

1 **Supporting Information for**

2 **Adaptive metrics for an evolving pandemic**

3 **A dynamic approach to area-level COVID-19 risk designations**

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7 **This PDF file includes:**

8 Supporting text

9 Figs. S1 to S15

10 Tables S1 to S2

11 SI References

## 12 Supporting Information Text

**A. Population-Weighted Performance.** Let  $S_i$  be the population of location  $i$ . The weight for location  $i$  is  $\omega_i = \frac{S_i}{\sum_{i=1}^N S_i}$ . To population-weight our accuracy measure, we estimate:

$$\delta_{wt} = 1 - \sum_i \omega_i (p_{FP} w_P + p_{FN} w_N)$$

**B. Optimal Threshold Selection.** We first specify a weight  $wt$  such that we consider false positives to be a factor of  $wt$  as costly as false negatives. For example, if  $wt = 3$ , we consider 3 false positives as costly as 1 false negative; 2 false positives would be less costly than 1 false negative. Denote the probability that an outcome of interest occurs given observed indicators for an observation,  $q_{i,w+3} = Pr(Y_{i,w+3} = 1|X_i)$ . We want to predict that the outcome will occur if, in expectation, triggering a response will decrease net costs. If an observation with probability  $q_{i,w+3}$  is classified with a prediction of 0, this has probability  $q_{i,w+3}$  of being a false negative. If it is classified with a prediction of 1, there is a probability  $1 - q_{i,w+3}$  of a false positive. We therefore should classify with a prediction of 1 if:

$$\begin{aligned} \text{Expected cost of FP} &\leq \text{Expected cost of FN} \\ (1 - q_{i,t+3}) &\leq q_{i,t+3} wt \\ q_{i,t+3} &\geq \frac{1}{1 + wt} \end{aligned}$$

**C. Simulations.** To conduct simulations, we generate data that assumes a the following relationship between the probability of a high outcome,  $Pr(Y_{i,w+3})$ , and a synthetic hospitalization indicator,  $X_{H,i,w}$ :

$$\text{logit}(Pr(Y_{i,w+3} = 1)) = \beta_0 + \beta_1 X_{H,i,w}, \quad [1]$$

We then draw  $Y_{i,w+3}$  from a binomial distribution with the corresponding probability. We vary simulations across 2 dimensions:

1. **Relationship between inputs and outputs:** The optimal cutoff for a metric with neutral weighting is  $\frac{\text{logit}(0.5) - \beta_0}{\beta_1} = \frac{-\beta_0}{\beta_1}$ . We vary this over time as displayed in Figure S13:
  - (a) Constant: 10 hospitalizations per 100,000 population
  - (b) Linear increase: linearly increasing from 5 to 15 hospitalizations per 100,000 over the study period
  - (c) Logistic increase: increasing from 5 to 15 hospitalizations per 100,000 over the study period per a logistic model with a sharp increase at week 25
  - (d) Non-monotonic: optimal cutoff increases to 15 and then decreases
2. **Prevalence of “high” outcomes:** We first use empirical hospitalization data for simulations, drawing synthetic outcomes according to 1. To build intuition, we then use two stylized scenarios, one in which prevalence is constant over quarters and one in which waves are even more pronounced.
  - (a) Empirical: We use true state-level hospitalization data from Q3 2021 through Q3 2022.
  - (b) Constant: We draw  $X_{H,i,w}$  from a  $Unif(2, 20)$  distribution for state-times from Q3 2021 through Q3 2022.
  - (c) Sharp waves: We alternate each quarter between drawing hospitalizations from a  $N(5, 1)$  distribution and a  $N(15, 1)$  distribution for each state-time from Q3 2021 through Q3 2022.

For illustration, we set  $\beta_0 = -3c$  and  $\beta_1 = 3$  and use the first quarter (synthetic Q3 2021) as training data. For each scenario, we simulate 50 draws. As in the main text, we select the best-performing static metric during training data and compare performance in terms of predictive accuracy to adaptive metrics, averaging over draws. Results are displayed in Figure S14.

**D. Comparison to CDC Community Levels Performance.** In the published evaluation of the performance of CDC’s Community Levels, the risk designation is considered a true positive if, for two counties with different Community Levels, the county with the higher level had the more severe outcome 3 weeks later (1). This values the ordering of two areas’ outcomes as equally important everywhere, whereas our methods prioritize correctly classifying areas on either side of the a priori-specified threshold (e.g., 1 death/100k/week).

Although these are not directly comparable to our measures, we compared our results to the CDC’s own published evaluation of the performance of Community Levels (1). These analyses use data from 3/1/2021 to 1/24/2022 to compute the area under the receiver operator curve (AUROC) for Community Levels (comparing High versus Medium/Low) for mortality at 0.71. During approximately the same period (Q2-Q4 2021, which is our training period), we found that Community Levels had unweighted accuracy of 0.67 for predicting  $>1$  death/100k/week and 0.80 for  $>2$  deaths/100k/week at the county level,

49 falling on either side of the AUROC value. We obtained similar estimates for accuracy compared to AUROC estimates of bed  
50 occupancy (0.86 CDC AUROC vs. 0.84 accuracy for predicting >10%), but lower estimates for ICU admissions (0.82 CDC  
51 AUROC vs. 0.66 accuracy for predicting >2 ICU hospitalizations/100k/week), which may reflect our choice of a lower cutoff as  
52 most policy-relevant, but with stronger Community Levels performance at higher cutoff values.

**Table S1. Optimal cutoffs for static metrics. Static metrics designated an area as high-risk if all included indicators exceeded their respective optimal thresholds from the training period (4/1/2021-12/31/2021). This table lists optimal cutoffs for each level of geography, risk preference, outcome, and indicator combination. Cutoffs are listed in the order CHO, i.e. 0 5 0 means a cutoff of greater than or equal to 0 per 100K for cases, 5 per 100K for hospitalizations, and 0% inpatient bed occupancy. When an indicator is excluded from a particular functional form, it takes the cutoff 0 by default.**

Geography	Risk preference	Outcome	Indicators	Optimal training cutoff
States	Neutral	>1 death/100K/wk	H	0 5 0
States	Neutral	>1 death/100K/wk	HO	0 5 5
States	Neutral	>1 death/100K/wk	C	50 0 0
States	Neutral	>1 death/100K/wk	CH	50 5 0
States	Neutral	>1 death/100K/wk	CHO	50 5 5
States	Neutral	>2 deaths/100K/wk	H	0 15 0
States	Neutral	>2 deaths/100K/wk	HO	0 15 5
States	Neutral	>2 deaths/100K/wk	C	200 0 0
States	Neutral	>2 deaths/100K/wk	CH	200 5 0
States	Neutral	>2 deaths/100K/wk	CHO	200 5 5
States	Don't cry wolf (0.5x FN)	>1 death/100K/wk	H	0 10 0
States	Don't cry wolf (0.5x FN)	>1 death/100K/wk	HO	0 5 5
States	Don't cry wolf (0.5x FN)	>1 death/100K/wk	C	100 0 0
States	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CH	100 5 0
States	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CHO	50 5 5
States	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	H	0 15 0
States	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	HO	0 15 5
States	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CH	150 15 0
States	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	C	200 0 0
States	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CHO	200 10 5
States	Better safe than sorry (0.5x FP)	>1 death/100K/wk	H	0 5 0
States	Better safe than sorry (0.5x FP)	>1 death/100K/wk	HO	0 5 5
States	Better safe than sorry (0.5x FP)	>1 death/100K/wk	C	50 0 0
States	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CH	50 5 0
States	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CHO	50 5 5
States	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	H	0 10 0
States	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	HO	0 10 5
States	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	C	150 0 0
States	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CH	150 10 0
States	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CHO	150 5 5
HSAs	Neutral	>1 death/100K/wk	H	0 5 0
HSAs	Neutral	>1 death/100K/wk	HO	0 5 5
HSAs	Neutral	>1 death/100K/wk	C	50 0 0
HSAs	Neutral	>1 death/100K/wk	CH	50 5 0
HSAs	Neutral	>1 death/100K/wk	CHO	50 5 5
HSAs	Neutral	>2 deaths/100K/wk	H	0 15 0
HSAs	Neutral	>2 deaths/100K/wk	HO	0 15 5
HSAs	Neutral	>2 deaths/100K/wk	CH	150 10 0
HSAs	Neutral	>2 deaths/100K/wk	CHO	150 10 5
HSAs	Neutral	>2 deaths/100K/wk	C	200 0 0
HSAs	Don't cry wolf (0.5x FN)	>1 death/100K/wk	H	0 10 0
HSAs	Don't cry wolf (0.5x FN)	>1 death/100K/wk	HO	0 5 5
HSAs	Don't cry wolf (0.5x FN)	>1 death/100K/wk	C	100 0 0
HSAs	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CH	100 5 0
HSAs	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CHO	50 5 5
HSAs	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	H	0 15 0
HSAs	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	HO	0 15 5
HSAs	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CHO	150 15 5
HSAs	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CH	200 15 0
HSAs	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	C	250 0 0
HSAs	Better safe than sorry (0.5x FP)	>1 death/100K/wk	H	0 5 0
HSAs	Better safe than sorry (0.5x FP)	>1 death/100K/wk	HO	0 5 5
HSAs	Better safe than sorry (0.5x FP)	>1 death/100K/wk	C	50 0 0
HSAs	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CH	50 5 0
HSAs	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CHO	50 5 5

