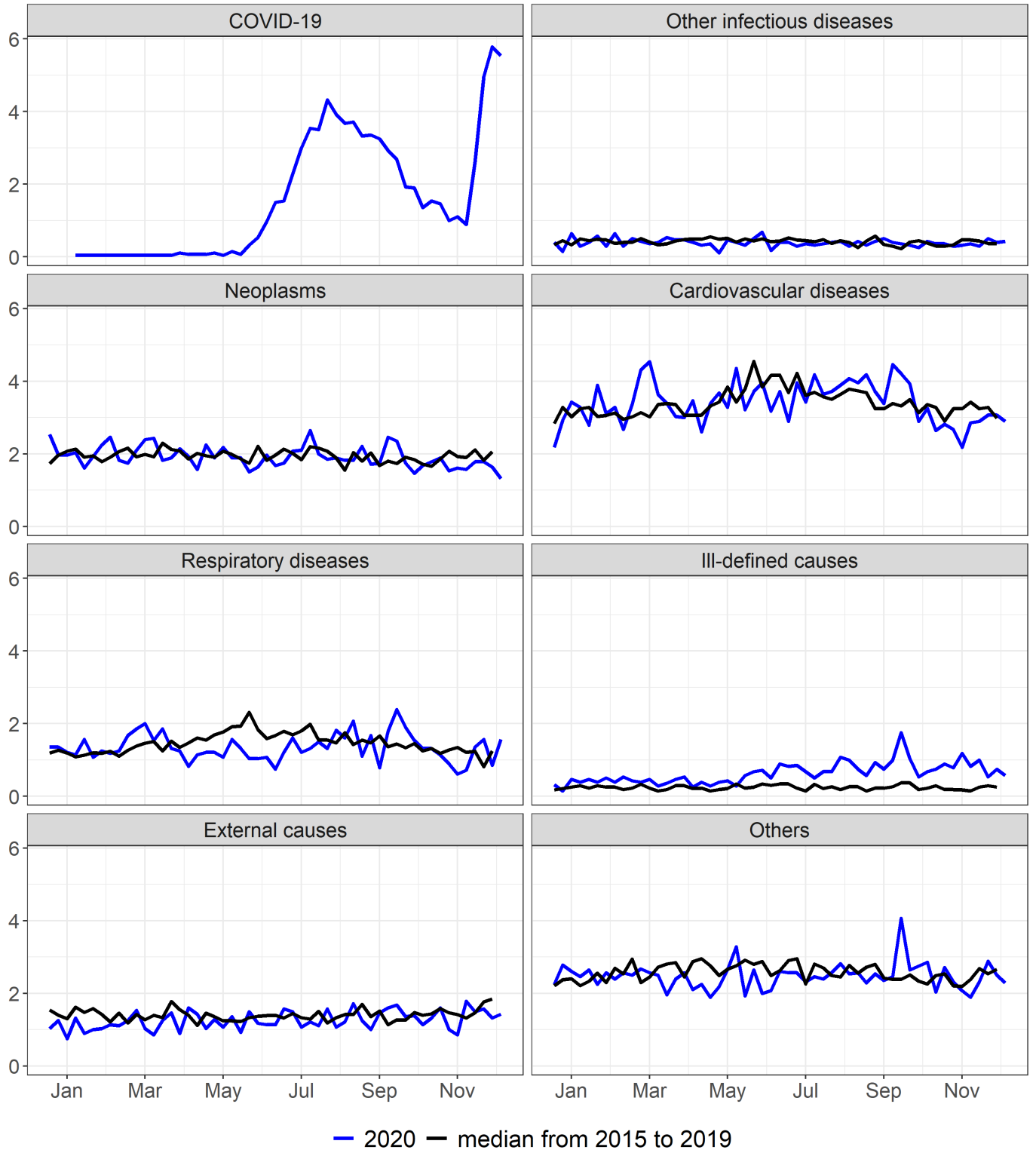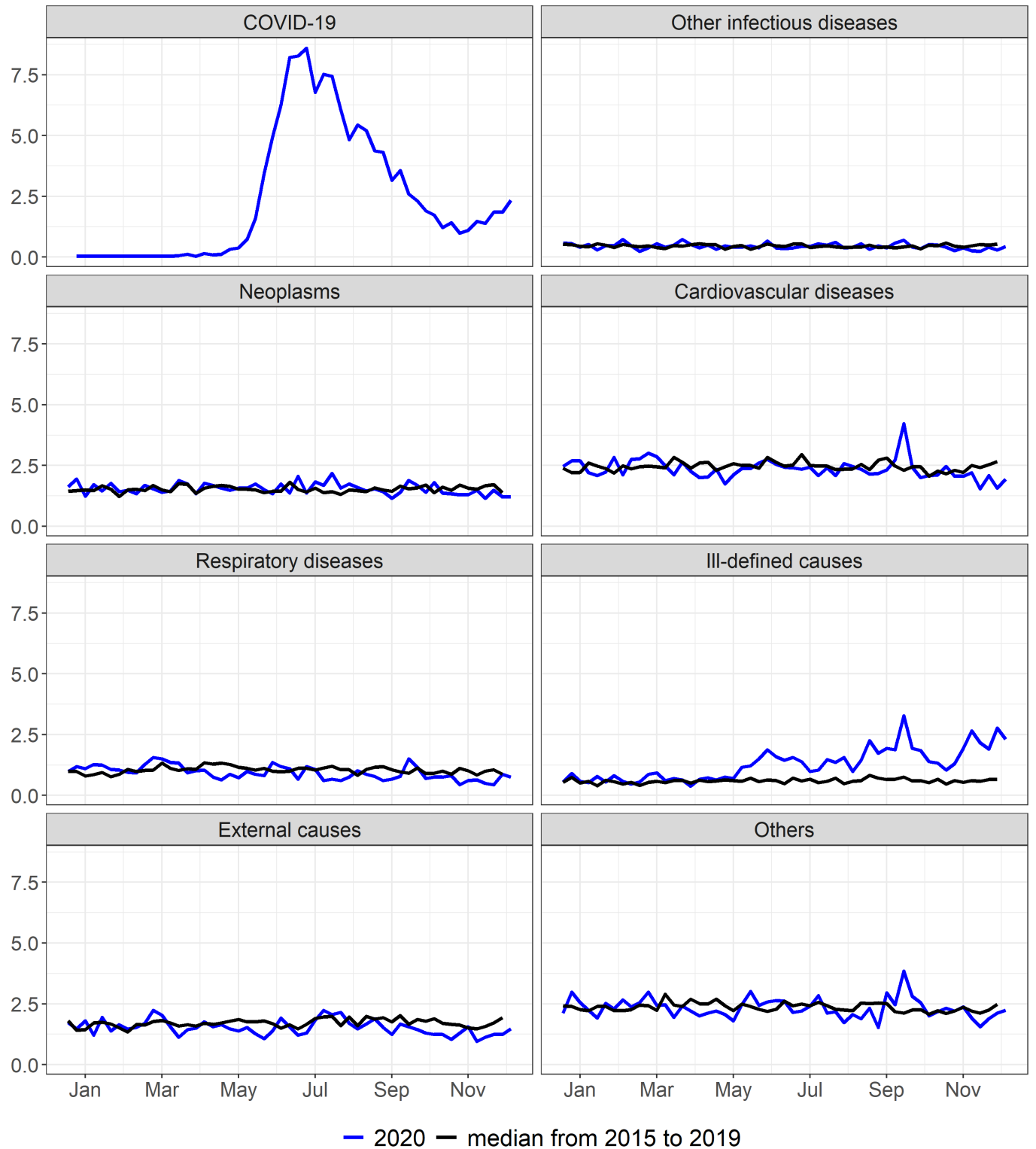
Supplementary figure 22. Mortality rate (per 100.000) by epidemiological week
according to selected causes, SE, 2015 to 2020

Supplementary figure 23. Mortality rate (per 100.000) by epidemiological week according to selected causes, BA, 2015 to 2020

