

Supplemental Information

This supplemental information file contains the following:

- Text S1 is an appendix containing further details on model development and performance as well as differences we found between our model re-creations and that presented in the original article¹.
- Figure S1 illustrates the number of human plague cases, degree days, and total precipitation for Arizona Climate Division 2 (1960-2022). It also provides boxplot summaries of the covariate values in the training (1960-1997) and testing (1998-2022) periods.
- Figure S2 compares the week of symptom onset for human plague cases in Arizona Climate Division 2 and the western United States (1960-2022); environmental plague exposures only occurred in the western United States.
- Figure S3 provides the fitted and predicted relationship for models not included in Figure 2.
- Figure S4 graphically presents the fitted climate coefficients from the Poisson generalized linear models presented in Table 1.
- Figures S5-S6 show training and testing error for all models fitted. Figure S5 shows mean absolute error (MAE) while Figure S6 shows violin plots of raw error. Both plots indicate the average number of cases for the time periods to contextualize presented error metrics.
- Figure S7 presents a scatterplot of the observed temperature and precipitation conditions and associated number of human plague cases in the training (1960-1997) and testing (1998-2022) periods.
- Figures S8-S9 present the cross-correlation analysis of lagged covariates in relation to the number of human cases per plague year for the training (1960-1997), testing (1998-2022), and full (1960-2022) time periods. Figure S8 uses plague data per June-to-June plague year and presents a selection of scatterplots from key lags. Figure S9 presents a side-by-side comparison of the cross-correlation using plague data from either the June-to-June or calendar plague year. Lags used in our modeling are highlighted in each plot.
- Table S1 contains the likelihood ratio tests (LRT) for model comparisons when dropping the covariate for July-August precipitation (one- or two-plague year lags). LRT performed separately for each model fitted to a dataset completed through multiple imputation.
- Tables S2-S11 contain fitted covariates for the Poisson generalized linear models or autoregressive order-1 Poisson time series model presented in Table 1. Results from the regression-based test for overdispersion for each model are also included.

Text S1. Appendix

Choice of model setting

Ensore et al.¹ originally fitted models for both Arizona Climate Division 2 (AZ-2) and New Mexico Climate Division 1 (NM-1). We focused only on AZ-2 for our analysis because exposure site locations were not reported consistently to the Centers for Disease Control and Prevention (CDC) after 2004; instead, case reports only indicated county of exposure. The boundary of AZ-2 (previously referred to as the Arizona Palmer Drought District 2) aligns with the county boundaries of Coconino, Navajo, and Apache counties. Thus, we could select appropriate cases for the whole time period based on county-level data here. However, we could not confidently identify appropriate cases in NM-1 because this climate division includes San Juan County along with portions of four other counties (Rio Arriba, Sandoval, McKinley, and Cibola). In the original timeframe (1960-1997), similar numbers of cases had exposure sites for these two climate zones (51 in AZ-2 and 43 in NM-1).

Data sources and processing

We calculated a slightly different number of human plague cases (three vs. two in plague year 1978; nine vs. ten in plague year 1983), potentially due to differences in data inclusion criteria between studies (use of longitude/latitude vs. county-level exposure). Note that human plague cases were reported to CDC through the National Notifiable Diseases Surveillance System (NNDSS)² and through direct provisioning of plague case information to CDC prior to the advent of NNDSS (i.e., prior to 1990). Additional detailed case information (i.e., clinical course, exposure, and treatment) was identified from sources like state reports and peer-reviewed literature³.

In terms of numbering plague years, it appears that plague years were numbered by the calendar year in which they ended (e.g., plague year 1980 was June 16, 1979-June 15, 1980) in the presented fits¹. This is different from the original description which indicated that plague years were numbered by the calendar year in which they began (e.g., plague year 1980 was June 16, 1980-June 15, 1981). This discrepancy did not directly impact the model fit but was rather a semantic difference for labeling plague years. It is possible that this difference in labeling June-to-June plague years could have led to the inadvertent shifting of degree day covariates forward in time. Here, we number plague years based on the calendar year in which they ended.

When acquiring climate data, we tried to use the same or a similar dataset as originally used based on the description in the text. We felt confident that we acquired the same airport temperature data, and the calculated “degree day” values were identical between our calculations and the original data, providing support for this assumption. The inter-annual patterns in precipitation appeared very similar, but we calculated somewhat higher magnitudes than originally presented for February-March and July-August. This difference in magnitude of precipitation could contribute to the differences we found in the fitted coefficients. For the covariates of lagged February-March precipitation, we had slightly lower magnitudes of coefficients (e.g., lagged February-March precipitation coefficients were 0.66-0.68 while our corresponding coefficients were in the range of 0.3-0.4), but the direction of the relationship (positive) was the same. The previous model also included lagged July-August precipitation (one-plague year lag), but this was not significant in our re-creation and thus dropped from the final model without degradation of fit (Table S1).

We performed multiple imputation to fill in missing temperature for Winslow Airport, AZ ($N = 33$ total days (0.14%); 20 days in 1996, 7 days in 2013, and 6 days in 2022) in a similar manner as done in the original¹. Specifically, we took advantage of the strong linear relationship ($r = 0.97$) between daily maximum temperature at Winslow (AZ) and Gallup (NM) municipal airports for imputation. Data were only available from 1973 onward from the Gallup airport. We were unable to locate records for the Zuni FAA Beacon NWS station, as was done previously, to have equal temporal coverage by airports in AZ and NM¹. We produced three complete datasets through imputation (using the mice R package⁴, version 3.16.0), each of which were used for model training (1960-1997) and testing (1998-2022). When imputing missing temperatures in the training dataset (1960-1997), we used data from 1973-1997, the length of time data was available from both the Winslow and Gallup municipal airports. To complete the testing dataset (1998-2022), we used temperature data from 1973-2022. We fitted models with each of the three imputed datasets, then averaged the fitted models’ coefficients to produce the final model. Rubin’s rules⁵ were used to calculate appropriate standard errors for the fitted coefficients.

Model fitting and prediction

We fitted a Poisson generalized linear model (GML; using the stats R package⁶) of human plague cases per plague year (defined as June 16-June 15) relative to temperature and lagged precipitation to re-create the original model. We used lagged February-March precipitation (one- and two-plague year lags),

lagged July-August precipitation (one-plague year lag), and “degree days” (90° and 95°F (32.2° and 35°C) thresholds) as covariates. For additional models fitted in our investigation, we used the same modeling framework. Any non-significant variables were dropped if likelihood ratio tests indicated no degradation of model fit without this variable. All models were fitted to human plague case data for June-to-June or calendar plague years 1960-1997. We did not fit a variety of models with different temporal relationships of temperature and the calendar plague year, as we did with the June-to-June plague year models, because our goal was to compare the performance of a model using a more intuitive definition of a plague year and not try to determine what relationships had been used in the original model.