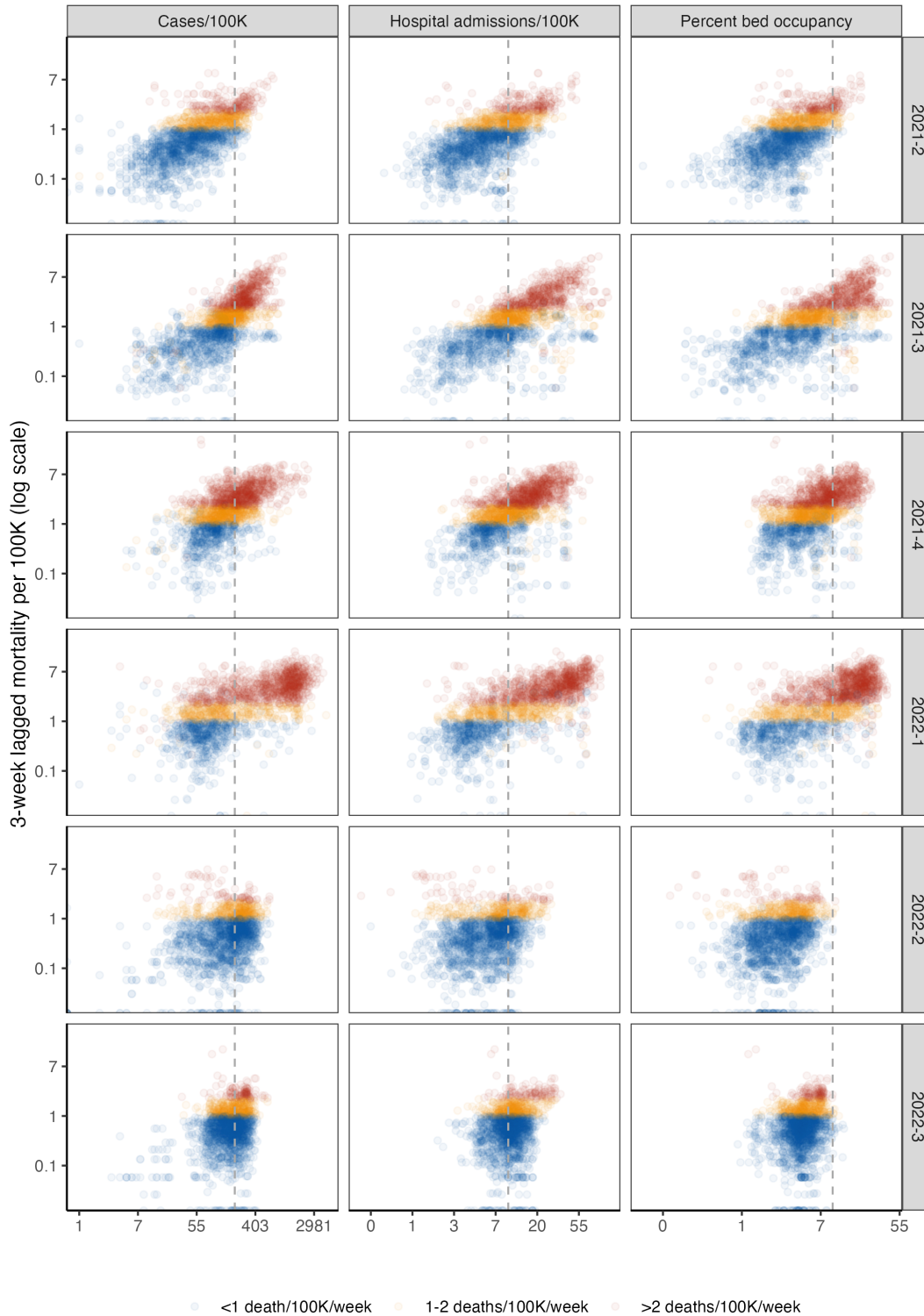
HSAs	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	H	0 10 0
HSAs	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	HO	0 10 5
HSAs	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CH	100 10 0
HSAs	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CHO	100 5 5
HSAs	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	C	150 0 0
Counties	Neutral	>1 death/100K/wk	H	0 5 0
Counties	Neutral	>1 death/100K/wk	HO	0 5 5
Counties	Neutral	>1 death/100K/wk	C	100 0 0
Counties	Neutral	>1 death/100K/wk	CH	50 5 0
Counties	Neutral	>1 death/100K/wk	CHO	50 5 5
Counties	Neutral	>2 deaths/100K/wk	H	0 15 0
Counties	Neutral	>2 deaths/100K/wk	HO	0 15 5
Counties	Neutral	>2 deaths/100K/wk	CH	150 15 0
Counties	Neutral	>2 deaths/100K/wk	CHO	150 15 5
Counties	Neutral	>2 deaths/100K/wk	C	200 0 0
Counties	Don't cry wolf (0.5x FN)	>1 death/100K/wk	H	0 10 0
Counties	Don't cry wolf (0.5x FN)	>1 death/100K/wk	HO	0 5 5
Counties	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CH	100 10 0
Counties	Don't cry wolf (0.5x FN)	>1 death/100K/wk	CHO	100 5 5
Counties	Don't cry wolf (0.5x FN)	>1 death/100K/wk	C	150 0 0
Counties	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	HO	0 15 10
Counties	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	H	0 20 0
Counties	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CH	200 15 0
Counties	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	CHO	200 15 5
Counties	Don't cry wolf (0.5x FN)	>2 deaths/100K/wk	C	250 0 0
Counties	Better safe than sorry (0.5x FP)	>1 death/100K/wk	H	0 5 0
Counties	Better safe than sorry (0.5x FP)	>1 death/100K/wk	HO	0 5 5
Counties	Better safe than sorry (0.5x FP)	>1 death/100K/wk	C	50 0 0
Counties	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CH	50 5 0
Counties	Better safe than sorry (0.5x FP)	>1 death/100K/wk	CHO	50 5 5
Counties	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	H	0 10 0
Counties	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	HO	0 10 5
Counties	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CH	100 10 0
Counties	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	CHO	100 10 5
Counties	Better safe than sorry (0.5x FP)	>2 deaths/100K/wk	C	150 0 0

**Table S2. Switches between high-risk and non-high risk episodes.** We estimated the number of switches between predicted high-risk and non-high risk designations using two definitions: 1) any change from the prior week and 2) a change that lasted at least two weeks (following a previous episode at least two weeks in duration). Across states and counties, we find that best-performing adaptive metrics of those in Figure S4 generally predicted fewer unique episodes than CDC Community Levels, and both often predict fewer episodes were observed, with one exception being the outcome >1 death/100K/week. In this case, adaptive metrics had more episodes, but these were substantially closer than static metrics to the values.

