The influence of model structure and geographic specificity on predictive accuracy among European COVID-19 forecasts

Supplementary information

Contents

1 Code and data availability

1.1 Code

The codebase for this paper is publicly available at:

- Github: https://github.com/epiforecasts/eval-by-method
- Zenodo with DOI: https://doi.org/10.5281/zenodo.14903162

Comments and code contributions are welcome - please use Github Issues.

Please cite code using:

- Katharine Sherratt & Sebastian Funk. (2025). epiforecasts/eval-by-method: Zenodo. https://doi.org/10.5281/zenodo.14903162

1.2 Source data

Forecast and observed data were sourced from the European COVID-19 Forecast Hub, available to view at https://covid19forecasthub.eu/ . All Hub data are now archived at:

- Github: https://github.com/european-modelling-hubs/covid19-forecast-hub-europe_archive
- Zenodo with DOI: https://doi.org/10.5281/zenodo.13986751

Data for this work were downloaded on 30th May 2023. These data are available in the Github repository for this paper at: https://github.com/epiforecasts/eval-by-method/tree/main/data

2 Model characteristics

2.1 Eligibility criteria

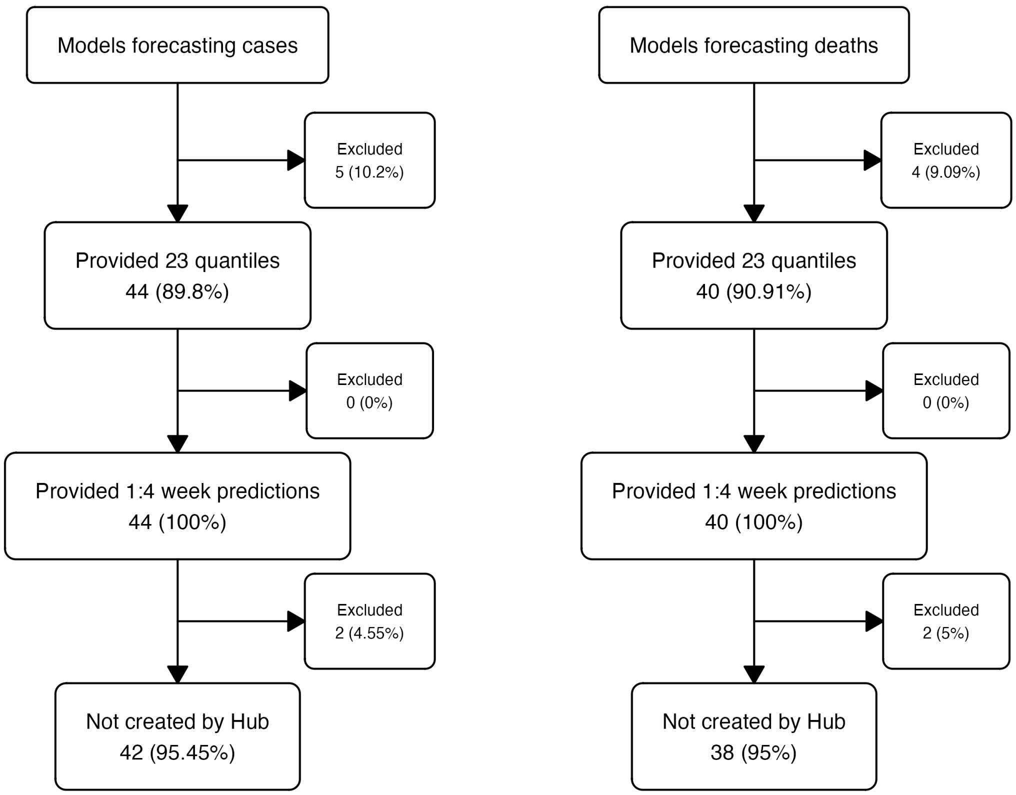


Figure 1: Eligibility criteria for models contributing case (left) and death (right) forecasts to the European COVID-19 Forecast Hub, March 2021 - March 2023

2.2 Model characteristics

Table 1: Model characteristics contributing to the European COVID-19 Forecast Hub, by method used, number of countries targeted, and number of forecasts contributed.