Supplementary figure 24. Mortality rate (per 100.000) by epidemiological week
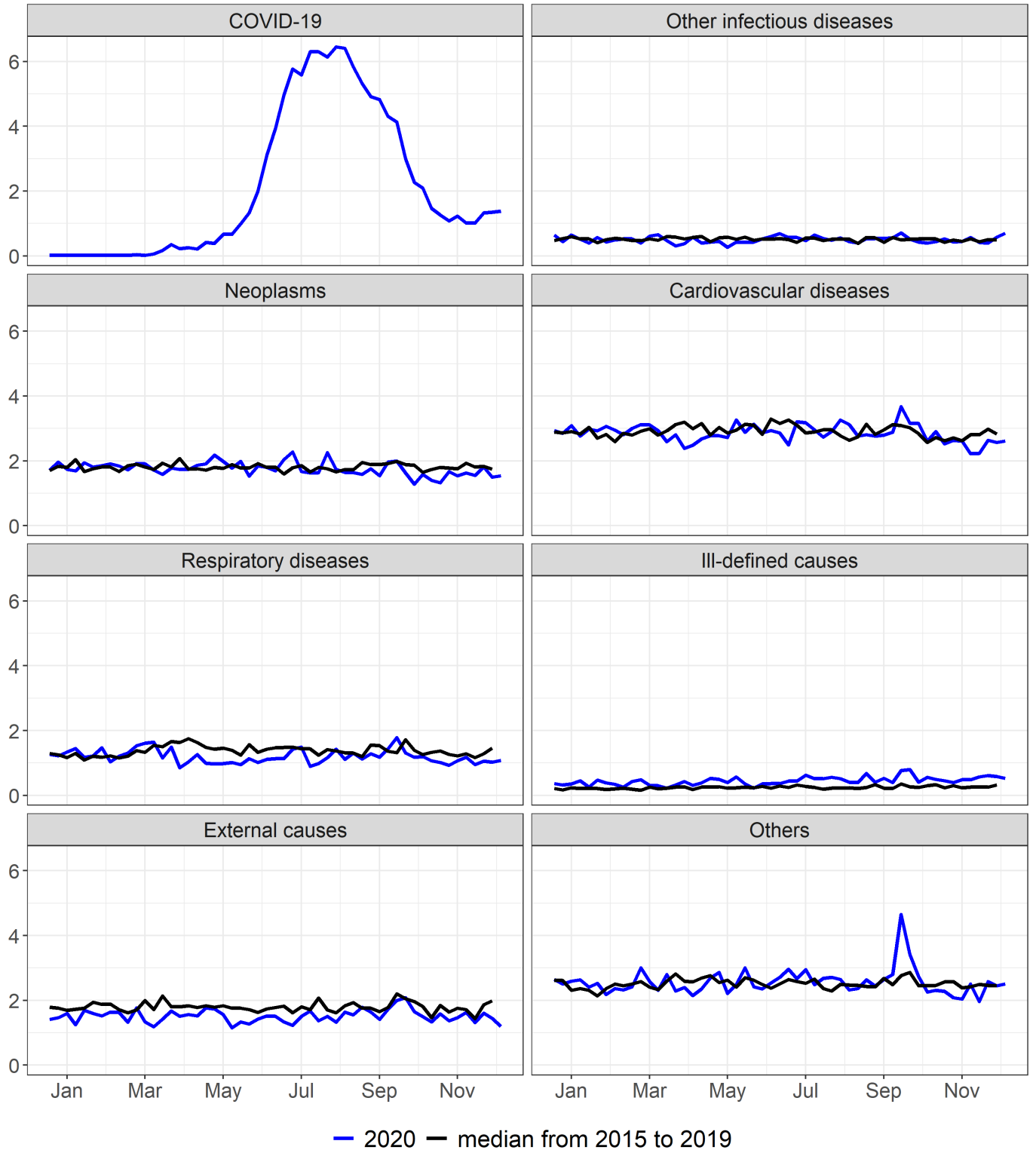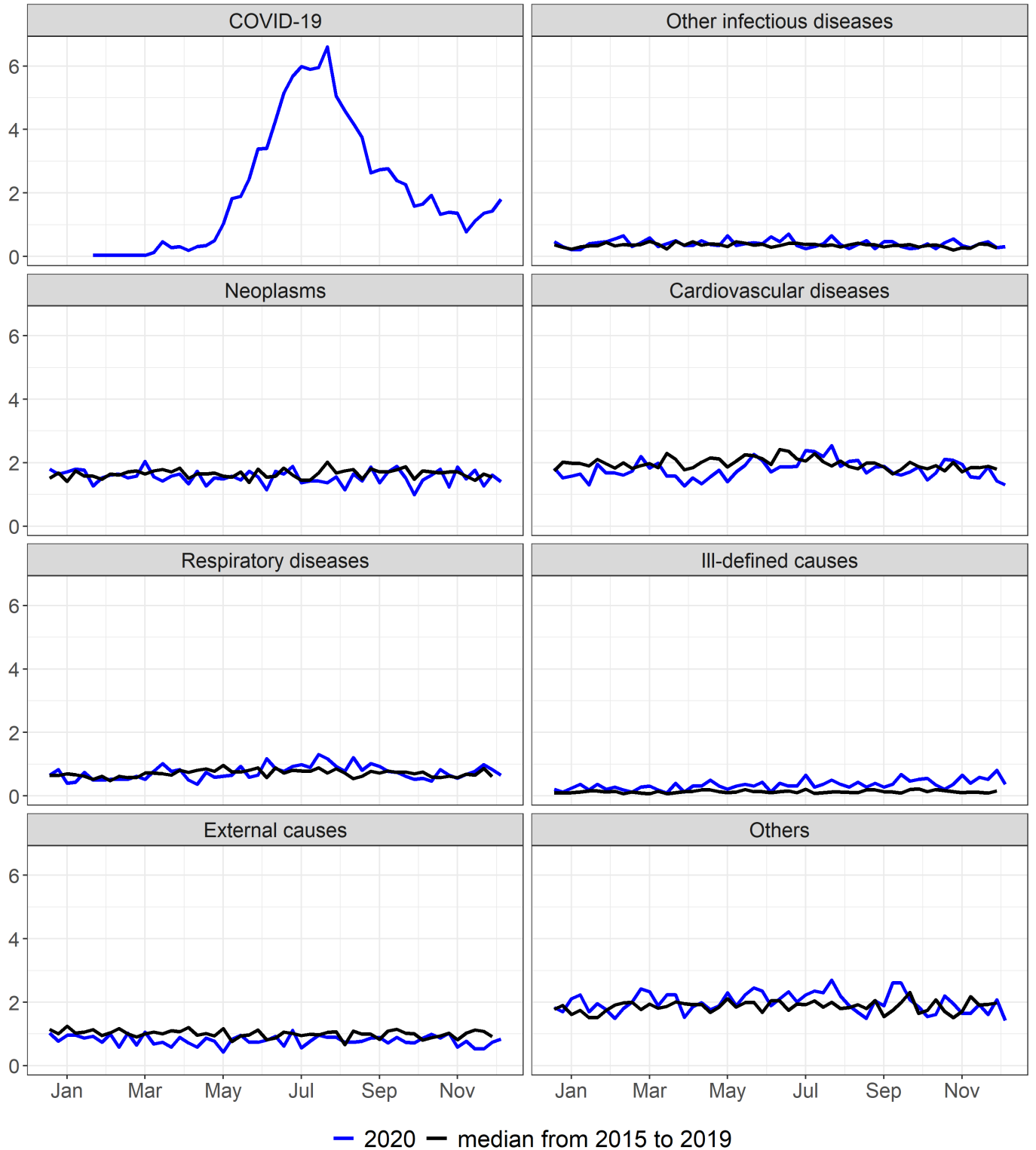according to selected causes, MG, 2015 to 2020

Supplementary figure 25. Mortality rate (per 100.000) by epidemiological week
according to selected causes, ES, 2015 to 2020

Supplementary figure 26. Mortality rate (per 100.000) by epidemiological week according to selected causes, RJ, 2015 to 2020