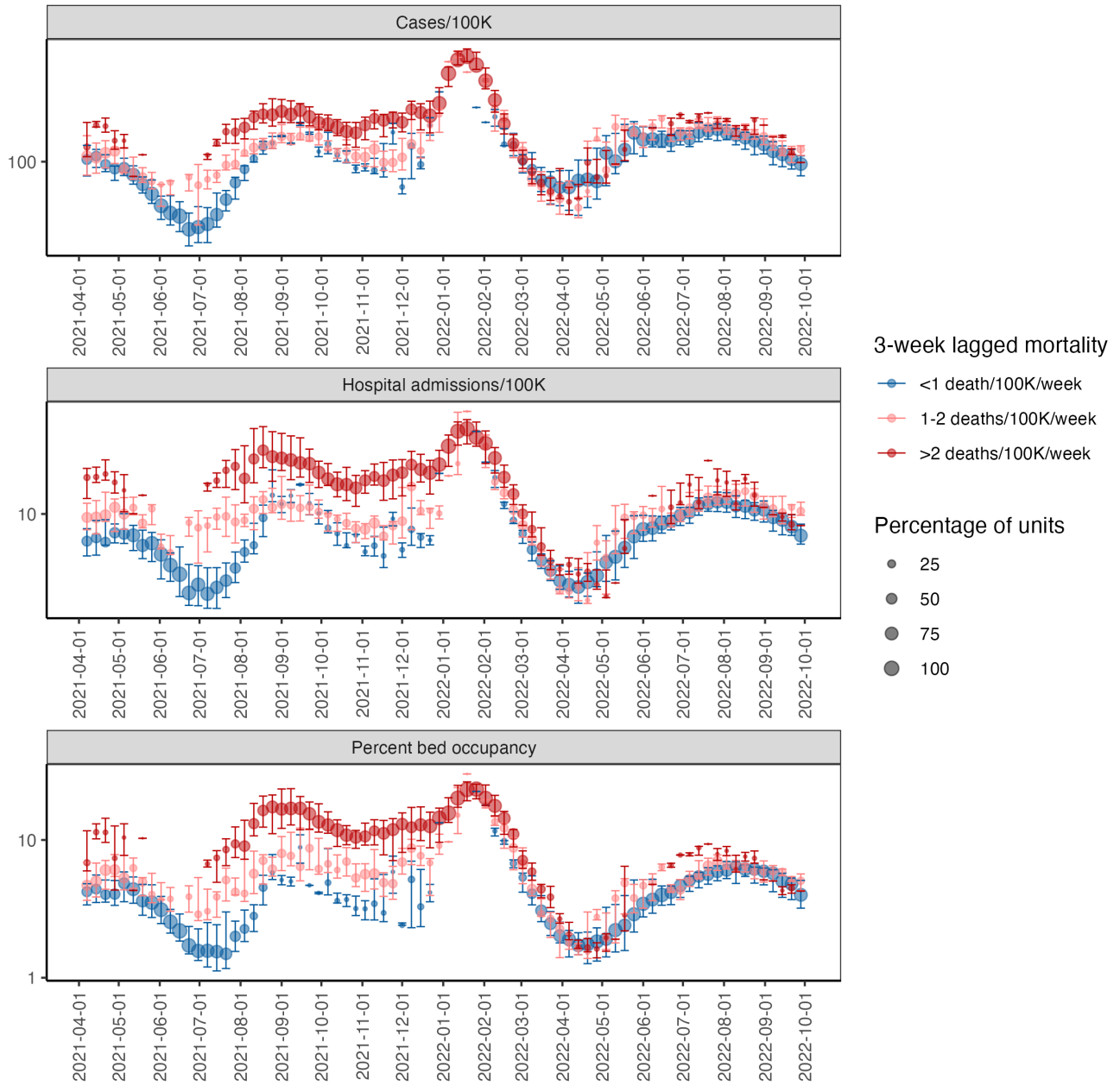
Geography	Outcome	Episode definition	True episodes	Adaptive episodes	Community Level episodes
State	>1 death/100K/wk	1	707	450	370
State	>1 death/100K/wk	2	428	309	327
State	>2 deaths/100K/wk	1	447	226	370
State	>2 deaths/100K/wk	2	304	188	327
State	>2 ICU patients/100K/wk	1	280	319	370
State	>2 ICU patients/100K/wk	2	236	254	327
State	>10% inpatient bed occupancy	1	205	320	370
State	>10% inpatient bed occupancy	2	203	240	327
County	>1 death/100K/wk	1	47,978	30,373	29,451
County	>1 death/100K/wk	2	38,299	22,095	20,811
County	>2 deaths/100K/wk	1	46,346	21,410	29,451
County	>2 deaths/100K/wk	2	36,905	16,016	20,811
County	>2 ICU patients/100K/wk	1	23,124	19,065	29,451
County	>2 ICU patients/100K/wk	2	16,762	14,858	20,811
County	>10% inpatient bed occupancy	1	14,058	23,451	29,451
County	>10% inpatient bed occupancy	2	12,103	16,004	20,811

53 **References**

- 54 1. CDC, Science Brief: Indicators for Monitoring COVID-19 Community Levels and Making Public Health Recommendations  
55 (<https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/indicators-monitoring-community-levels.html>) (2022).

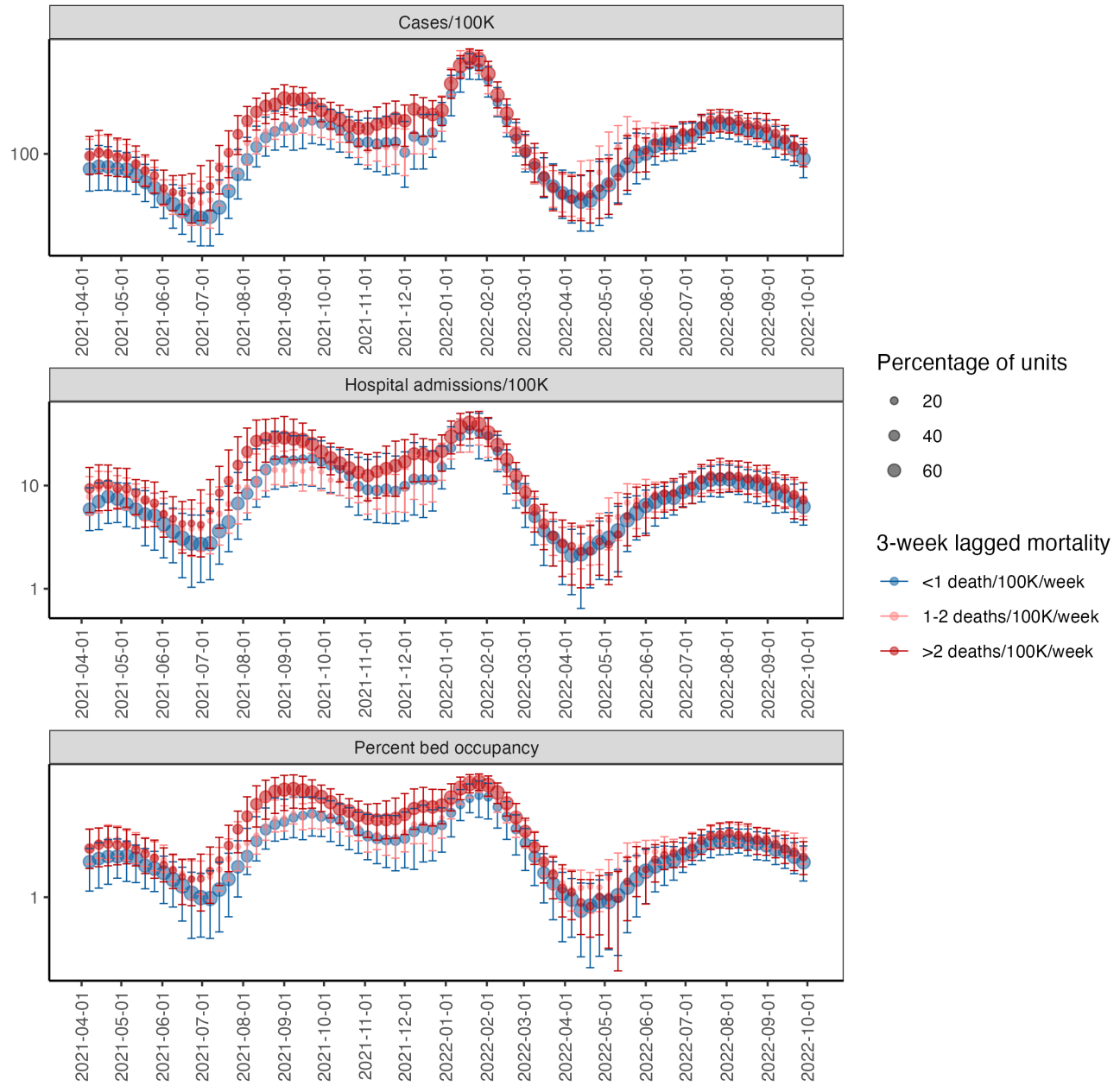


**Fig. S1.** County-level lagged mortality vs. indicator levels by quarter. Columns indicate different indicators (weekly cases per 100,000 population, new hospital admissions per 100,000 population, and percentage of inpatient beds occupied by COVID-19 patients), and rows indicate quarters. The x-axis displays indicator values on a log scale and y-axis displays 3-week ahead mortality per 100,000 population on a log scale. Each point on the scatterplot is a county-week, and counties with greater than 500,000 population are displayed. Colors show mortality outcome level. The vertical gray dotted lines indicate thresholds from CDC Community Levels for each indicator ( $\geq 200$  cases/100K/week and  $\geq 10$  new admissions/100K/week or  $\geq 10\%$  COVID-19 bed occupancy.)



**Fig. S2.** Indicators by lagged mortality (state). Indicators vary across rows. The x-axis displays time and the y-axis displays the median (point) and interquartile range (bars) of each indicator by future mortality status.





**Fig. S3.** Indicators by future mortality (county). Indicators vary across rows. The x-axis displays time and the y-axis displays the median (point) and interquartile range (bars) of each indicator by future mortality status.