Model	Method	Country Targets	Case forecasts	Death forecasts
AMM-EpiInvert	Statistical	Multi-country	2,788 (1.3%)	
CovidMetrics-epiBATS	Statistical	Single-country	343 (0.2%)	
DSMPG-bayes	Semi-mechanistic	Multi-country	760 (0.4%)	
EuroCOVIDhub-baseline	Statistical	Multi-country	13,082 (6.3%)	13,040 (6.3%)
FIAS_FZJ-Epi1Ger	Mechanistic	Single-country	264 (0.1%)	264 (0.1%)
GoeWroc-BaseBayes	Semi-mechanistic	Single-country	12 (0%)	
HZI-AgeExtendedSEIR	Mechanistic	Single-country	382 (0.2%)	382 (0.2%)
ICM-agentModel	Agent-based	Single-country	334 (0.2%)	334 (0.2%)
IEM_Health-CovidProject	Mechanistic	Multi-country	7,710 (3.7%)	7,708 (3.7%)
ILM-EKF	Semi-mechanistic	Multi-country	11,998 (5.8%)	11,961 (5.8%)
ITWW-county_repro	Semi-mechanistic	Single-country	650 (0.3%)	600 (0.3%)
Imperial-DeCa	Semi-mechanistic	Multi-country		571 (0.3%)
Imperial-RtI0	Semi-mechanistic	Multi-country		571 (0.3%)
Imperial-sbkp	Semi-mechanistic	Multi-country		571 (0.3%)
JBUD-HMXK	Mechanistic	Multi-country	1,324 (0.6%)	1,324 (0.6%)
KITmetricslab-bivar_branching	Statistical	Single-country	8 (0%)	
Karlen-pypm	Mechanistic	Multi-country	3,208 (1.5%)	3,186 (1.5%)
LANL-GrowthRate	Semi-mechanistic	Multi-country	3,692 (1.8%)	3,696 (1.8%)
LeipzigIMISE-SECIR	Mechanistic	Single-country	16 (0%)	16 (0%)
MIMUW-StochSEIR	Mechanistic	Single-country	76 (0%)	76 (0%)
MIT_CovidAnalytics-DELPHI	Mechanistic	Single-country	348 (0.2%)	500 (0.2%)
MOCOS-agent1	Agent-based	Single-country	386 (0.2%)	386 (0.2%)
MUNI-ARIMA	Statistical	Multi-country	10,979 (5.3%)	11,314 (5.4%)
MUNI-LaggedRegARIMA	Statistical	Multi-country		736 (0.4%)
MUNI-VAR	Statistical	Multi-country	976 (0.5%)	976 (0.5%)
MUNI_DMS-SEIAR	Mechanistic	Single-country	224 (0.1%)	200 (0.1%)
PL_GRedlarski-DistrictsSum	Mechanistic	Single-country	378 (0.2%)	
RobertWalraven-ESG	Statistical	Multi-country	9,190 (4.4%)	10,465 (5%)
SDSC_ISG-TrendModel	Statistical	Multi-country	1,756 (0.8%)	1,744 (0.8%)
UB-BSLCoV	Statistical	Single-country	96 (0%)	96 (0%)
UC3M-EpiGraph	Agent-based	Single-country	94 (0%)	
ULZF-SEIRC19SI	Mechanistic	Single-country	249 (0.1%)	249 (0.1%)
UMass-MechBayes	Mechanistic	Multi-country		5,948 (2.9%)
UMass-SemiMech	Semi-mechanistic	Multi-country	1,888 (0.9%)	1,904 (0.9%)
UNED-PreCoV2	Statistical	Single-country	147 (0.1%)	147 (0.1%)
UNIPV-BayesINGARCHX	Statistical	Multi-country	426 (0.2%)	
USC-SIkJalpha	Mechanistic	Multi-country	12,900 (6.2%)	12,688 (6.1%)
UpgUmibUsi-MultiBayes	Semi-mechanistic	Single-country	99 (0%)	99 (0%)
bisop-seirfilter	Mechanistic	Single-country	32 (0%)	32 (0%)
bisop-seirfilterlite	Mechanistic	Multi-country	336 (0.2%)	336 (0.2%)
epiMOX-SUIHTER	Mechanistic	Single-country	134 (0.1%)	134 (0.1%)
epiforecasts-EpiExpert	Other	Multi-country	945 (0.5%)	948 (0.5%)
epiforecasts-EpiExpert_Rt	Other	Multi-country	404 (0.2%)	404 (0.2%)
epiforecasts-EpiExpert_direct	Other	Multi-country	394 (0.2%)	392 (0.2%)
epiforecasts-EpiNow2	Semi-mechanistic	Multi-country	8,843 (4.3%)	7,721 (3.7%)
epiforecasts-weeklygrowth	Statistical	Multi-country	5,971 (2.9%)	
itwm-dSEIR	Mechanistic	Single-country	406 (0.2%)	406 (0.2%)
prolix-euclidean	Semi-mechanistic	Multi-country	800 (0.4%)	800 (0.4%)