Supplementary figure 27. Mortality rate (per 100.000) by epidemiological week according to selected causes, SP, 2015 to 2020
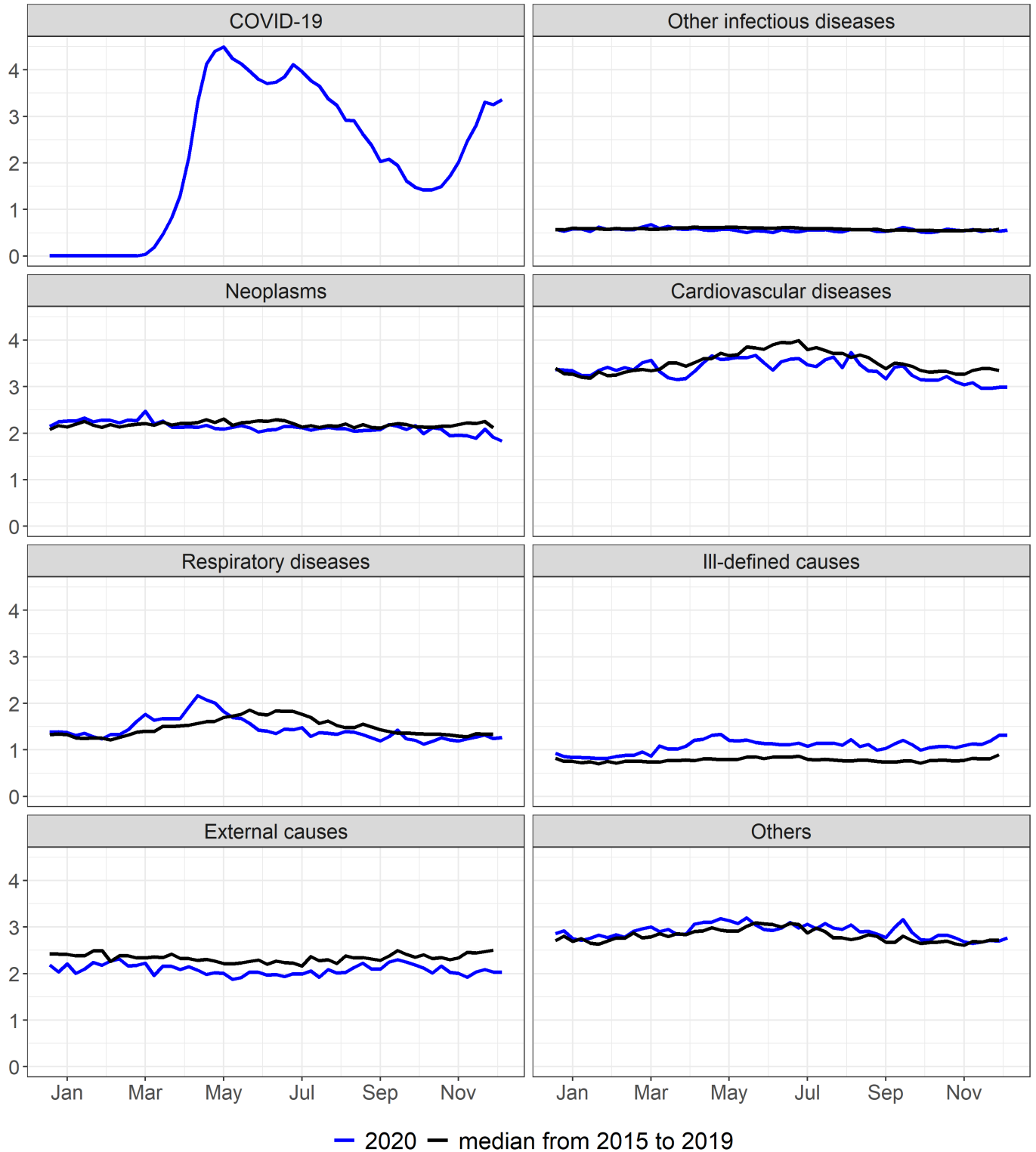
Supplementary figure 28. Mortality rate (per 100.000) by epidemiological week
according to selected causes, PR, 2015 to 2020