### States

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
Adaptive: CHO	88	3	80	10	87	5	86	2	90	3	75	14	>1 death/100K/wk	
Adaptive: CHOZ	88	3	83	5	88	5	87	2	90	2	80	10		
Adaptive: CHOD	86	6	77	17	85	9	84	4	87	5	74	16		
Adaptive: HZ	89	1	83	5	89	3	87	1	91	3	81	8		
Simplified adaptive: HZ	86	6	82	8	85	12	84	5	89	5	82	4		
Community Levels	64	44	71	24	76	28	72	29	53	62	70	24		
Z	80	15	81	8	81	19	79	12	80	25	83	3		
CHO	86	7	68	41	87	5	63	58	84	11	73	22		
HO	85	7	68	41	87	6	63	58	84	11	73	22		
CH	87	5	56	52	86	9	47	67	90	3	68	26		
H	86	15	56	52	84	19	63	45	88	8	62	26		
C	86	5	45	60	86	9	41	67	90	2	62	33		
Prevalence	68		41		68		41		68		41			
Adaptive: CHO	87	7	93	3	87	6	94	2	87	8	93	3		>2 deaths/100K/wk
Adaptive: CHOZ	88	6	92	3	88	5	93	3	88	8	92	5		
Adaptive: CHOD	85	10	91	4	86	12	92	5	85	10	90	6		
Adaptive: HZ	90	2	93	3	91	1	93	4	90	2	92	3		
Simplified adaptive: HZ	87	6	94	0	89	3	94	2	88	7	93	1		
Community Levels	88	7	77	36	90	4	72	51	87	12	82	24		
Z	83	11	87	19	85	10	86	24	82	13	89	15		
CHO	89	7	76	37	90	4	75	49	88	6	77	38		
HO	88	6	91	5	90	3	91	10	88	8	81	35		
CH	88	8	70	39	90	2	91	10	88	7	79	35		
H	88	6	91	6	89	5	91	10	87	9	79	38		
C	88	8	70	39	90	4	62	55	88	7	68	42		
Prevalence	36		23		36		23		36		23			

### HSAs

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
Adaptive: CHO	80	4	73	6	81	3	80	2	84	5	70	11	>1 death/100K/wk	
Adaptive: CHOZ	83	1	77	7	83	1	81	2	86	1	78	0		
Adaptive: CHOD	80	4	74	7	81	3	81	2	84	5	71	11		
Adaptive: HZ	82	3	77	0	83	1	81	2	86	2	78	0		
Simplified adaptive: HZ	81	3	76	1	80	7	80	3	85	3	78	1		
Community Levels	64	31	68	13	75	14	73	13	52	49	63	27		
Z	78	9	75	2	78	11	74	12	77	16	77	3		
CHO	75	15	70	13	81	4	73	18	68	26	66	16		
HO	75	15	70	13	81	4	73	18	68	26	66	16		
CH	81	4	58	31	81	3	52	47	81	8	66	15		
H	80	6	58	31	81	6	68	26	82	6	67	15		
C	79	5	50	42	80	3	46	54	83	5	64	23		
Prevalence	66		48		66		48		66		48			
Adaptive: CHO	82	4	88	0	84	5	91	1	83	5	87	2		>2 deaths/100K/wk
Adaptive: CHOZ	84	1	88	0	86	2	91	1	85	1	88	0		
Adaptive: CHOD	81	6	89	0	83	7	90	2	82	5	87	1		
Adaptive: HZ	83	4	88	1	85	3	90	4	84	4	87	1		
Simplified adaptive: HZ	82	5	87	2	83	5	91	1	82	4	86	2		
Community Levels	83	5	76	24	85	2	73	37	81	13	78	14		
Z	80	6	82	11	81	11	81	17	79	9	84	9		
CHO	82	4	80	19	85	3	86	10	82	5	80	17		
HO	82	7	85	5	85	2	86	10	82	7	81	12		
CH	82	3	72	34	85	4	85	12	82	5	75	23		
H	82	7	83	9	84	2	84	15	82	5	75	24		
C	82	7	66	33	85	5	73	27	82	8	66	31		
Prevalence	37		26		37		26		37		26			

### Counties

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
Adaptive: CHO	75	4	73	4	78	3	79	4	79	4	70	9	>1 death/100K/wk	
Adaptive: CHOZ	77	0	75	0	79	0	80	2	80	0	75	1		
Adaptive: CHOD	75	3	74	2	77	3	81	1	79	3	71	6		
Adaptive: HZ	75	4	75	1	78	2	80	3	78	5	75	1		
Simplified adaptive: HZ	74	5	74	4	76	5	78	5	79	4	75	1		
Community Levels	67	18	69	8	75	6	73	15	58	35	65	20		
Z	73	6	72	4	74	13	71	12	73	14	73	5		
CHO	74	6	70	9	78	2	73	19	70	16	68	12		
HO	73	7	70	10	77	4	73	21	70	16	68	11		
CH	75	4	57	31	78	2	68	28	78	3	66	13		
H	73	10	56	33	76	4	67	31	78	4	66	13		
C	75	3	54	32	77	2	55	39	78	3	63	21		
Prevalence	58		44		58		44		58		44			
Adaptive: CHO	79	4	86	1	82	4	88	0	80	4	84	3		>2 deaths/100K/wk
Adaptive: CHOZ	81	1	86	0	84	0	88	1	82	0	85	0		
Adaptive: CHOD	78	5	86	1	81	5	89	0	79	4	85	1		
Adaptive: HZ	80	4	85	2	83	1	87	3	80	4	84	2		
Simplified adaptive: HZ	79	3	85	2	83	3	89	0	79	4	84	2		
Community Levels	80	3	75	23	81	4	72	33	79	9	77	13		
Z	78	6	80	10	78	12	79	15	77	8	81	10		
CHO	80	4	83	5	84	1	85	7	80	5	80	11		
HO	79	4	83	6	83	2	88	0	79	5	80	12		
CH	80	4	82	8	83	1	84	10	80	3	74	21		
H	79	4	82	9	82	3	87	2	79	4	74	23		
C	80	4	65	31	83	3	71	26	79	5	66	28		
Prevalence	35		25		35		25		35		25			

**Fig. S4.** Head-to-head comparison results, including HSA-level results. The top plots display results from state-level analyses, middle from HSA-level analyses, and bottom from county-level analyses, all weighted for population. Metrics are displayed on the left, with training data from Q2-Q4 2021 and test data from Q1-Q3 2022. Cells report weighted accuracy and maximum regret (MR) over training and test periods. Rows vary outcomes, and columns vary preferences for false positives versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the population-weighted proportion of high location-weeks in a given time period. Secondary outcomes are presented in Figure S5, and weighted accuracy by quarter is presented in Figures S6-S8. For adaptive metrics, models vary functional form to include: 1) CHO (cases, hospitalizations, inpatient bed occupancy); 2) CHOZ (cases, hospitalizations, inpatient bed occupancy, current risk designation); 3) CHOD (cases, hospitalizations, inpatient bed occupancy, weekly changes in each indicator); 4) HZ (hospitalizations, current risk designation); 5) Simplified HZ (hospitalizations, current risk designation – updated quarterly). (For additional adaptive functional forms, see Figure S9.)

States

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
	Adaptive: CHO	87	6	93	5	88	5	92	5	86	7	94		3
Adaptive: CHOZ	86	9	91	7	87	9	89	8	86	7	93	4		
Adaptive: CHOD	90	4	93	3	91	0	93	4	90	5	94	3		
Adaptive: HZ	86	8	93	5	87	9	92	6	87	7	94	4		
Simplified adaptive: HZ	85	14	89	17	86	11	87	20	85	15	91	14		
Community Levels	60	42	79	34	73	24	73	48	47	58	86	21		
Z	84	12	90	14	85	13	87	19	83	18	92	9		
CHO	84	16	61	68	87	9	48	93	80	23	74	44		
HO	83	16	61	68	87	9	48	93	80	23	74	44		
CH	88	7	38	88	87	9	27	96	89	6	59	57		
H	84	17	37	89	81	17	59	77	88	7	58	57		
C	87	9	24	90	87	6	22	96	89	3	49	58		
Prevalence	73		17		73		17		73		17			
Adaptive: CHO	85	5	93	9	85	11	93	9	87	5	95	7	≥10% inpatient bed occupancy	
Adaptive: CHOZ	85	6	91	13	85	11	90	16	86	5	94	10		
Adaptive: CHOD	88	4	97	0	88	5	96	0	89	2	97	0		
Adaptive: HZ	83	10	91	15	84	10	89	22	84	8	94	10		
Simplified adaptive: HZ	82	16	93	11	86	9	92	13	80	25	94	11		
Community Levels	88	4	74	43	89	6	65	58	87	5	82	29		
Z	64	39	89	23	76	23	93	11	52	59	85	37		
CHO	87	4	73	44	89	4	78	31	87	4	76	43		
HO	85	8	88	12	86	10	91	8	84	10	78	40		
CH	88	4	74	43	89	4	77	32	87	4	78	40		
H	84	8	88	12	86	10	91	8	83	12	75	44		
C	87	4	66	46	89	4	72	32	86	7	78	31		
Prevalence	36		11		36		11		36		11			