3 Statistical methods

3.1 Epidemic trend identification

We retrospectively categorised each week as “Stable”, “Decreasing”, or “Increasing”, based on the difference over a three-week moving average of incidence (with a change of +/-5% as “Stable”).

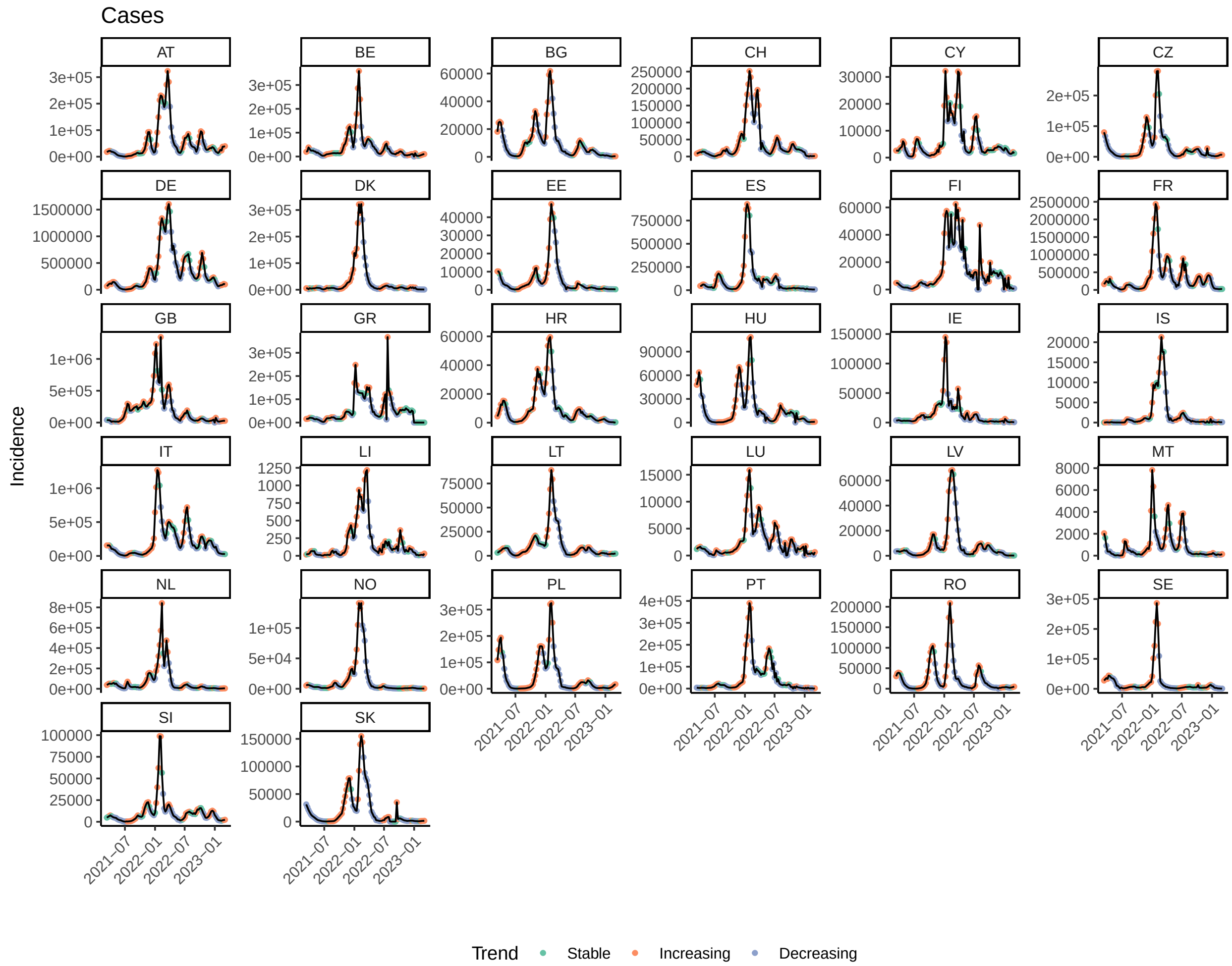


Figure 2: Trends (cases)