Supplementary figure 29. Mortality rate (per 100.000) by epidemiological week according to selected causes, SC, 2015 to 2020
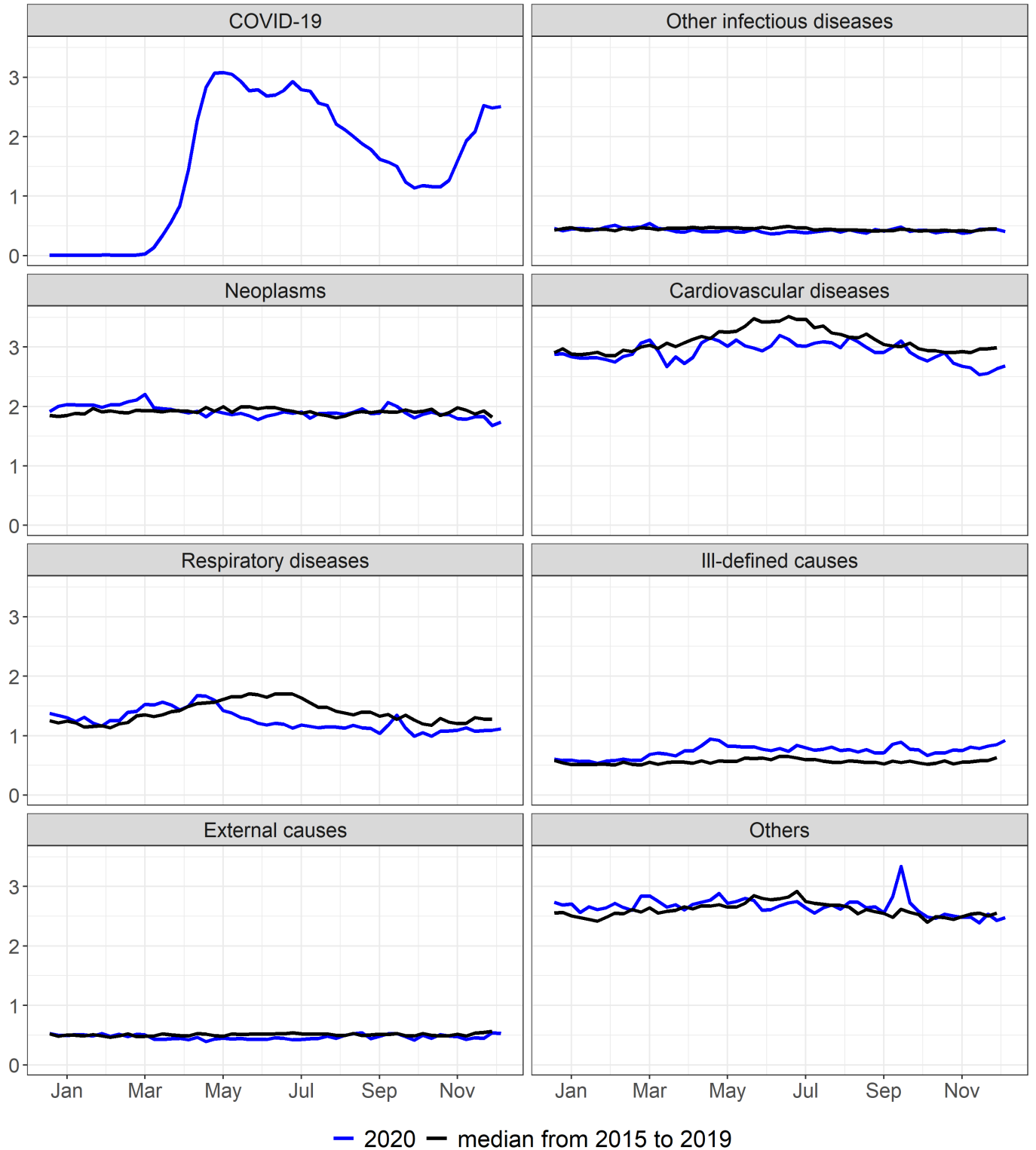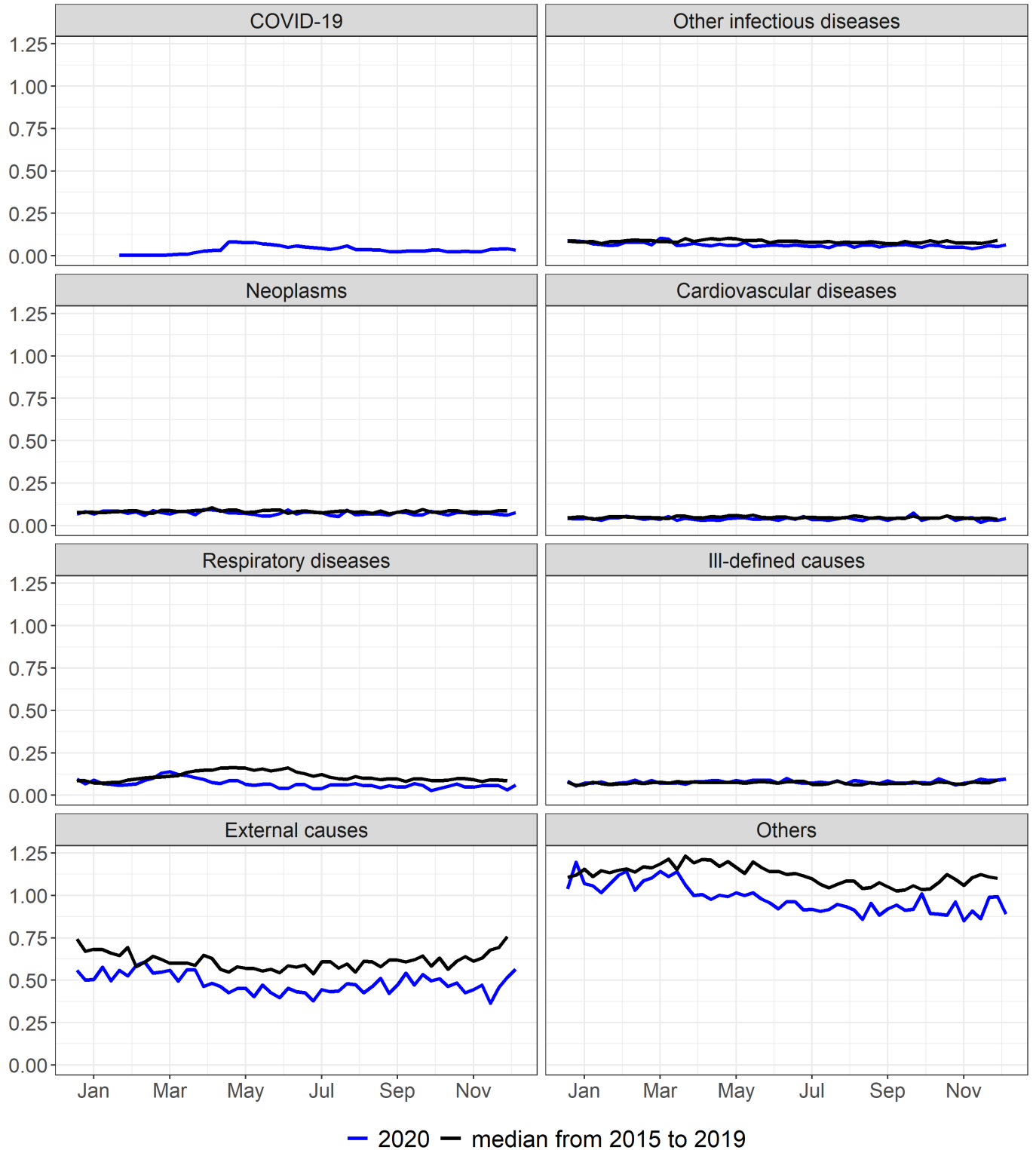
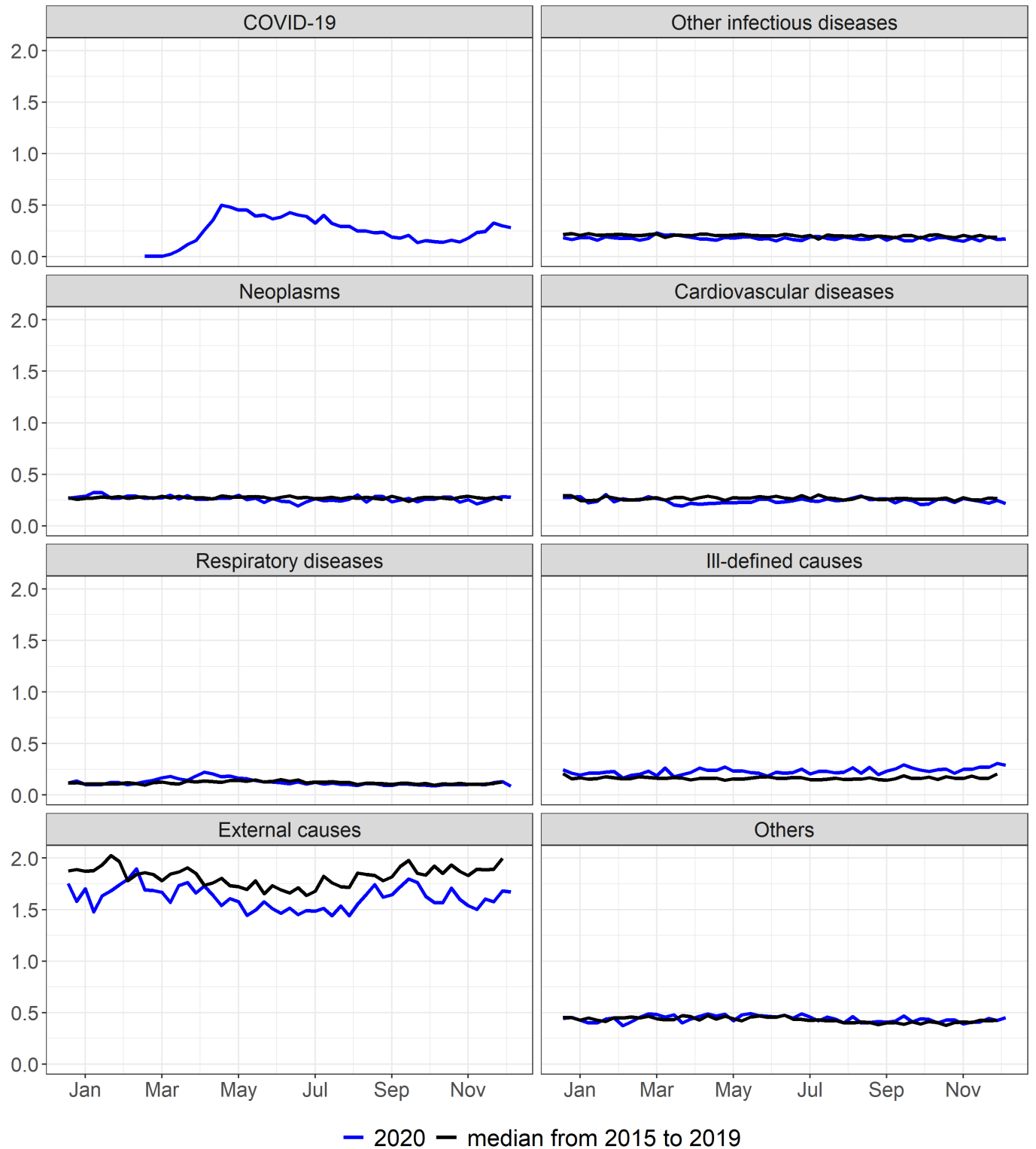Supplementary figure 30. Mortality rate (per 100.000) by epidemiological week according to selected causes, RS, 2015 to 2020

Supplementary figure 31. Mortality rate (per 100.000) by epidemiological week
according to selected causes, MS, 2015 to 2020

Supplementary figure 32. Mortality rate (per 100.000) by epidemiological week according to selected causes, MT, 2015 to 2020

Supplementary figure 33. Mortality rate (per 100.000) by epidemiological week according to selected causes, GO, 2015 to 2020

Supplementary figure 34. Mortality rate (per 100.000) by epidemiological week according to selected causes, DF, 2015 to 2020

Supplementary figure 35. Mortality rate (per 100.000) by epidemiological week according to selected causes, Male sex, 2015 to 2020