HSAs

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
	Adaptive: CHO	81	4	91	1	82	4	90	4	83	3	91		3
Adaptive: CHOZ	82	2	91	1	83	4	91	3	83	3	92	1		
Adaptive: CHOD	82	3	90	2	83	4	92	1	84	3	91	3		
Adaptive: HZ	80	6	91	3	82	3	90	4	82	7	91	3		
Simplified adaptive: HZ	80	7	88	11	80	9	86	16	80	13	88	14		
Community Levels	66	25	80	25	76	12	74	36	55	39	85	16		
Z	80	6	89	9	81	7	86	15	79	13	91	5		
CHO	75	14	75	32	81	5	70	43	70	24	82	22		
HO	75	14	75	32	81	5	68	45	70	24	82	22		
CH	81	6	43	78	83	2	33	95	83	5	62	50		
H	80	11	42	78	80	6	62	59	83	4	61	50		
C	80	7	42	74	82	3	23	95	83	5	51	53		
Prevalence	63		17		63		17		63		17			
Adaptive: CHO	84	10	90	15	86	10	90	15	84	6	93	7	≥10% inpatient bed occupancy	
Adaptive: CHOZ	84	10	90	15	86	10	90	16	84	7	93	7		
Adaptive: CHOD	89	1	95	0	90	1	95	1	88	0	95	0		
Adaptive: HZ	83	9	90	15	86	7	87	24	83	8	93	7		
Simplified adaptive: HZ	79	18	91	12	84	10	90	15	79	21	93	8		
Community Levels	83	8	75	33	82	9	67	45	85	5	83	22		
Z	72	26	91	13	81	15	94	4	63	39	88	25		
CHO	85	8	84	16	87	4	85	15	84	39	86	17		
HO	83	8	91	11	87	6	92	9	82	7	85	19		
CH	85	8	77	25	87	5	83	15	84	8	77	29		
H	82	10	91	6	86	8	92	6	82	8	90	10		
C	85	8	76	26	87	5	79	18	84	8	76	30		
Prevalence	28		9		28		9		28		9			

Counties

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)					
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR		
	Adaptive: CHO	81	4	91	2	82	4	91	4	83	4	91		3
Adaptive: CHOZ	82	3	91	3	83	3	91	3	83	3	92	2		
Adaptive: CHOD	82	3	91	2	83	3	92	1	84	4	91	3		
Adaptive: HZ	81	6	91	3	82	3	91	4	82	6	91	4		
Simplified adaptive: HZ	80	7	88	12	80	8	87	15	80	11	88	14		
Community Levels	66	25	80	23	76	12	75	34	55	38	86	15		
Z	80	6	89	9	81	8	86	14	80	12	91	6		
CHO	76	14	76	32	81	4	69	44	70	23	82	21		
HO	76	14	76	32	81	4	69	44	70	22	82	21		
CH	81	5	45	76	83	3	35	94	83	4	63	48		
H	80	11	43	77	81	6	63	58	83	5	62	49		
C	79	8	44	71	81	4	25	95	82	7	53	52		
Prevalence	63		19		63		19		63		19			
Adaptive: CHO	84	8	90	13	86	8	90	15	84	6	93	6	≥10% inpatient bed occupancy	
Adaptive: CHOZ	84	8	90	13	86	8	89	16	84	6	93	6		
Adaptive: CHOD	88	1	95	0	89	1	95	1	87	0	95	0		
Adaptive: HZ	83	7	90	14	86	5	87	22	83	7	93	7		
Simplified adaptive: HZ	79	17	91	11	84	9	90	14	79	20	93	7		
Community Levels	84	6	76	31	83	9	68	42	85	4	84	21		
Z	72	24	91	13	81	14	94	4	62	38	87	24		
CHO	84	7	84	16	87	5	86	13	83	8	86	16		
HO	83	7	91	9	87	5	92	7	82	7	91	8		
CH	84	7	77	25	87	5	83	15	83	8	77	27		
H	82	9	91	5	86	7	92	5	82	7	90	11		
C	84	7	76	26	86	5	78	18	83	8	76	28		
Prevalence	28		9		28		9		28		9			

**Fig. S5.** Head-to-head comparison results for secondary outcomes. The top plots display results from state-level analyses, middle from HSA-level analyses, and bottom from county-level analyses, all weighted for population. Metrics are displayed on the left, with training data from Q2-Q4 2021 and test data from Q1-Q3 2022. Cells report weighted accuracy and maximum regret (MR) over training and test periods. Rows vary outcomes, and columns vary preferences for false positives versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the population-weighted proportion of high location-weeks in a given time period. Weighted accuracy by quarter is presented in Figures S6-S8. For adaptive metrics, models vary functional form to include: 1) CHO (cases, hospitalizations, inpatient bed occupancy); 2) CHOZ (cases, hospitalizations, inpatient bed occupancy, current risk designation); 3) CHOD (cases, hospitalizations, inpatient bed occupancy, weekly changes in each indicator); 4) HZ (hospitalizations, current risk designation); 5) Simplified HZ (hospitalizations, current risk designation – updated quarterly)