For each model presented in the text, we performed a regression-based test⁷ for overdispersion (using the AER R package⁸) and found no evidence for this so used a Poisson distribution. See Tables S2-S11 for these test results.

We checked each models for evidence of residual autocorrelation using PACF plots of model deviance residuals. For this, we used the stats package in R⁶. We did not detect any significant residual autocorrelation in all but one model. The intercept-only model (“simple”) using a June-to-June plague year (model 7) had significant residual autocorrelation at lag-1. Thus, we use an autoregressive order-1 (AR(1)) Poisson time series framework for model 7 using the tscount R package^{9, 10}.

Using each fitted model, we predicted case counts for June-to-June or calendar plague years 1998-2022, depending on the modeling framework. We used a bootstrap approach to produce 95% pointwise prediction intervals (PI) for each year’s prediction for all models except model 7. For this, we generated 1,000 bootstrap samples for each year in the testing period (1998-2022) to account for model and distributional uncertainty in the following way. We first generated 1,000 bootstrapped sets of data by random sampling with replacement from the original training data. We then refitted the model with each bootstrap sample and produced predictions for the testing period (model uncertainty). Using the predicted values from the refitted model as the mean (λ), we generated an observation from a Poisson distribution (distributional uncertainty). We used the 2.5% and 97.5% quantiles of the generated random Poisson observations as the lower and upper bounds of the 95% pointwise prediction interval. For models fitted with imputed datasets, we generated 1,000 bootstrap samples per model and averaged the quantiles calculated from each model’s bootstrap samples.

Since there was residual autocorrelation in model 7, we could not produce pointwise PIs as done for the other model. We made predictions and associated 95% PIs that incorporated an autoregressive order-1 component using the tscount R package^{9, 10}. Prediction intervals were calculated recursively for the 25-year testing time period, based on the conditional distribution of the model with the unknown parameters replaced by their respective estimates. The Pearson residuals of this fitted AR(1) time series model with lag-1 did not show any significant autocorrelation.

All analyses were performed in R (version 4.3.1)⁶.

Model performance during training and testing periods

During training (1960-1997) and testing (1998-2022) periods, model fit and prediction were similar across all models, as measured by mean absolute error (MAE; Table 1, Fig S5). As all models accurately predicted the wholly low reported case counts with minimal difference in error, using a modeling framework to predict low/baseline vs. elevated case counts may be useful for public health since the exact number of plague cases may be of less practical importance than the qualitative level (“baseline” or “high”).

Controlling for model construction (i.e., degree days concurrent to plague year, no degree days, and intercept-only models), training and testing MAE were similar for models using a June-to-June or a calendar plague year (Figs S5-S6). Calendar years align with natural climatic cycles in the Northern hemisphere, show similar behavior in the fitted models, aids in clarity for model interpretation, and could therefore be used in future models. Additionally, the intercept-only model for a calendar plague year (model 10) did not have any significant residual autocorrelation while the intercept-only model using a June-to-June plague year (model 7) did. Using a plague year that includes all human plague cases that occurred in one transmission season (i.e., one calendar year) removes autocorrelation from the analyses. The one-year lag in the June-to-June plague year model could be attributed to splitting cases from one transmission season into two plague years. A June-to-June plague year was originally used because its beginning aligned with the observed increase in monthly precipitation due to the North American monsoons (monsoonal activity generally occurs June-September in this area)¹¹ and a dip in the observed weekly plague case counts¹ (Fig S2).

Across models, over- and underprediction of fitted values occurred at similar rates during the training period with larger magnitudes of underprediction (Fig S6). In the testing period, overprediction occurred more often with overall smaller magnitudes of error due to the fewer number of reported cases. From a public health perspective, overprediction could be favored over underprediction; it could be better to misclassify a low-risk period as a high-risk period than to miss a high-risk period.

The combination of weather conditions associated with elevated cases (≥ 4 cases) in the training period (1960-1997) largely did not occur in the testing period (1998-2022; Fig S7). More than six inches of precipitation across the previous two February-March timeframes appears to have been associated with, but not exclusively resulting in, elevated cases. Both plague year 1980 and 2021 had at least this amount of precipitation, but no cases were reported in each, indicating that the total amount alone is not sufficient to result in elevated human cases. The ratio of precipitation between these two lags, or another unaccounted-for factor may also be needed. The difference in degree days (i.e., days at least 90°F, but less than 95°F) for these plague two years (25 days in 1980 and 41 days in 2021) were within the range observed for years with elevated cases (22-63 days). Thus, we did not identify a threshold difference in degree days, either marginally or jointly with cumulative spring precipitation, between low and elevated numbers of cases. Weather conditions in years with low cases (≤ 2 cases) appeared similar in both the testing and training periods. Thus, conditions in the last quarter century were not such as to result in elevated numbers of human plague cases.

Cross-correlation analysis of plague and lagged climate covariates

To further investigate the weather-plague relationship across a range of lags, we performed cross-correlation analysis (using the stats R package⁶) to compare the strength of the relationship (correlation) between lagged weather and the number of human cases in a plague year for the original timeseries (1960-1997), the additional 25 years (1998-2022), and the whole timeframe (1960-2022). We considered both observed human plague cases per June-to-June (Fig S8) and calendar (Fig S9) plague year in this analysis. We used Pearson correlations to assess the linear relationship between lagged climate and plague cases, considering lags of -5 to +5 calendar years. Negative lags indicate the climate covariates were shifted backward in time and positive lags indicate the climate covariates were shifted forward in time relative to plague cases. A lag of 0 indicates concurrent timing of climate and plague cases. For the June-to-June plague year, a lag of 0 corresponds to the calendar year in which it began. To assess if the climate-plague relationships remained consistent (e.g., magnitude and direction of correlations) across time, we performed cross-correlation analyses for the training (1960-1997), testing (1998-2022), and the full (1960-2022) periods.

In the analyses, we used lagged relationships of climate conditions used in the original model: degree days (90° and 95°F thresholds), total February-March precipitation, and total July-August precipitation. We also considered the number of days with temperatures at least 90°, but less than 95°F. While this was not a covariate in any model, we included it to capture the relationship of fitted degree day covariates in the models. The original article¹ presented the visual correspondence of this relationship with plague cases to illustrate that the balance of warm ($\geq 90^\circ\text{F}$), but not too hot ($< 95^\circ\text{F}$) summer temperatures were a key contributor to model fit and associated with large case counts.