Supplementary figure 36. Mortality rate (per 100.000) by epidemiological week according to selected causes, Female sex, 2015 to 2020
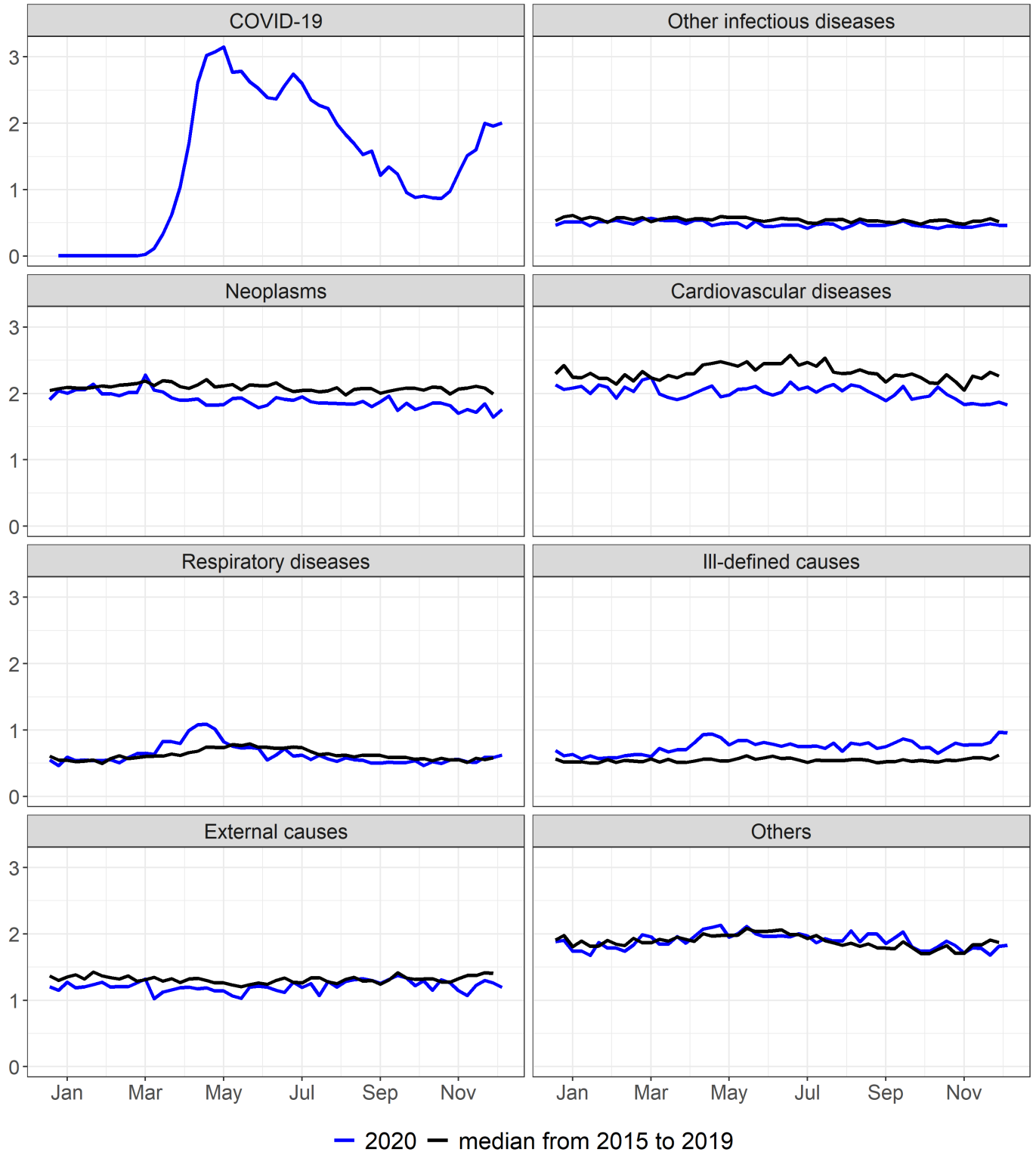
Supplementary figure 37. Mortality rate (per 100.000) by epidemiological week according to selected causes, Age_00_to_19, 2015 to 2020
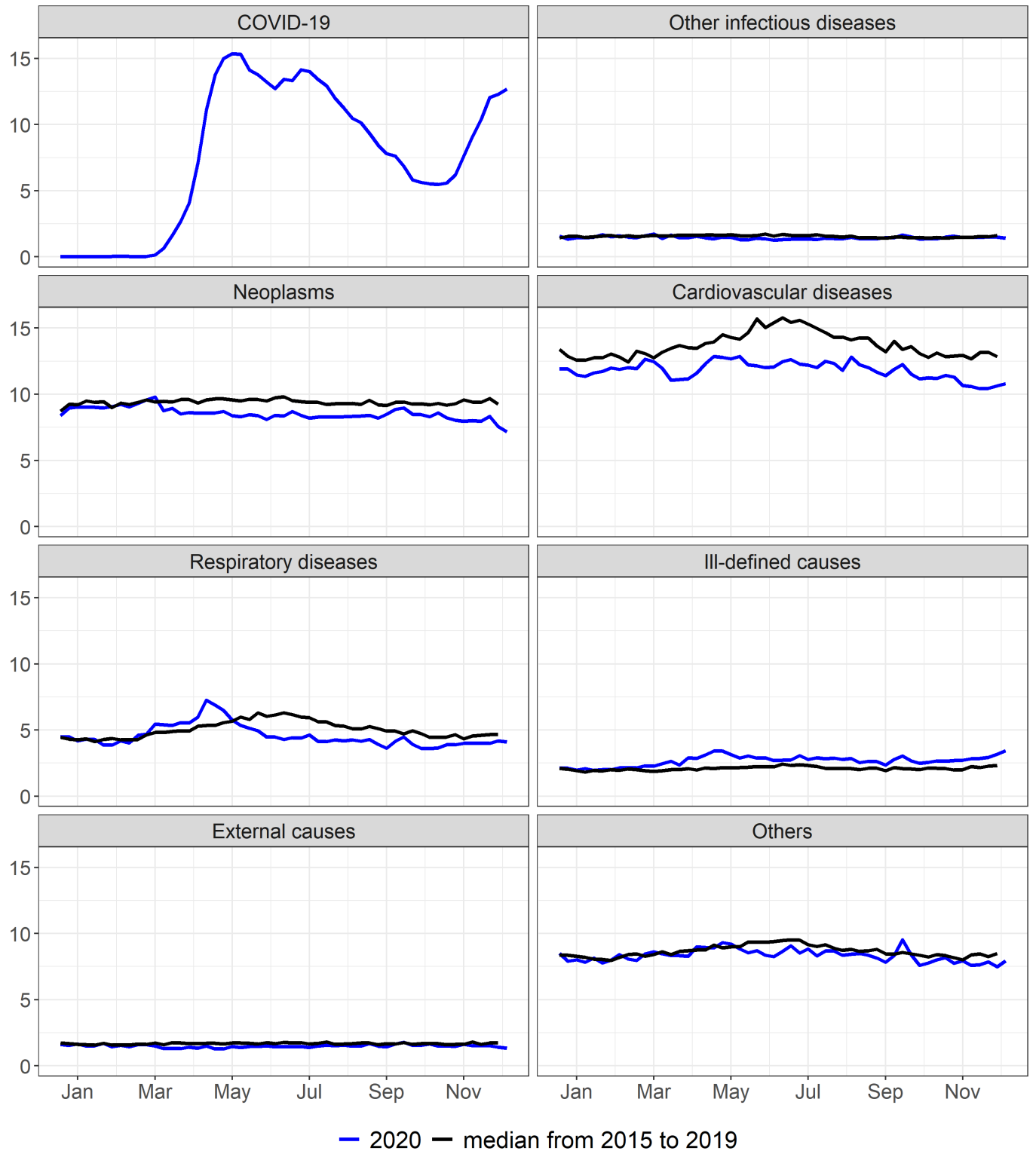