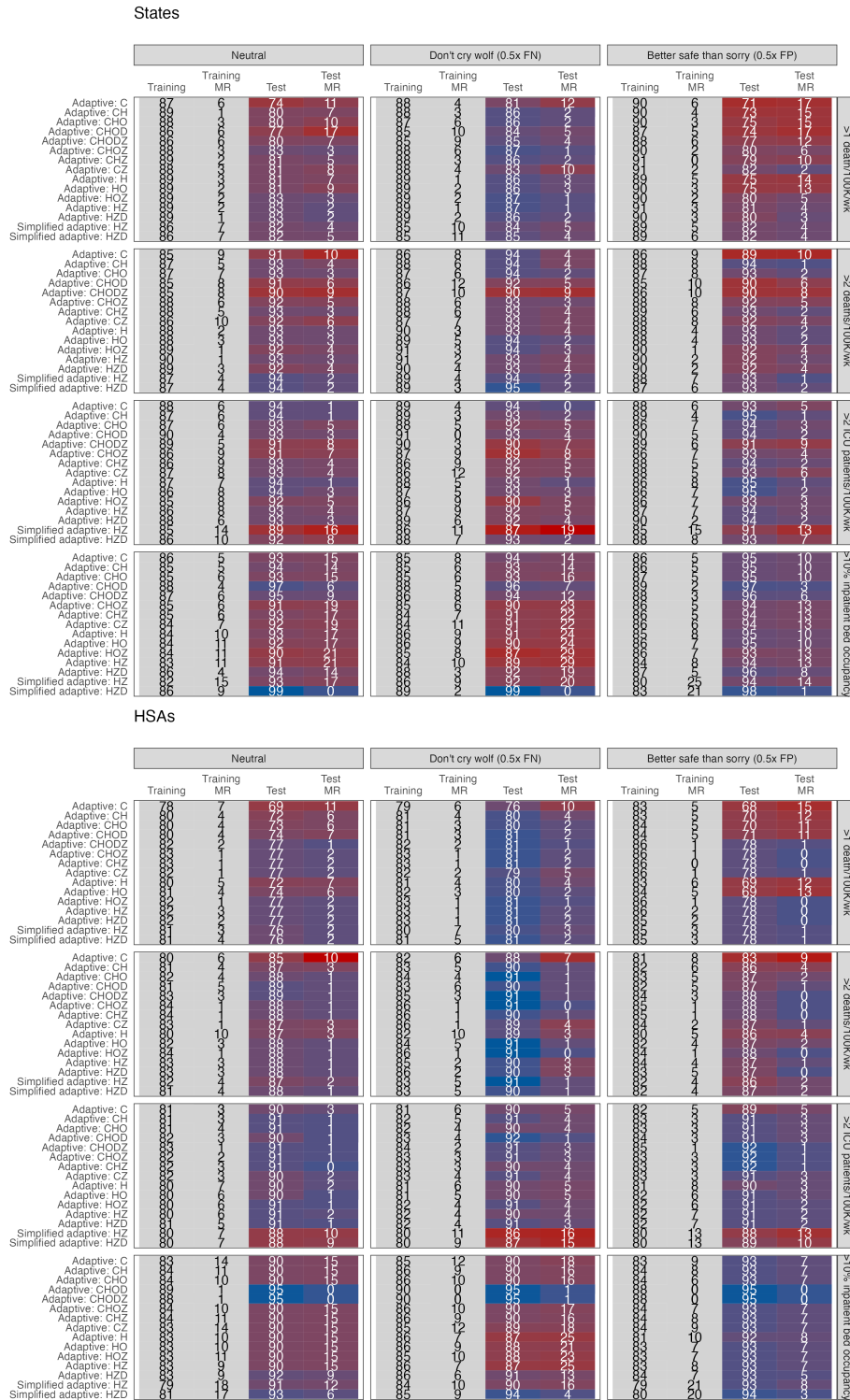
States

	Neutral									Don't cry wolf (0.5x FN)									Better safe than sorry (0.5x FP)										
	21-2	21-3	21-4	22-1	22-2	22-3	Test	Training	Overall	21-2	21-3	21-4	22-1	22-2	22-3	Test	Training	Overall	21-2	21-3	21-4	22-1	22-2	22-3	Test	Training	Overall		
Adaptive: CHO	80	90	93	85	83	73	80	88	84	81	88	92	87	89	83	86	87	87	81	93	96	81	78	66	75	90	82	~1 death/100K/wk	
Adaptive: CHOD	81	90	92	85	84	80	83	88	85	83	88	91	87	89	84	87	88	87	83	93	94	80	82	76	80	90	85		
Adaptive: HZ	80	87	90	83	82	66	77	86	81	81	84	90	85	87	80	84	85	84	80	90	91	80	78	64	74	87	80		
Simplified adaptive: HZ	75	89	94	82	81	83	82	86	84	82	93	92	88	90	84	87	89	88	84	92	96	82	82	80	81	91	86		
Community Levels	71	72	50	75	79	59	71	64	68	81	81	66	83	80	55	72	76	74	79	91	96	86	79	80	82	89	85		
Z	72	78	91	82	81	80	81	80	81	66	85	91	77	81	80	79	81	80	62	62	34	66	79	64	70	53	61		
CHO	79	90	87	87	75	42	68	86	77	80	92	90	89	75	26	63	87	75	79	88	85	85	76	58	73	84	78		
HO	79	90	87	87	75	42	68	85	77	79	92	90	89	75	26	63	87	75	79	88	85	85	76	58	73	84	78		
CH	76	93	93	88	48	31	56	87	72	81	92	85	86	36	17	47	86	66	81	95	94	88	63	54	68	90	79		
H	66	91	94	90	49	31	56	83	70	85	93	75	87	79	39	68	84	76	76	94	96	90	63	54	69	88	79		
C	76	89	93	80	24	29	45	86	65	81	92	85	84	23	17	41	86	64	82	93	94	84	49	53	62	90	76		
Prevalence	35	75	94	78	17	29	41	68	55	35	75	94	78	17	29	41	68	55	35	75	94	78	17	29	41	68	55		
Adaptive: CHO	95	84	81	87	96	96	93	87	90	95	84	83	88	97	98	94	87	91	95	86	81	87	95	95	93	87	90		~2 death/100K/wk
Adaptive: CHOD	96	86	82	87	96	93	92	88	90	96	86	83	88	97	95	93	88	91	95	88	81	87	95	92	92	88	90		
Adaptive: HZ	96	79	80	87	94	92	91	85	88	97	78	83	89	96	93	92	86	89	96	81	79	87	93	91	90	85	88		
Simplified adaptive: HZ	95	87	88	87	97	95	93	90	91	96	89	88	86	97	95	93	91	92	95	87	87	88	95	94	92	90	91		
Community Levels	93	83	86	90	97	96	94	87	91	94	87	87	89	98	96	94	89	92	94	81	88	89	95	96	93	88	91		
Z	92	81	77	71	95	96	87	83	85	91	86	78	66	95	96	86	85	85	94	75	77	75	95	97	89	82	86		
CHO	96	89	81	86	84	59	76	89	83	96	90	84	89	87	49	75	90	83	94	88	83	86	87	59	77	88	83		
HO	95	88	82	88	96	91	91	88	90	94	89	87	90	95	88	91	90	91	89	87	89	90	92	62	81	88	85		
CH	96	89	80	86	66	57	70	88	79	95	89	86	90	95	88	91	90	90	94	87	82	86	88	62	79	88	83		
H	94	88	82	88	95	90	91	88	90	92	89	87	90	95	88	91	89	90	88	86	88	90	88	59	79	87	83		
C	96	89	80	86	66	57	70	88	79	96	89	84	88	55	43	62	90	76	94	88	82	86	64	55	68	88	78		
Prevalence	5	47	56	61	3	5	23	36	29	5	47	56	61	3	5	23	36	29	5	47	56	61	3	5	23	36	29		
Adaptive: CHO	78	92	90	90	94	94	93	87	90	81	92	91	87	94	96	92	88	90	79	92	89	93	95	94	94	86	90	~2 ICU patients/100K/wk	
Adaptive: CHOD	75	92	90	86	92	94	91	86	88	77	92	92	82	91	95	89	87	88	78	92	89	90	94	94	93	86	90		
Adaptive: HZ	84	95	91	89	96	95	93	90	92	86	95	93	86	95	96	93	91	92	83	95	91	91	96	95	94	90	92		
Simplified adaptive: HZ	76	88	95	86	98	94	93	86	89	77	90	92	82	98	95	92	87	89	79	88	96	90	97	94	94	87	91		
Community Levels	68	58	53	91	86	61	79	60	70	79	72	69	88	81	48	73	73	73	80	80	95	80	98	94	91	85	88		
Z	76	83	93	77	99	94	90	84	87	73	88	93	69	99	93	87	85	86	80	77	93	85	98	94	92	83	88		
CHO	81	79	91	73	82	27	61	84	72	82	86	93	64	76	3	48	87	67	79	72	89	82	88	51	74	80	77		
HO	80	79	91	73	82	27	61	83	72	81	86	93	64	76	3	48	87	67	79	72	89	82	88	51	74	80	77		
CH	77	92	95	67	41	7	38	88	63	83	89	88	72	23	0	27	87	57	81	89	96	78	60	38	59	89	74		
H	67	93	93	65	40	6	37	84	61	83	85	76	77	80	19	59	81	70	76	91	95	77	60	38	58	88	73		
C	75	93	94	55	11	5	24	87	56	83	89	88	68	10	0	22	87	54	80	92	96	70	41	37	49	89	69		
Prevalence	37	89	92	45	1	5	17	73	45	37	89	92	45	1	5	17	73	45	37	89	92	45	1	5	17	73	45		
Adaptive: CHO	96	77	83	81	98	100	93	85	89	95	74	86	80	98	100	93	85	89	95	81	83	86	98	100	95	87	91		>1% inpatient bed occupancy
Adaptive: CHOD	95	76	83	77	98	100	91	85	88	95	74	86	73	97	100	90	85	87	95	81	83	83	98	100	94	86	90		
Adaptive: HZ	95	81	88	90	100	100	97	88	92	94	80	91	89	100	100	96	88	92	96	84	88	93	100	100	97	89	93		
Simplified adaptive: HZ	96	76	78	75	99	100	91	83	87	97	75	81	67	100	100	89	84	87	96	77	80	83	99	100	94	84	89		
Community Levels	99	66	81	79	100	100	93	82	87	99	76	82	76	100	100	92	86	89	98	59	82	82	100	100	94	80	87		
Z	95	82	86	80	85	57	74	88	81	93	85	87	73	80	42	65	89	77	96	79	85	86	90	71	82	87	85		
CHO	98	83	87	77	85	68	77	89	83	99	62	68	78	100	100	93	76	84	97	25	35	56	100	100	85	52	69		
HO	95	81	86	80	84	56	73	87	80	98	83	87	78	88	69	78	89	84	94	80	85	83	88	57	76	87	81		
CH	93	81	80	79	96	88	88	85	86	98	79	81	81	99	94	91	86	89	88	81	82	81	93	60	78	84	81		
H	95	81	87	80	85	57	74	88	81	98	83	87	77	85	68	77	89	83	94	80	86	84	89	60	78	87	82		
C	92	81	80	79	96	88	88	84	86	98	79	81	81	99	94	91	86	89	86	82	82	81	89	56	75	83	79		
Prevalence	2	57	49	33	0	0	11	36	23	2	57	49	33	0	0	11	36	23	2	57	49	33	0	0	11	36	23		