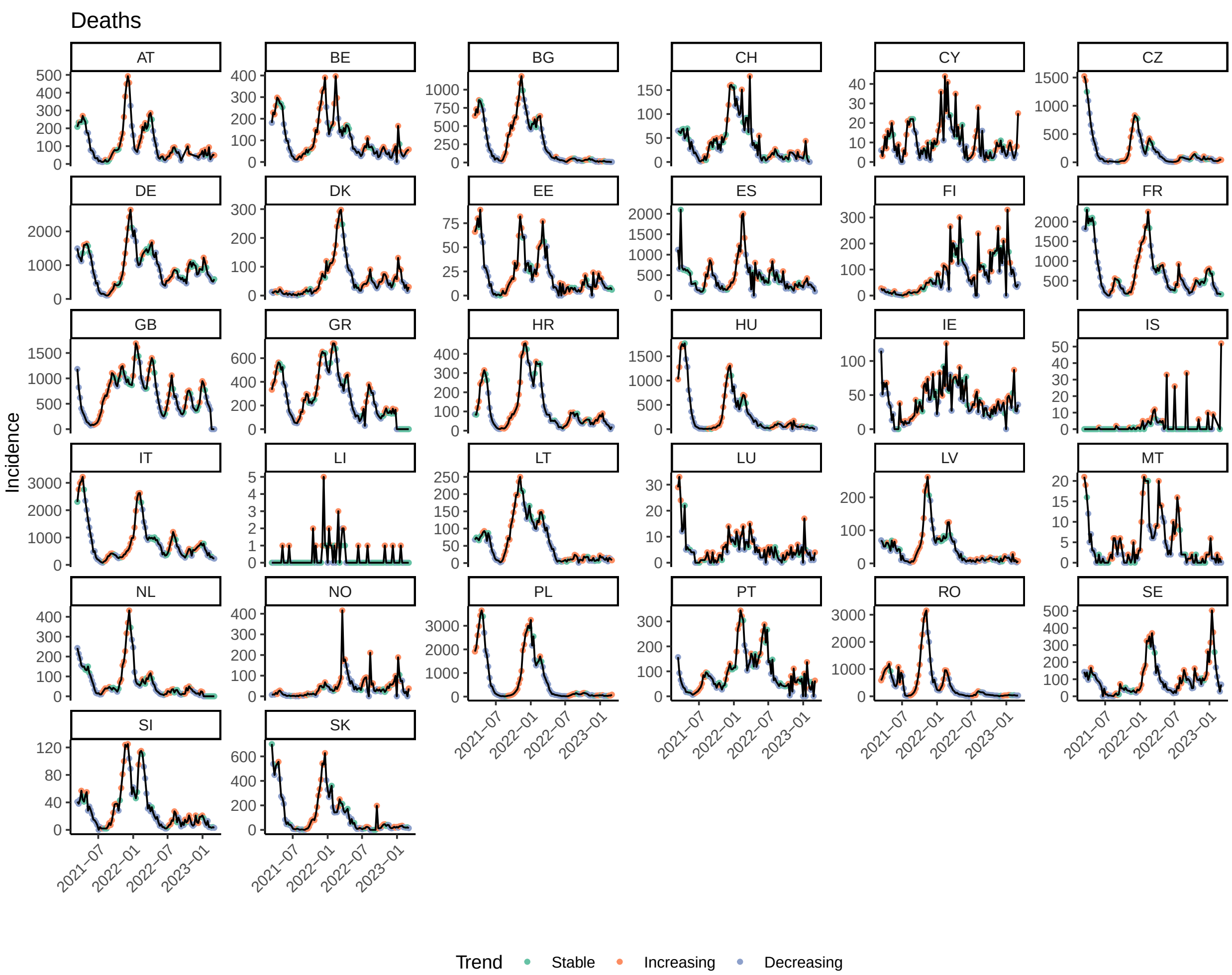


Figure 3: Trends (deaths)