Supplementary figure 38. Mortality rate (per 100.000) by epidemiological week according to selected causes, Age_20_to_39, 2015 to 2020
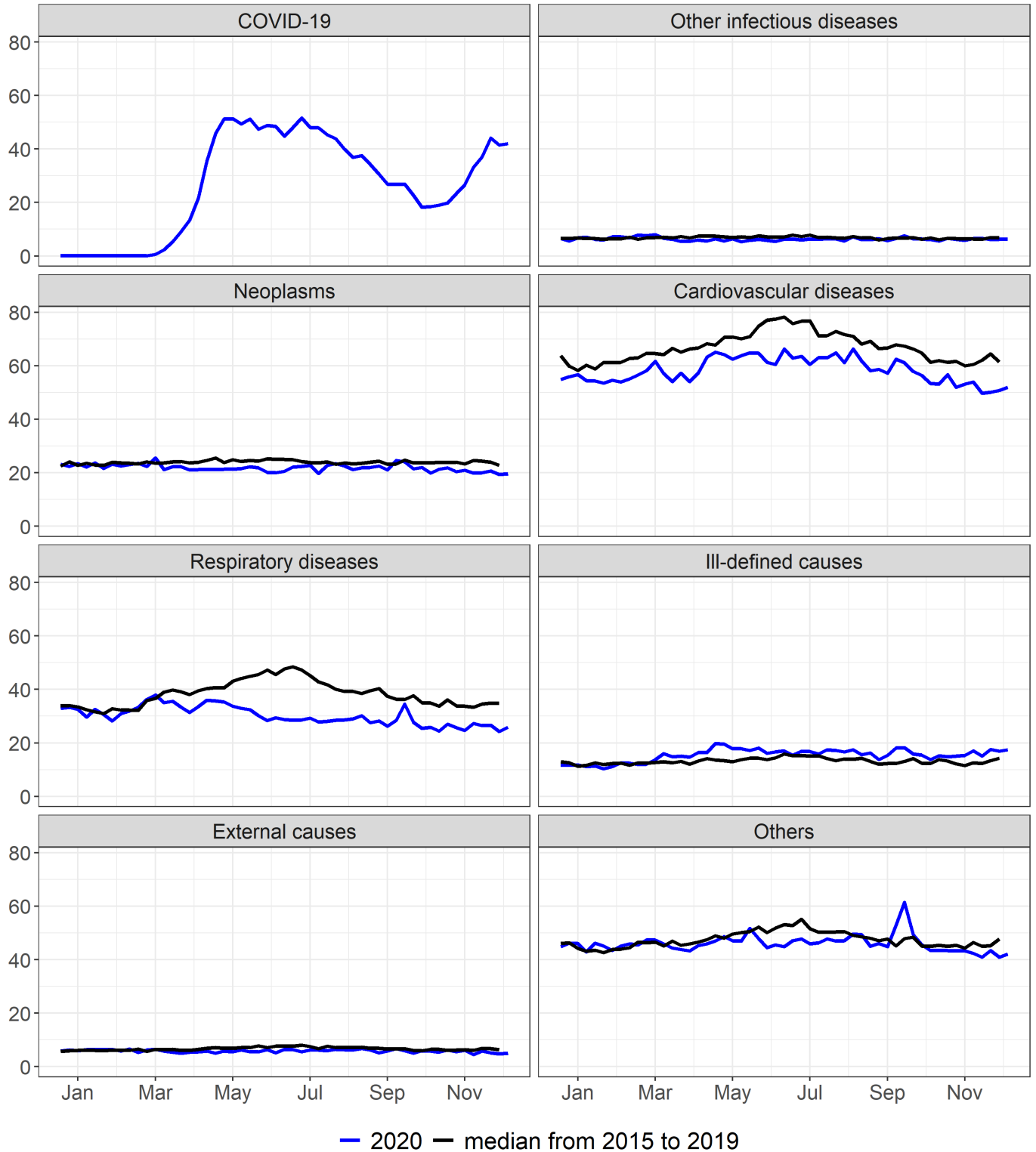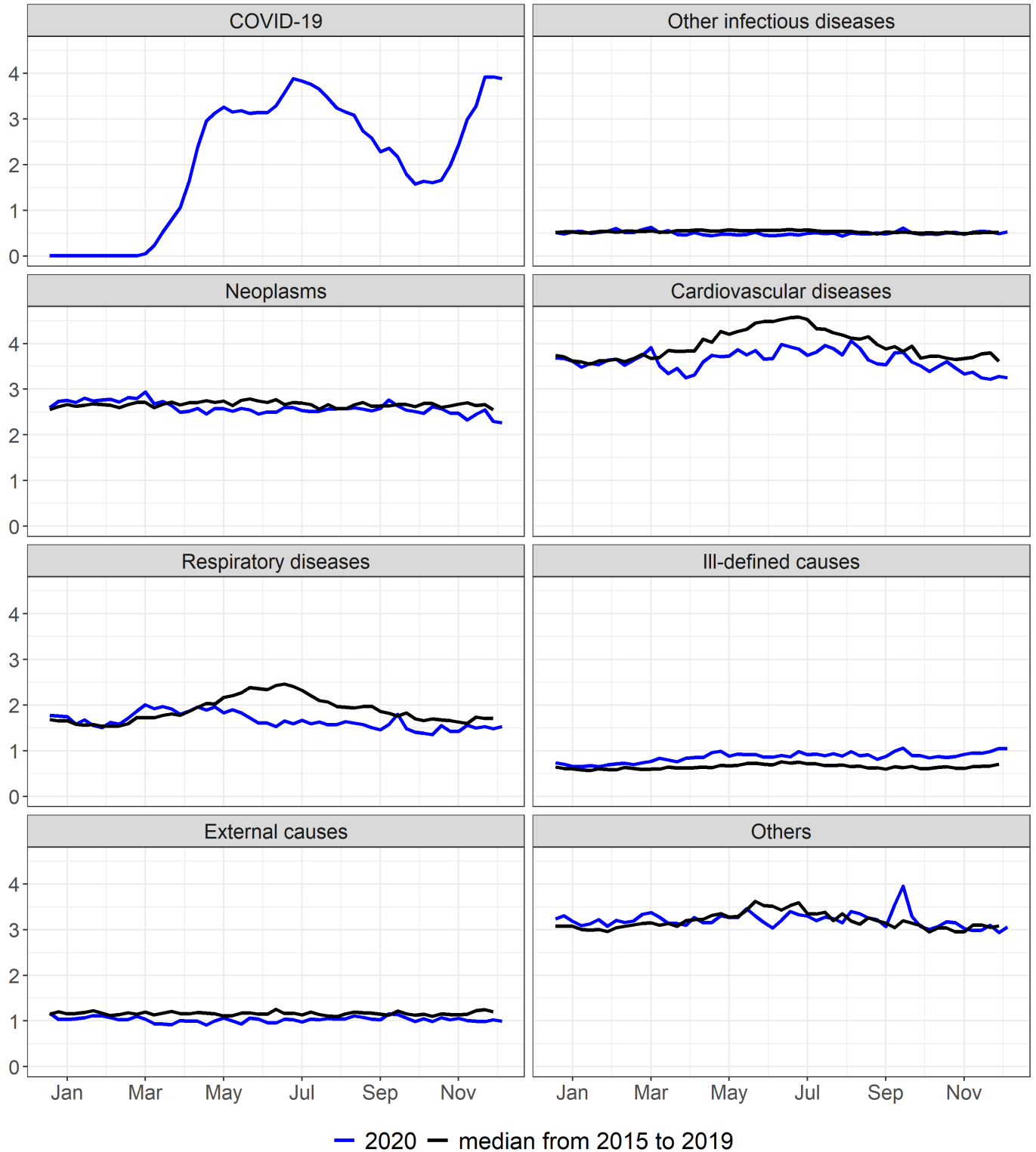
Supplementary figure 39. Mortality rate (per 100.000) by epidemiological week
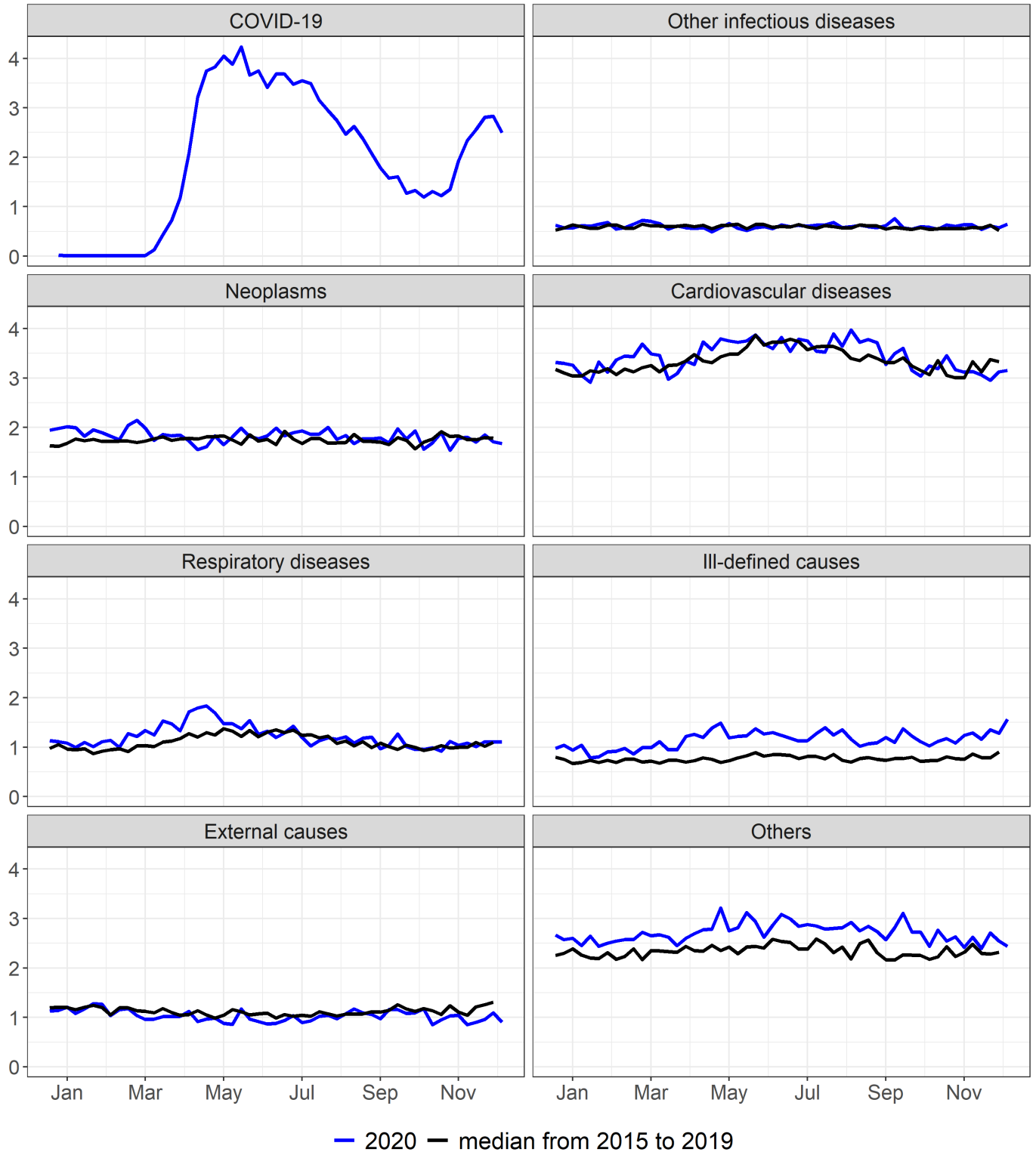according to selected causes, Age_40_to_59, 2015 to 2020