These analyses confirmed that the original modeling framework used highly associated lags (i.e., had high correlations). A selection of other lags may not have further improved the original model fit. Across lag lengths, we found that the correlations varied between the training and testing periods. Correlations often had much smaller magnitudes or opposite directions for the testing versus the training period. This was especially true for the lagged relationships corresponding to covariates in the original model and could contribute to the observation that models with weather data did not outperform “simple” models (intercept-only GLM or AR(1) Poisson time series model). However, the “simple” models had poor performance in the testing period so these similarities in performance during the testing period do not hold much significance. Correlations for the whole period were similar but weaker than those for only the training period, likely due to the larger number of cases in the training as compared to the testing period. Also, the cross-correlation analyses only consider the linear marginal associations of lagged weather and plague cases and thus may not have captured nonlinear relationships with multiple weather conditions. These findings do not mean that precipitation and temperature did not influence plague transmission given that models including weather data accurately predicted low plague cases in recent previous quarter-century.

Inspection of scatterplots of the relationships (Fig S8b-e) illustrated that the large numbers of cases reported in plague year 1983 (9 cases) had a strong impact on the estimated relationship between climate variables and plague cases. The moderate number of cases (4 cases) in plague years 1982, 1984, and 1994 also influenced the estimated relationships.

References:

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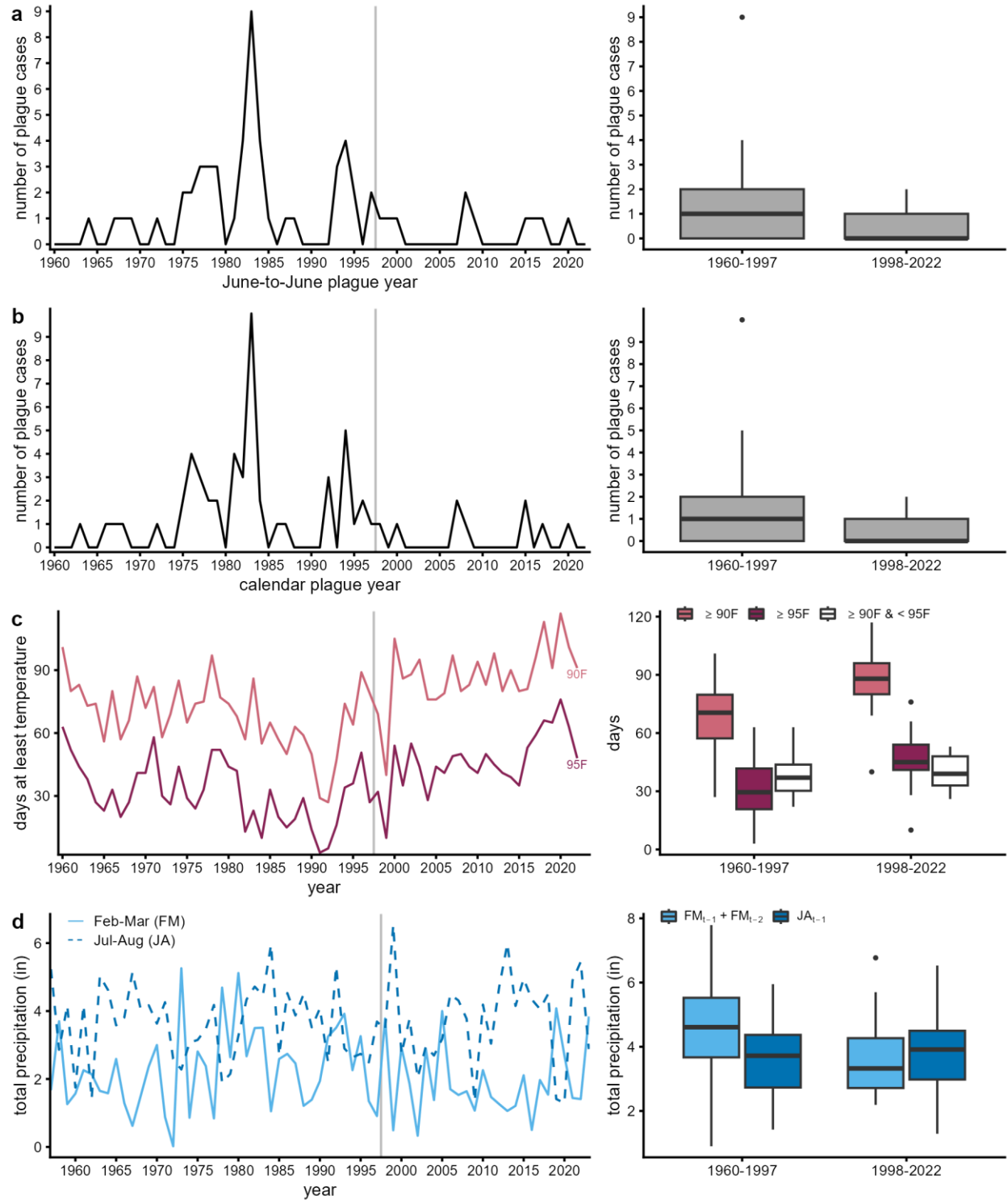


Figure S1. Plague case and weather data for Arizona Climate Division 2 (1960-2022). Human plague cases by a) June-to-June or b) calendar plague year (June 16-June 15), c) degree days, and d) total precipitation (February-March and July-August). Boxplots summarize data as used in models during training (1960-1997) and testing (1998-2022) time periods with observations beyond $1.5 \times IQR$ (inter-quartile range) represented as points. Degree day values indicate the number of days with a maximum temperature at least a certain threshold. While not a covariate in any model, the difference between these

degree day thresholds (i.e., days with max temperature $\geq 90^{\circ}\text{F}$, but $< 95^{\circ}\text{F}$) also presented in the boxplot as this represents the fitted relationship of these covariates in the models. For years with missing data (1997, 2013, and 2022), the mean value of degree days from the three imputed datasets is presented in the plots. Vertical line divides periods training and testing time periods. FM_{t-x} : February-March total precipitation, x-year lag; JA_{t-x} : July-August total precipitation, x-year lag.