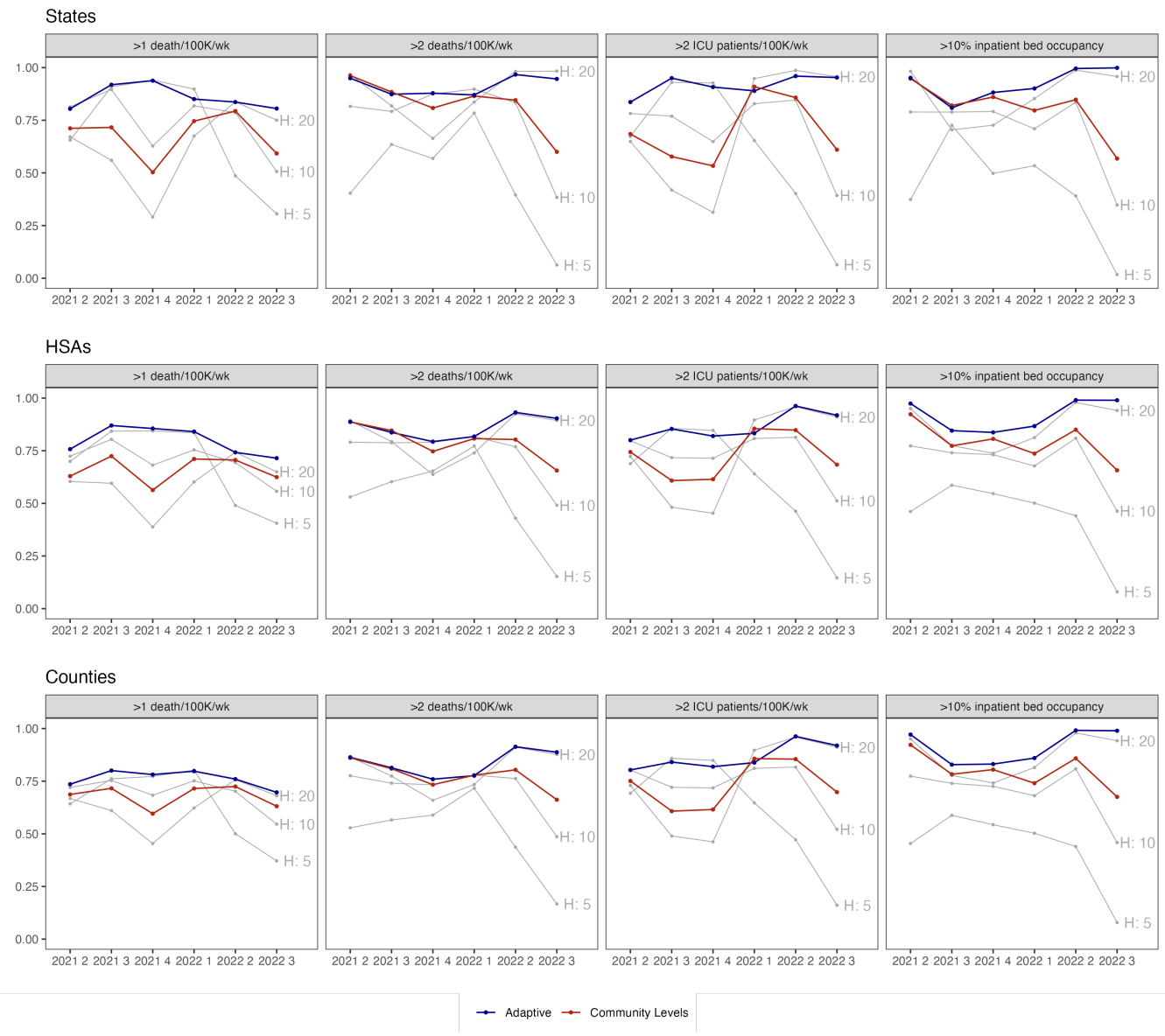
Fig. S6. State-level results by quarter. Metrics are displayed on the left, with training data from Q2-Q4 2021 and test data from Q1-Q3 2022. Cells report weighted accuracy. Preferences for false positives versus false negatives vary across columns (with "neutral" corresponding to unweighted accuracy) and outcomes across rows. Prevalence indicates the population-weighted proportion of high location-weeks in a given quarter.





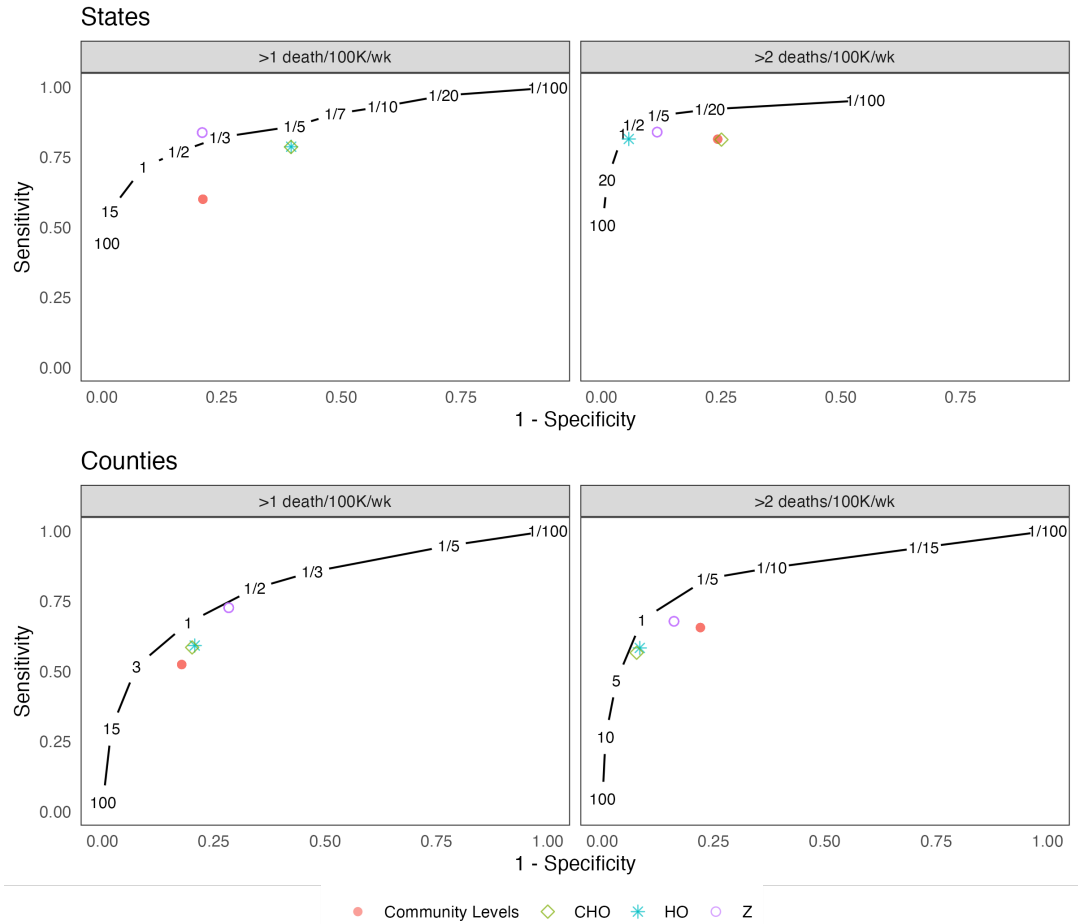


**Fig. S9.** Head-to-head comparison results with additional adaptive functional forms. The top plots display results from state-level analyses and middle from HSA-level analyses. Metrics are displayed on the left, with training data from Q2-Q4 2021 and test data from Q1-Q3 2022. Cells report weighted accuracy and maximum regret (MR) over training and test periods. Rows vary outcomes, and columns vary preferences for false positives versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the population-weighted proportion of high location-weeks in a given time period. Performance is similar across adaptive specifications, but unusually low-performing specifications (e.g., C and CHOD for >1 death/100K/week) generally had low performance in both training and test periods.



**Fig. S10.** Weighted accuracy by metric, including HSA-level results. Columns indicate different outcomes. The x-axis indicates quarter, and the y-axis predictive accuracy. Grey lines depict metrics based on new hospital admissions exceeding the labeled threshold. The red line indicates CDC Community Levels and the blue line the best-performing adaptive metric in the pre-intervention period of those listed in Figure S4.





**Fig. S11.** Receiver operating characteristic (ROC) curves for the test period from January 1, 2022 to September 30, 2022. The black line indicates performance of the adaptive metric (HZ) across different values of  $w_t$ , indicating the relative preference for false negatives over false positives. The top plot indicates state results and the bottom plot county results.