Supplementary figure 40. Mortality rate (per 100.000) by epidemiological week according to selected causes, Age_60_to_79, 2015 to 2020
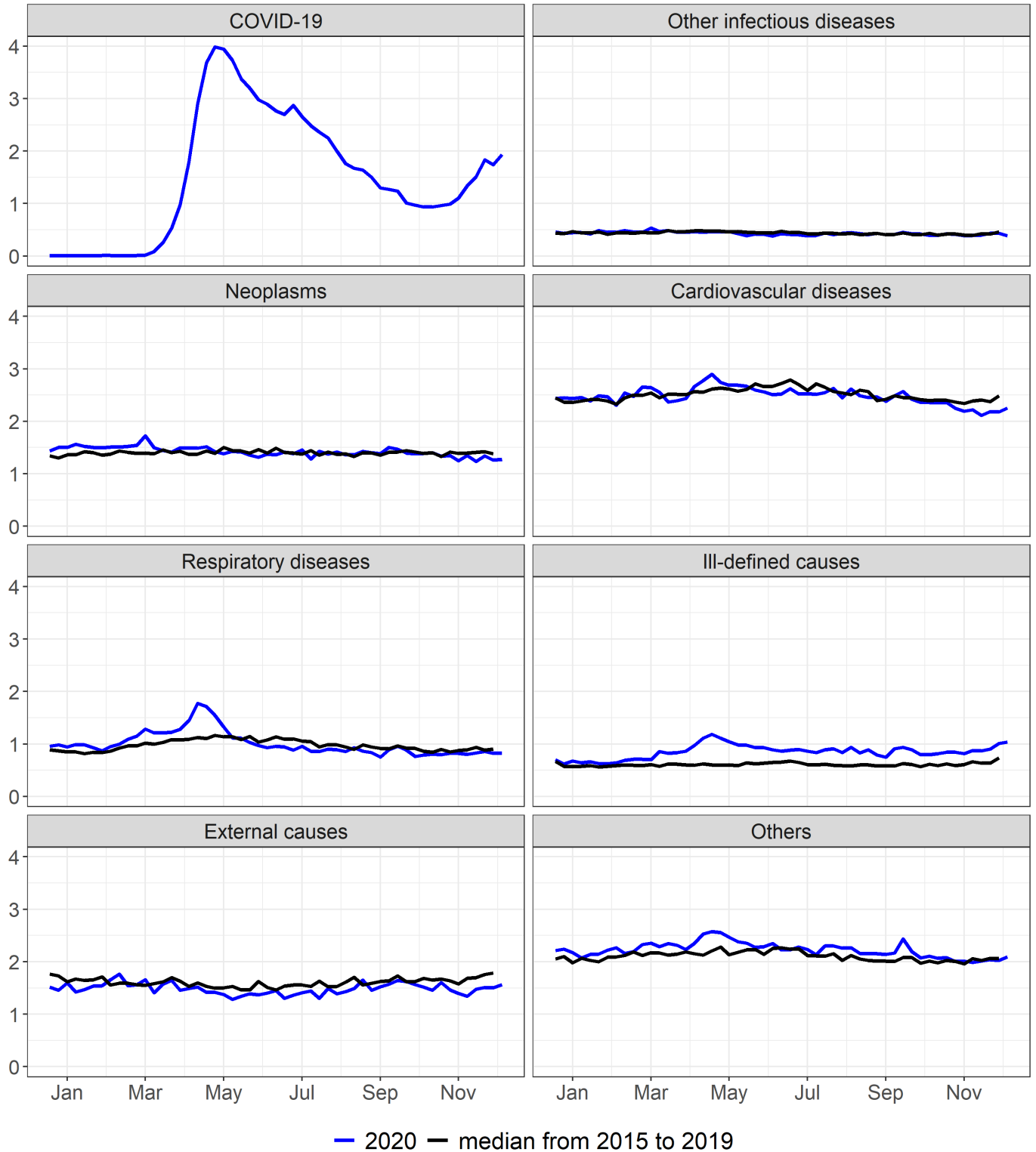
Supplementary figure 41. Mortality rate (per 100.000) by epidemiological week according to selected causes, Age_80_or_older, 2015 to 2020
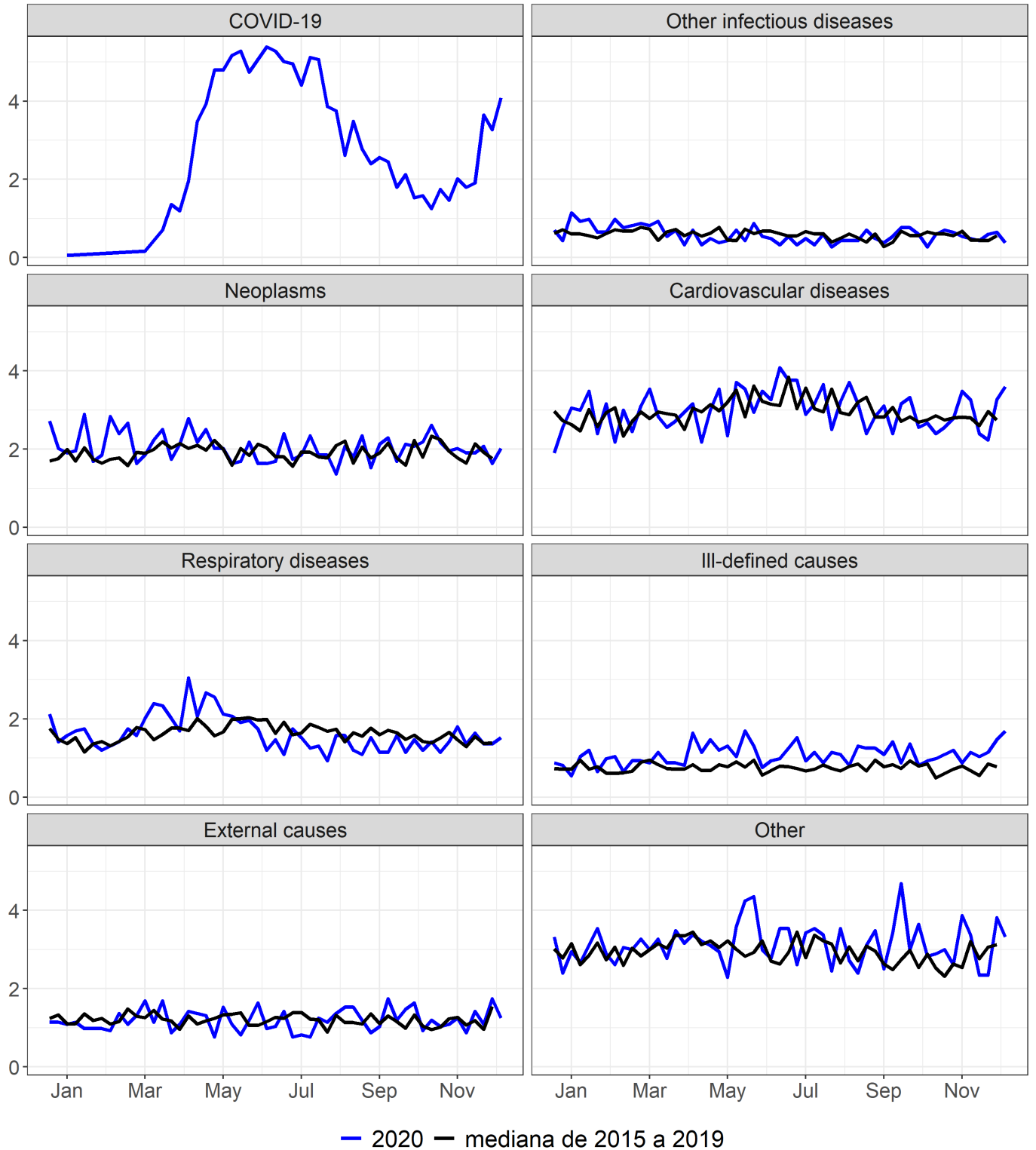
Supplementary figure 42. Mortality rate (per 100.000) by epidemiological week according to selected causes, White race, 2015 to 2020