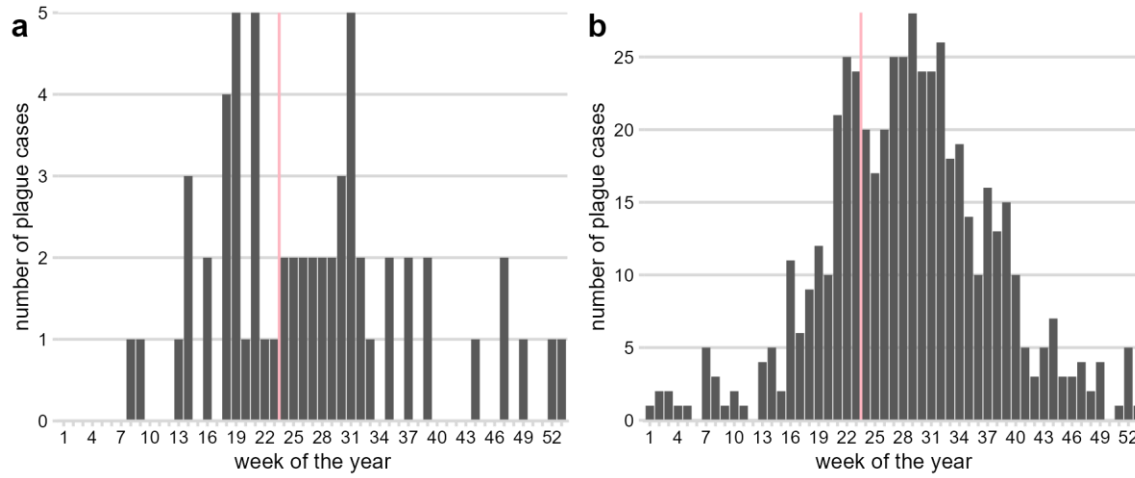


Figure S2. Histogram of case onset by week of the year for a) Arizona Climate Division 2 and b) the western United States (1960-2022). The vertical line in each indicates the week containing June 16 to visualize the start of a June-to-June plague year.

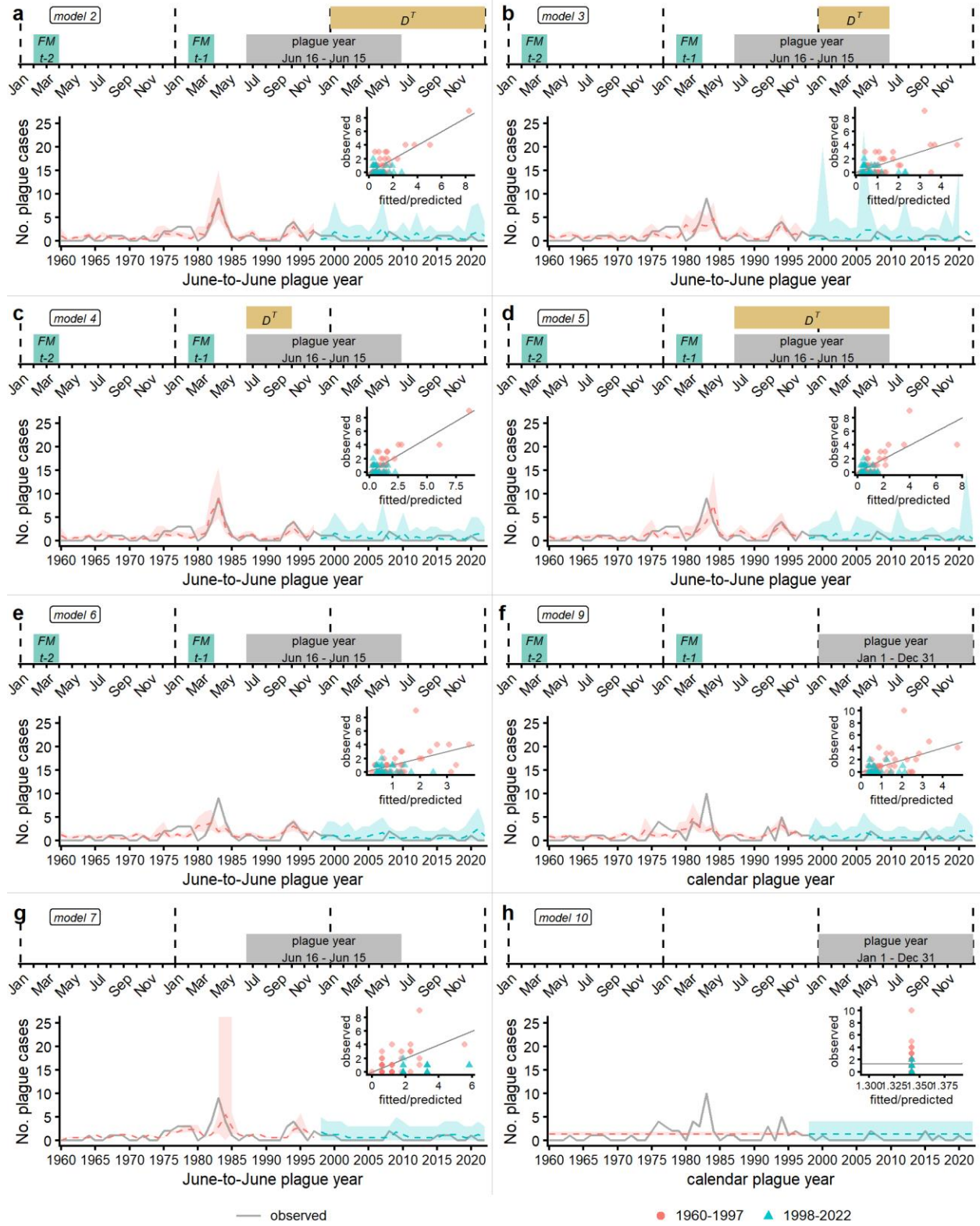


Figure S3. Fitted and predicted number of human plague cases in Arizona Climate Division 2 from a-d) re-created models not presented in Fig 2 and e-h) baseline models. Each panel annotated with the corresponding model number from Table 1. Top schematic illustrates temporal relationships between model parameters: FM_{t-x} (February-March total precipitation, x -plague year lag), D^T (days at least

temperature T , “degree days”), and plague year t . Vertical dashed lines indicate the start of a calendar year. Lower plots illustrate the observed vs. fitted (95% confidence interval, CI) or predicted (95% prediction interval, PI) number of human plague cases for the indicated model parameters. In panel g), the 95% CI for plague year 1984 is 0.04-748.40 cases (not shown given the large range). Inset scatterplot of observed vs. expected (fitted or predicted) cases with the diagonal representing the 1:1 relationship.