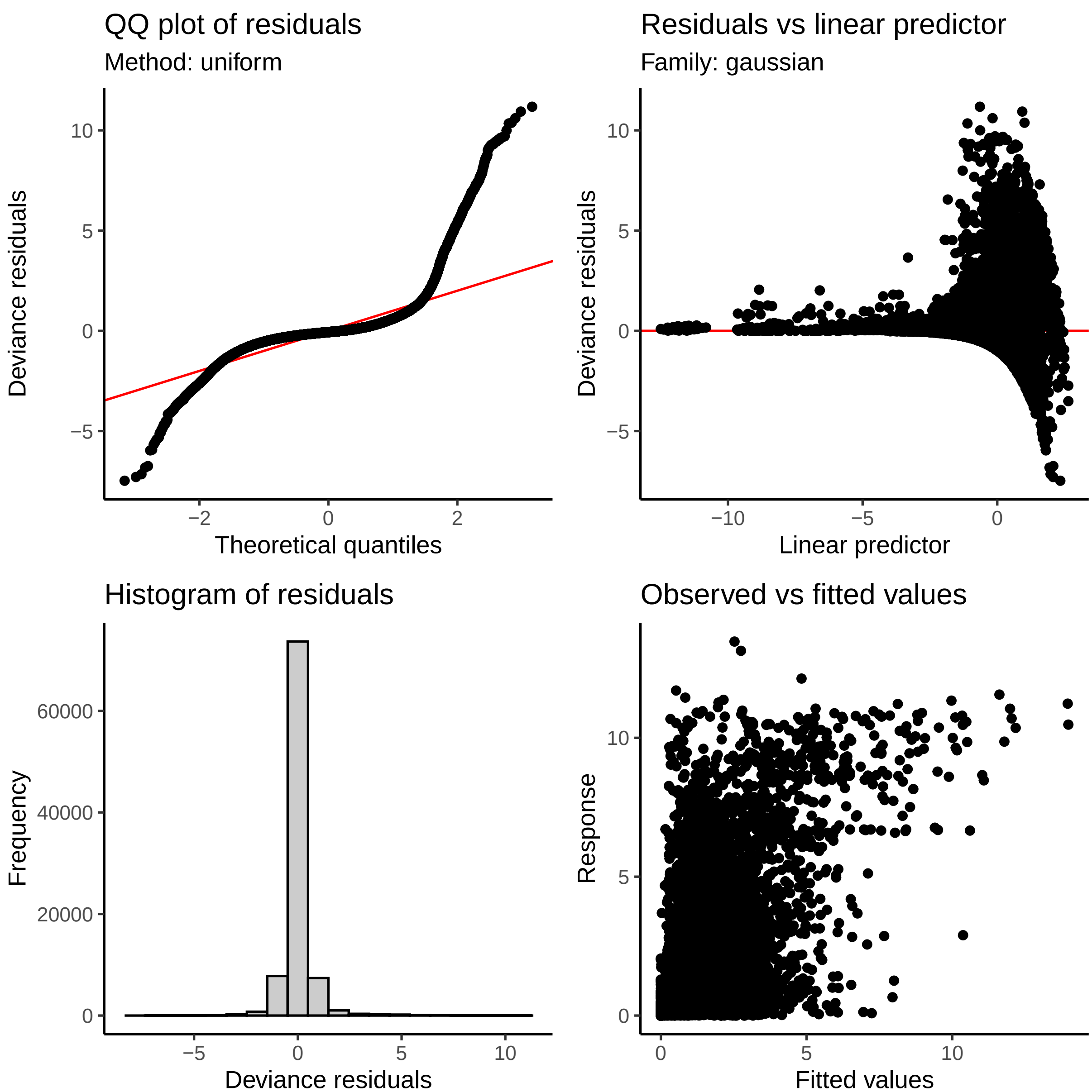
3.2 Model fitting

3.3 Model formula

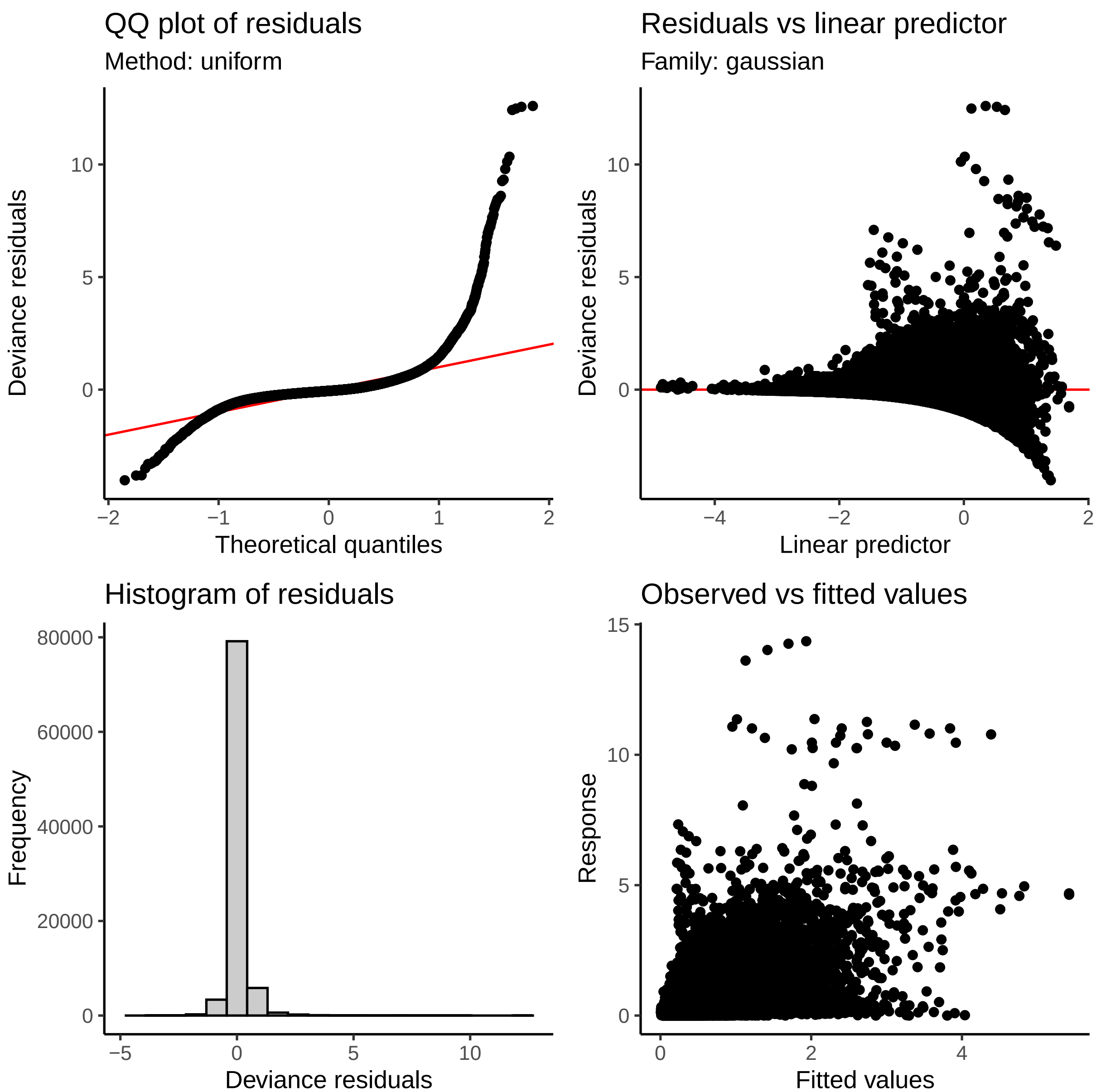
~, wis, s(Method, bs = “re”) + s(CountryTargets, bs = “re”) + s(Trend, bs = “re”) + s(location, bs = “re”) + s(time, by = location, k = 40) + s(Horizon, k = 3, by = Model, bs = “sz”) + s(Model, bs = “re”)

3.4 Model diagnostics

3.4.1 Cases



3.4.2 Deaths


QQ plot of residuals
Method: uniform
Deviance residuals
Theoretical quantiles
Residuals vs linear predictor
Family: gaussian
Deviance residuals
Linear predictor
Histogram of residuals
Frequency
Deviance residuals
Observed vs fitted values
Response
Fitted values