Supplementary figure 43. Mortality rate (per 100.000) by epidemiological week according to selected causes, Black race, 2015 to 2020

Supplementary figure 44. Mortality rate (per 100.000) by epidemiological week according to selected causes, Brown race, 2015 to 2020
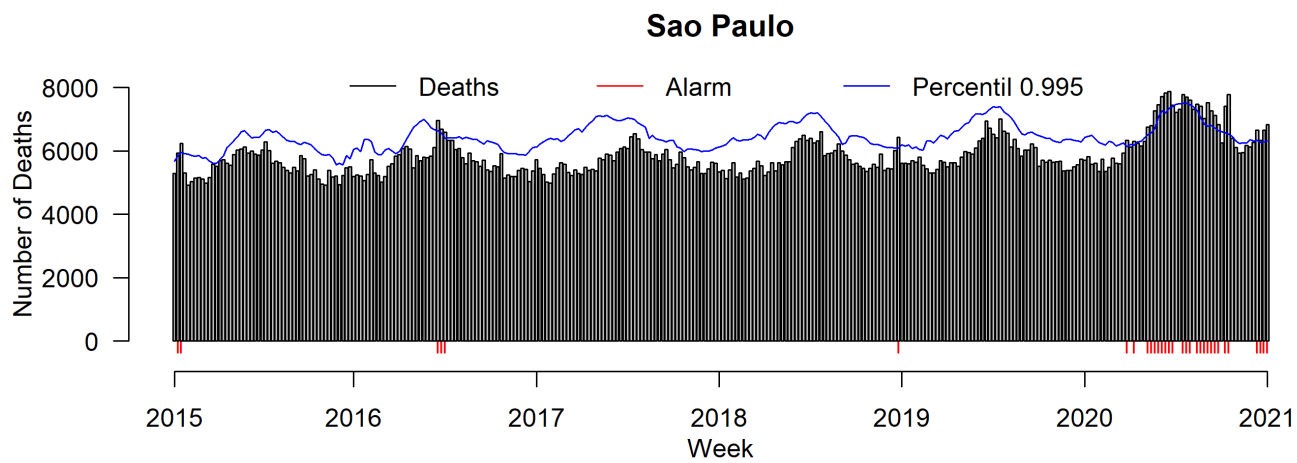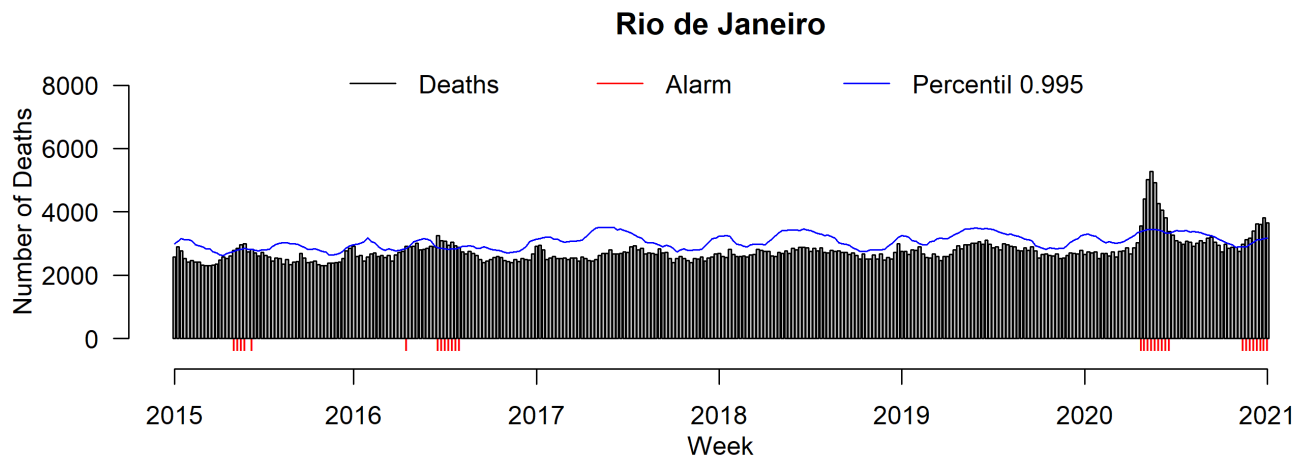
Supplementary figure 45. Mortality rate (per 100.000) by epidemiological week
according to selected causes, Other race, 2015 to 2020

Supplementary figure 46. Alarms identified by the Farrington algorithm, Northeast region, Brazil, 2015 to 2020
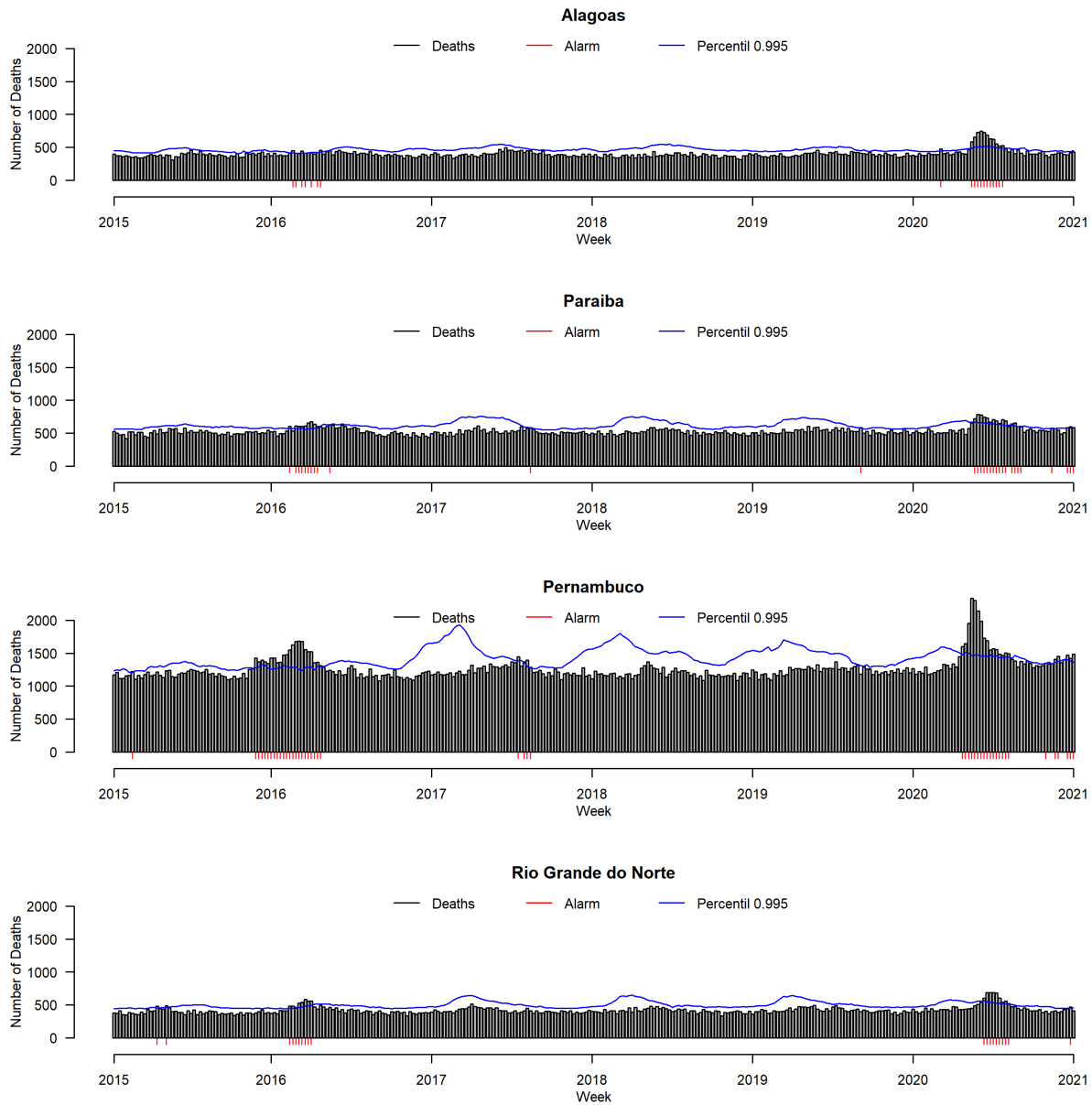
Supplementary figure 47. Alarms identified by the Farrington algorithm, Southeast region, Brazil, 2015 to 2020

Supplementary figure 48. Alarms identified by the Farrington algorithm, South region, Brazil, 2015 to 2020