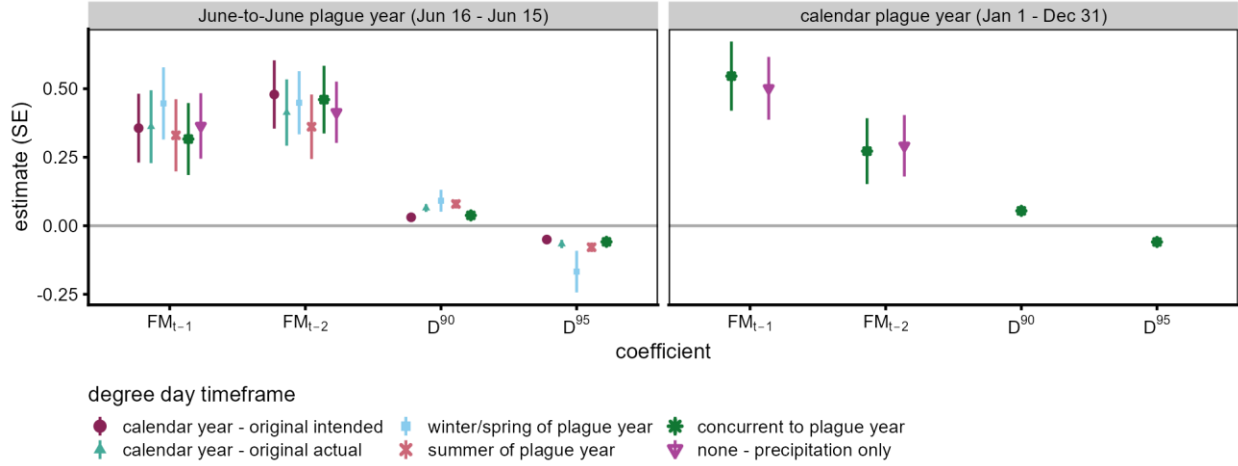


Figure S4. Fitted climate coefficients from Poisson generalized linear models. See Table 1 for further model details and Tables S2-S11 for covariate estimates. FM_{t-1} : February-March total precipitation (in), one-plague year lag; FM_{t-2} : February-March total precipitation (in), two-plague year lag; D^T : days at least temperature T (“degree days”; 90° and 95°F). Colors for model frameworks consistent across Figs S4-S6.

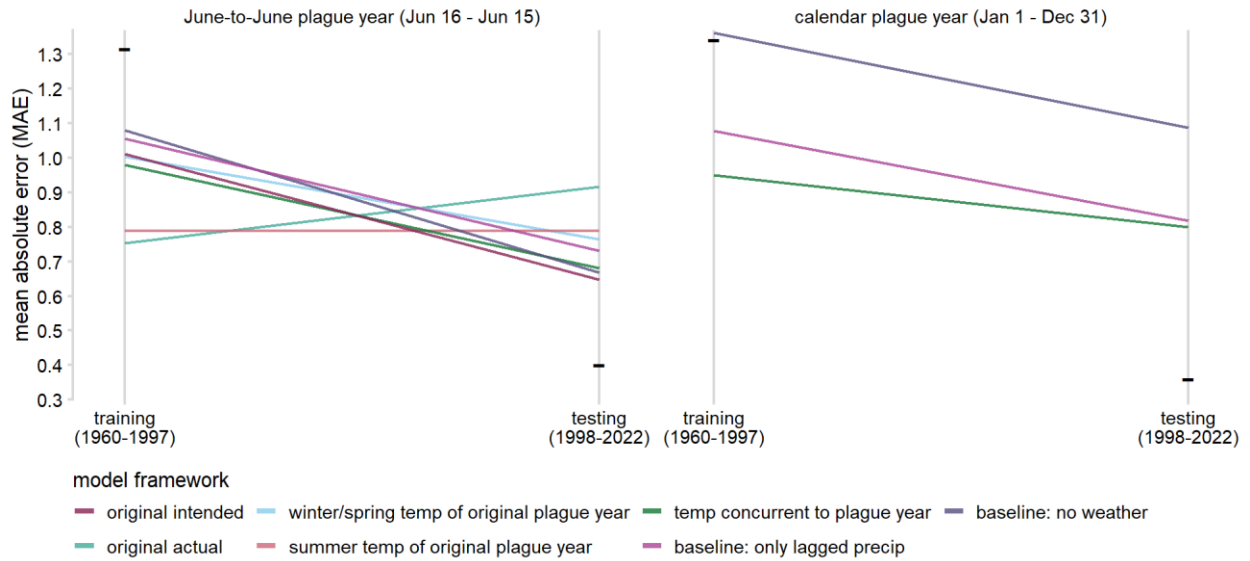


Figure S5. Mean absolute error (MAE) for testing and training periods for all models fitted. Small horizontal lines indicate the average case count for each period for contextualization of error magnitudes. Model framework names consistent with descriptors used in Table 1 and colors for model frameworks consistent across Figs S4-S6.

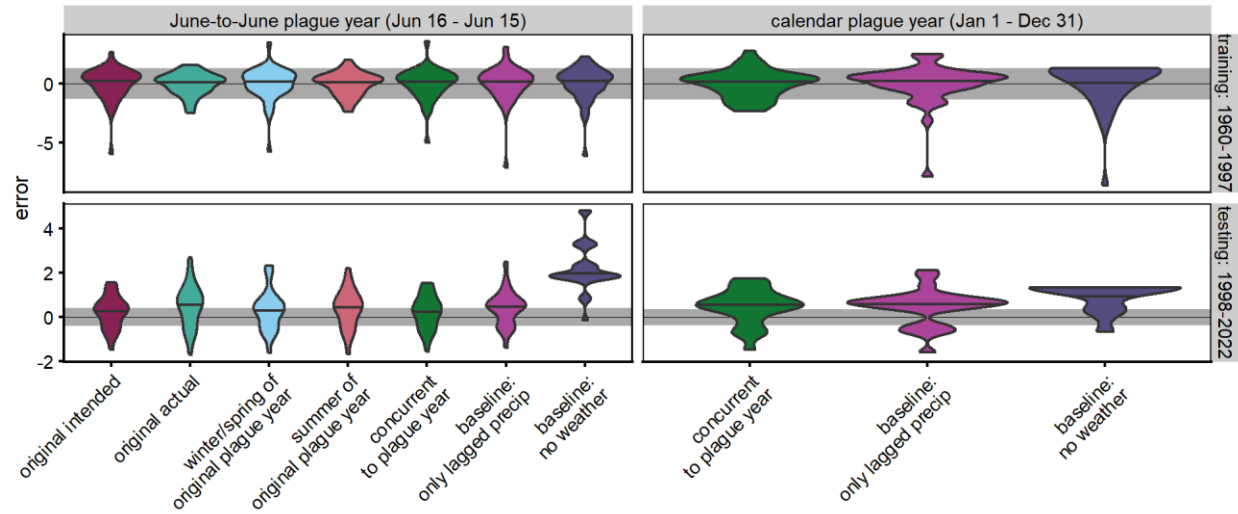


Figure S6. Error from training and testing periods. Violin plot illustrates density of error with the median indicated with the horizontal line. Positive error indicates overprediction and negative error indicates underprediction. Grey bar indicates $\pm$ average case count for the period as context of magnitudes of error. Model names consistent with descriptors used in Table 1 and colors for model frameworks consistent across Figs S4-S6.

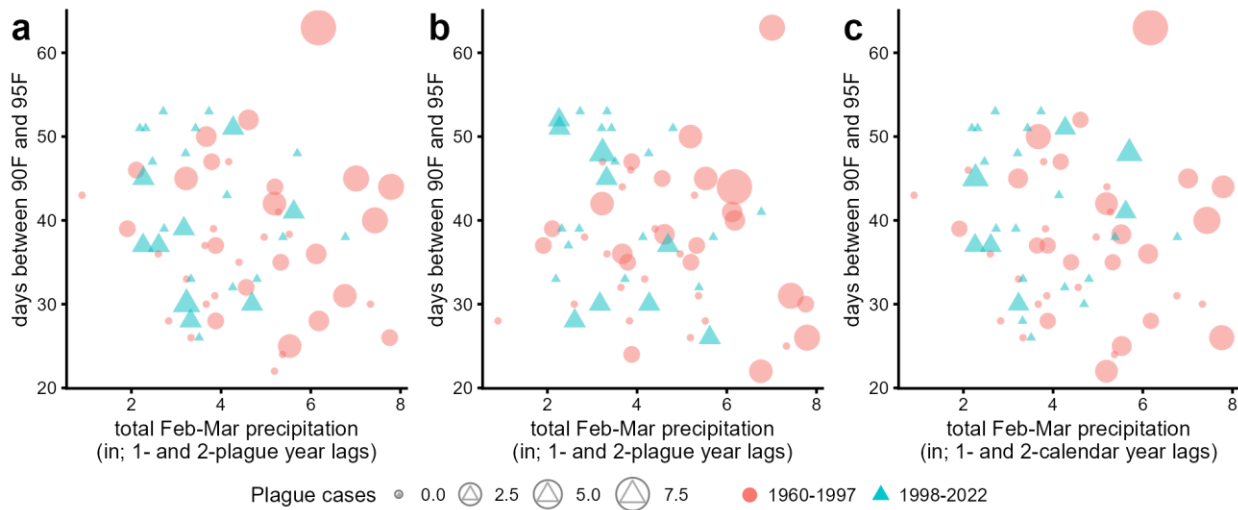


Figure S7. Weather conditions and associated number of human plague cases in the training (1960-1997) and testing (1998-2022) time periods. Temporal associations of weather conditions based on relationships defined in the a) original actual (model 2) and b) original intended (model 1) modeling frameworks as well as using a c) calendar plague year (model 8). Model numbers correspond to Table 1. Precipitation (x-axis) and temperature (y-axis) conditions represent the fitted relationship of lagged precipitation and “degree day” covariates, respectively, in the model, but do not include weighting (i.e., fitted coefficients) of individual conditions.

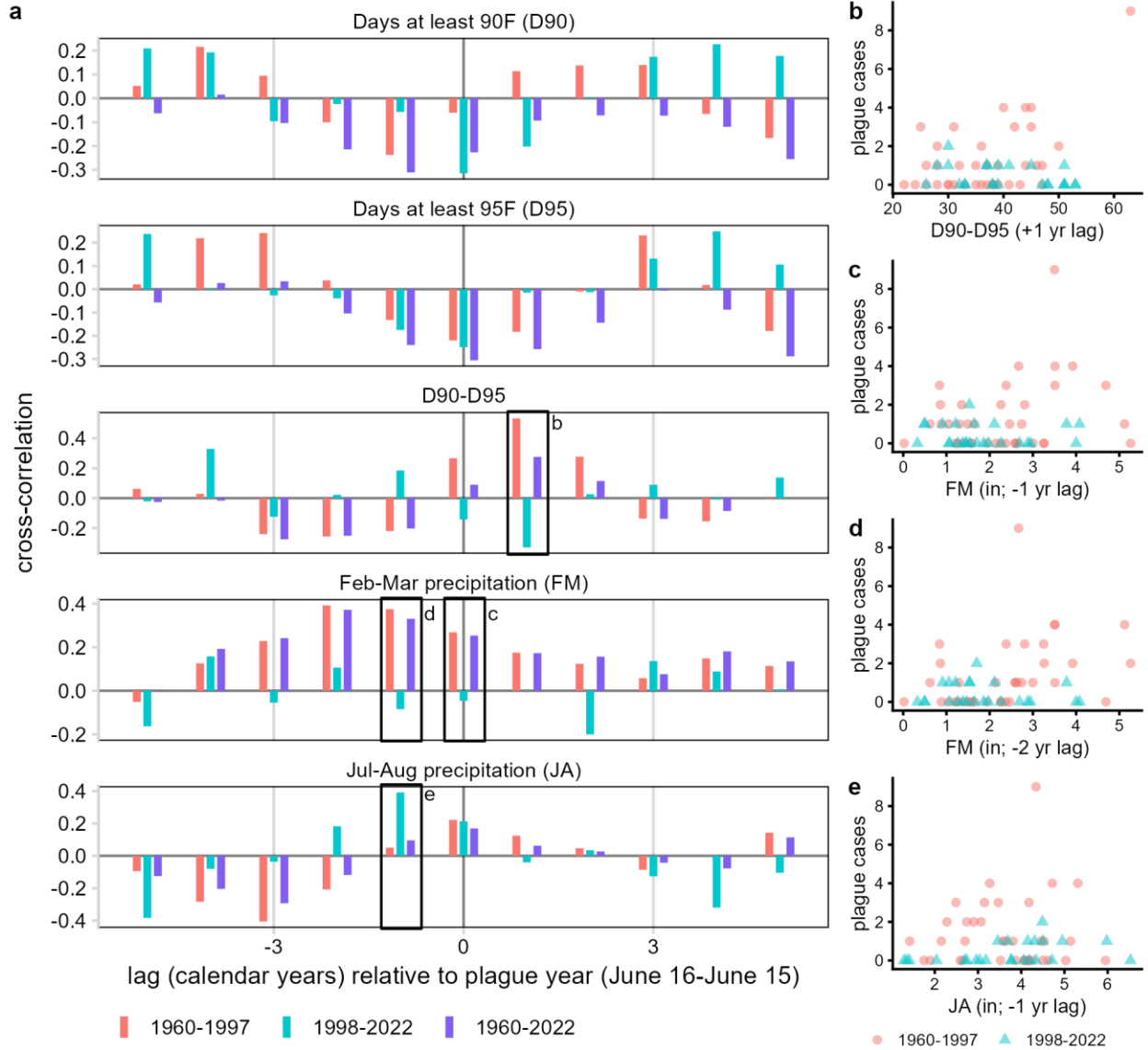


Figure S8. Cross-correlation and scatterplots of the relationship of lagged covariates and number of plague cases. a) Cross-correlations assessed for each covariate timeseries relative to the number of cases per June-to-June plague year (June 16-June 15) for training (1960-1997), testing (1998-2022), and the full (1960-2022) period. Lag of 0 corresponds to the calendar year in which the plague year starts. Positive lags indicate covariates shifted forward in time relative to the plague year and negative lags indicate the covariates shifted backward in time relative to the plague year. Temperature covariates assessed for a calendar year, as done in original modeling framework. Scatterplots for highlighted lags (b-e) illustrate relationships for the testing (1960-1997) and training (1998-2022) periods. Indicated lags in scatterplot x-axes refer to plague year lags. Highlighted lags correspond to covariates in our models (b-d) or the original¹ (b-e) modeling framework. Note that the number of days between 90° and 95°F (D90-D95) was not a single covariate in either model, but rather the resulting relationship of fitted covariates for D90 and D95.

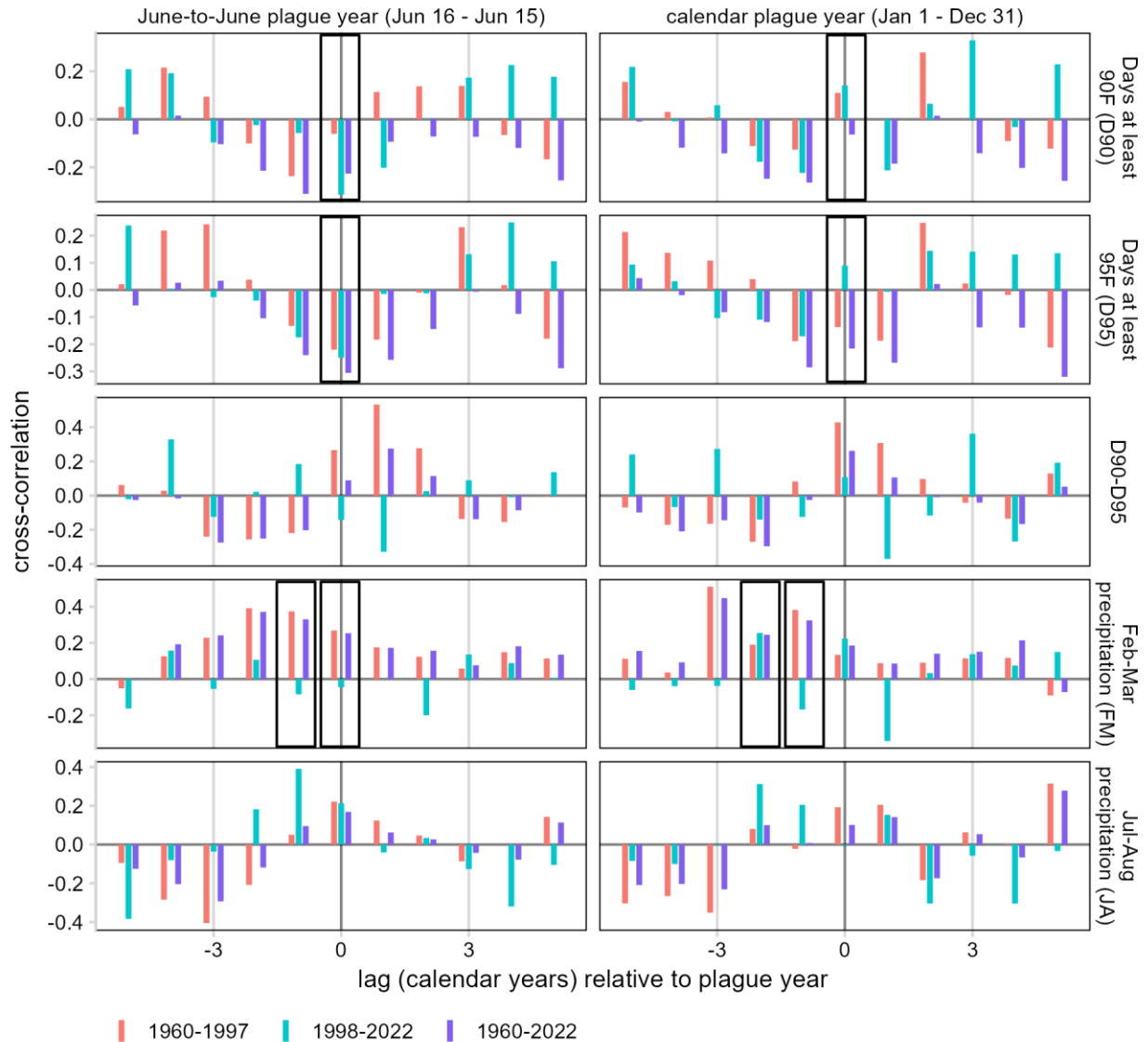


Figure S9. Cross-correlation of the relationship of lagged covariates and number of plague cases during the calendar (left) or June 16-June 15 (right) plague year. Cross-correlations assessed for each covariate timeseries relative to the number of cases per plague year for training (1960-1997), testing (1998-2022), and the whole (1960-2022) period. Lag of 0 corresponds to the calendar year in which the plague year starts (right) or concurrent with the plague year (left). Positive lags indicate covariates shifted forward in time relative to the plague year and negative lags indicate the covariates shifted backward in time relative to the plague year. Highlighted lags correspond to those used in model 2 (left) and model 8 (right). Temperature covariates assessed for a calendar year. Note that the number of days between 90° and 95°F (D90-D95) was not a covariate in either model, but rather the resulting relationship of fitted covariates for D90 and D95 and included here for visualization.

Table S1. Averaged results from likelihood ratio tests when dropping lagged July-August precipitation covariate from fitted Poisson generalized linear model.

Model [†]	Jul-Aug precipitation lag [‡]	Deviance ⁺	P-value [#]
1	1 plague year	-0.029	0.866
2	1 plague year	-0.294	0.588
3	1 plague year	-1.007	0.314
4	1 plague year	-0.446	0.505
5	1 plague year	-0.255	0.614
8	1 calendar year	-2.257	0.133
	2 calendar years	-0.394	0.530

Averaged deviance and *P*-values from likelihood ratio tests performed for each model fitted to a dataset completed with imputation. The July-August precipitation covariate was not considered for baseline comparison models (models 6, 7, 9, and 10). All tests were performed for nested models (i.e., between models with (full) and without (reduced) the indicated July-August precipitation covariate).

[†] Corresponds to the model number listed in Table 1.

[‡] Number of plague (June 16-June 15) or calendar (January 1-December 31) years for which July-August precipitation was lagged.

⁺ Average difference in residual deviance between full and reduced models across imputed models.

[#] Average *P*-value from likelihood ratio tests per imputed model.

Table S2. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for the calendar year in which a plague year begins (model 1, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-2.156	0.759	-2.840	0.006
FM _{t-1}	0.368	0.112	3.299	0.002
FM _{t-2}	0.447	0.110	4.078	<0.001
D ⁹⁰	0.025	0.012	2.116	0.039
D ⁹⁵	-0.050	0.014	-3.472	0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.38, statistic=1.23, *P*-value=0.10.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; FM_{t-1}: February-March total precipitation (in), one-plague year lag; D^T: days at least temperature *T* (degree days)

Table S3. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for the calendar year in which a plague year ends (model 2, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-4.271	1.032	-4.140	<0.001
FM _{t-1}	0.361	0.133	2.719	0.011
FM _{t-2}	0.413	0.121	3.414	0.002
D ⁹⁰	0.065	0.014	4.651	<0.001
D ⁹⁵	-0.067	0.015	-4.440	<0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.05, statistic=0.22, *P*-value=0.41.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; FM_{t-1}: February-March total precipitation (in), one-plague year lag; D^T: days at least temperature *T* (degree days)

Table S4. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for Jan 1-Jun 15 of a plague year (model 3, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-2.510	0.685	-3.665	0.001
FM _{t-1}	0.446	0.132	3.393	0.002
FM _{t-2}	0.449	0.115	3.900	<0.001
D ⁹⁰	0.091	0.040	2.288	0.029
D ⁹⁵	-0.167	0.076	-2.207	0.035

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.46, statistic=1.31, P-value=0.10.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; FM_{t-1}: February-March total precipitation (in), one-plague year lag; D^T: days at least temperature T (degree days)

Table S5. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for the summer (Jun 16-Sep 30) of the plague year (model 4, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-4.199	0.981	-4.282	<0.001
FM _{t-1}	0.330	0.132	2.506	0.018
FM _{t-2}	0.361	0.118	3.070	0.004
D ⁹⁰	0.079	0.016	4.861	<0.001
D ⁹⁵	-0.078	0.017	-4.52	<0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=0.99, statistic=-0.06, P-value=0.52.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; FM_{t-1}: February-March total precipitation (in), one-plague year lag; D^T: days at least temperature T (degree days)

Table S6. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for the plague year (model 5, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-2.619	0.811	-3.229	0.003
FM _{t-1}	0.317	0.131	2.410	0.022
FM _{t-2}	0.460	0.123	3.729	0.001
D ⁹⁰	0.038	0.012	3.119	0.004
D ⁹⁵	-0.059	0.015	-3.838	0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.21, statistic=1.00, P-value=0.16.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; FM_{t-1}: February-March total precipitation (in), one-plague year lag; D^T: days at least temperature T (degree days)

Table S7. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) without degree days (model 6, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-1.758	0.535	-3.287	0.001
FM _{t-1}	0.364	0.119	3.050	0.002
FM _{t-2}	0.414	0.112	3.704	<0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.74, statistic=1.18, *P*-value=0.12.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; *FM_{t-1}*: February-March total precipitation (in), one-plague year lag

Table S8. Fitted covariate for AR(1) Poisson[†] time series model of human cases of plague in Arizona Climate Division 2 (1960-1997; model 7, Table 1). A plague year runs June 16-June 15.

Covariate	Estimate	Std. error [*]	95% CI [*]
Intercept	-0.480	0.252	-0.975-0.015
AR1	0.952	0.198	0.564-1.341

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=10.12, statistic=1.40, *P*-value=0.08.

^{*}Standard error and confidence intervals obtained by normal approximation.

AR1: autoregressive order-1 coefficient.

Table S9. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) using degree days calculated for the calendar year concurrent with a plague year begins (model 8, Table 1). A plague year runs January 1-December 31.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-3.875	0.988	-3.923	<0.001
<i>FM_{t-1}</i>	0.546	0.126	4.326	<0.001
<i>FM_{t-2}</i>	0.272	0.120	2.267	0.030
<i>D⁹⁰</i>	0.054	0.013	4.111	<0.001
<i>D⁹⁵</i>	-0.059	0.014	-4.079	<0.001

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.08, statistic=0.39, *P*-value=0.35.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; *FM_{t-1}*: February-March total precipitation (in), one-plague year lag; *D^T*: days at least temperature *T* (degree days)

Table S10. Fitted covariates for Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997) without degree days (model 9, Table 1). A plague year runs January 1-December 31.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	-1.788	0.536	-3.337	<0.001
<i>FM_{t-1}</i>	0.502	0.115	4.377	<0.001
<i>FM_{t-2}</i>	0.292	0.112	2.603	0.009

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=1.87, statistic=1.26, *P*-value=0.10.

FM_{t-2}: February-March total precipitation (in), two-plague year lag; *FM_{t-1}*: February-March total precipitation (in), one-plague year lag

Table S11. Fitted covariates for intercept-only Poisson[†] model of human cases of plague in Arizona Climate Division 2 (1960-1997; model 10, Table 1). A plague year runs January 1-December 31.

Covariate	Estimate	Std. error	Z-value	P-value
Intercept	0.294	0.140	2.101	0.036

[†] No evidence of overdispersion (dispersion >1) using a regression-based test⁷: estimate=2.83, statistic=1.43, *P*-value=0.07.