States

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)				
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	
	Adaptive: CHO	97	4	77	10	97	4	84	2	98	2	70	
Adaptive: CHOZ	97	4	80	5	97	5	85	2	98	2	76	10	
Adaptive: CHOD	90	17	74	17	91	13	82	4	88	20	70	16	
Adaptive: HZ	98	3	80	5	98	4	85	1	99	2	77	8	
Simplified adaptive: HZ	98	4	79	8	98	3	82	5	99	2	78	4	
Community Levels	92	20	66	24	95	12	68	29	90	26	64	24	
Z	93	14	78	8	94	11	76	12	91	16	80	3	
CHO	98	4	62	41	98	2	57	58	98	4	68	22	
HO	98	4	62	41	98	2	57	58	98	4	68	22	
CH	99	0	49	46	99	0	37	67	99	0	60	23	
H	98	3	48	52	98	4	33	77	99	1	63	26	
C	99	0	44	46	98	0	31	67	99	0	58	24	
Prevalence	98		31		98		31		98		31		
Adaptive: CHO	92	3	93	3	90	9	94	2	94	1	92	3	
Adaptive: CHOZ	92	3	91	3	91	8	93	3	94	1	90	5	
Adaptive: CHOD	92	3	90	4	92	3	92	5	94	0	89	6	
Adaptive: HZ	93	0	92	3	93	0	93	4	94	1	92	3	
Simplified adaptive: HZ	92	2	94	0	92	2	94	2	93	2	93	1	
Community Levels	92	5	73	36	91	9	68	51	93	4	79	24	
Z	78	18	88	19	82	13	86	24	73	25	91	15	
CHO	93	1	71	49	94	2	91	6	94	0	78	33	
HO	93	2	91	5	93	0	91	10	94	0	78	35	
CH	93	2	90	6	94	2	91	7	94	1	75	35	
H	93	2	90	6	93	0	90	10	93	2	76	38	
C	92	6	65	39	91	10	74	27	94	1	63	42	
Prevalence	88		9		88		9		88		9		

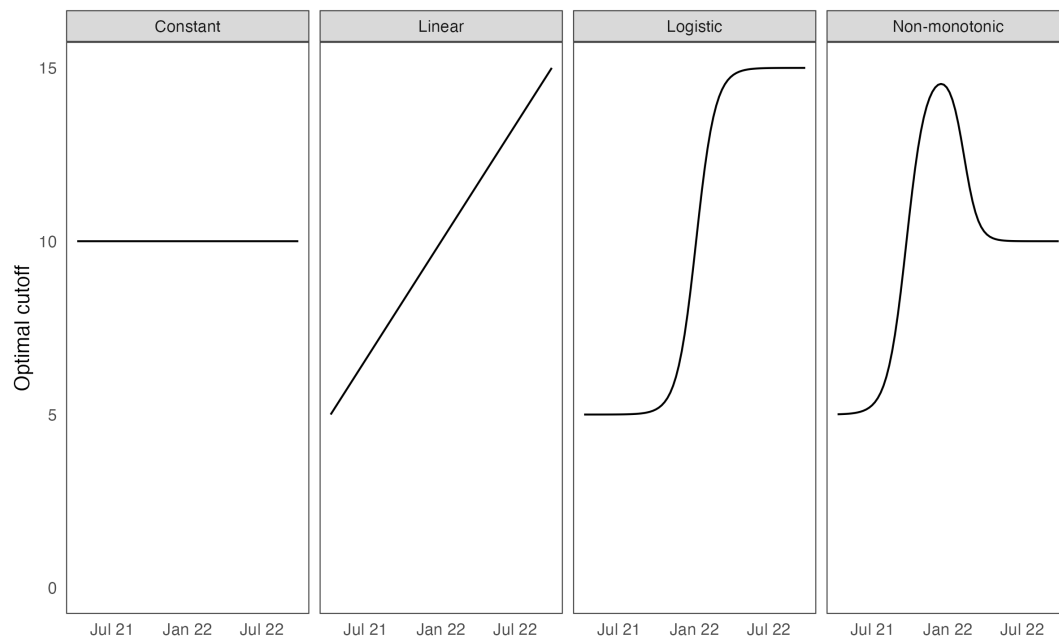
HSAs

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)				
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	
	Adaptive: CHO	95	2	69	6	94	1	77	2	96	1	65	
Adaptive: CHOZ	95	2	73	1	93	2	78	2	96	1	75	0	
Adaptive: CHOD	95	1	70	7	94	1	78	2	96	1	66	11	
Adaptive: HZ	95	0	73	0	94	1	78	2	96	0	75	0	
Simplified adaptive: HZ	94	2	72	1	93	3	77	3	96	1	74	1	
Community Levels	89	15	63	13	92	6	63	13	86	26	57	27	
Z	89	9	72	2	91	6	70	12	87	14	74	3	
CHO	92	7	65	13	94	1	69	18	91	15	61	16	
HO	92	7	65	13	94	1	69	18	91	15	61	16	
CH	94	2	50	31	94	0	44	47	95	3	60	15	
H	94	2	51	31	93	1	40	55	95	3	61	15	
C	95	2	47	32	94	1	37	54	96	2	58	23	
Prevalence	94		39		94		39		94		39		
Adaptive: CHO	87	3	88	0	85	3	91	1	90	2	86	2	
Adaptive: CHOZ	88	2	88	0	86	2	91	1	91	0	87	0	
Adaptive: CHOD	87	2	88	0	86	1	91	2	90	1	86	1	
Adaptive: HZ	88	0	88	1	86	1	90	4	90	1	86	1	
Simplified adaptive: HZ	85	8	87	2	85	5	91	1	87	10	85	2	
Community Levels	77	4	73	24	86	3	70	37	88	6	75	14	
Z	87	10	83	11	81	5	81	17	73	17	85	9	
CHO	87	3	78	21	85	0	86	10	89	3	77	17	
HO	87	3	78	21	85	0	86	10	89	3	77	17	
CH	87	2	66	40	85	1	84	15	89	4	58	41	
H	87	3	65	41	85	1	84	15	89	3	72	24	
C	86	7	49	52	85	5	70	27	90	3	54	42	
Prevalence	83		14		83		14		83		14		

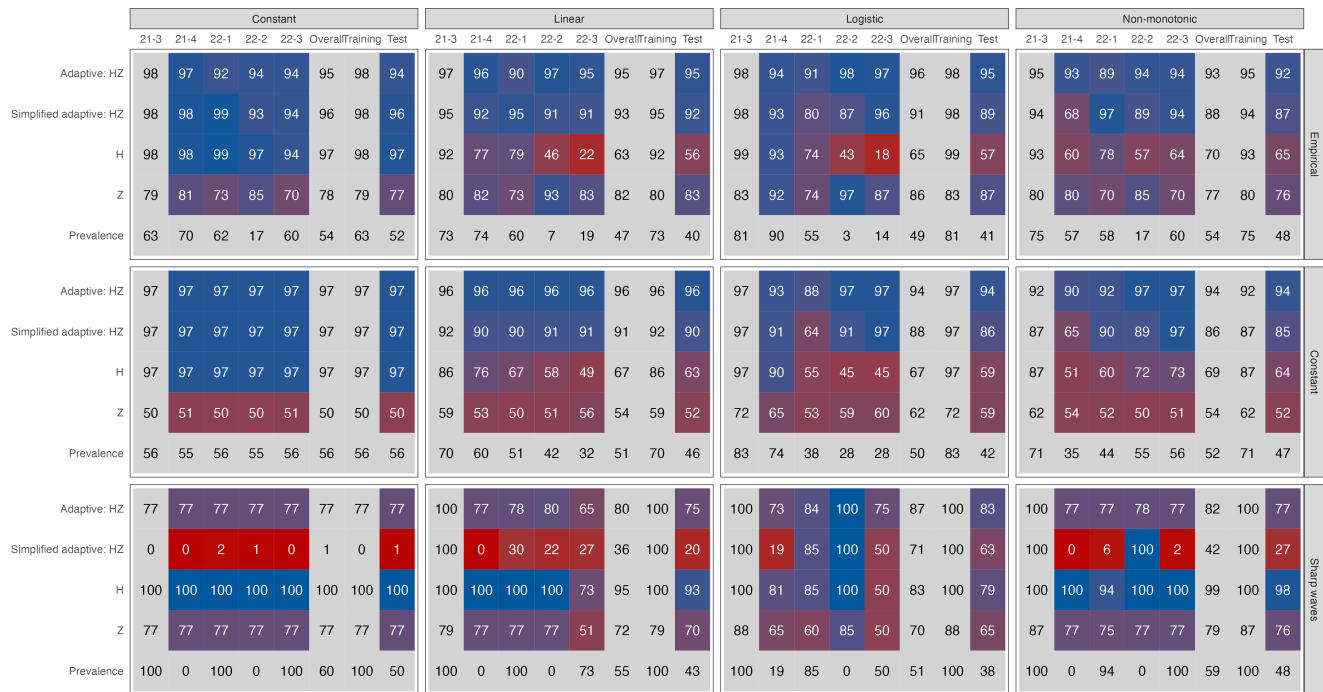
Counties

	Neutral				Don't cry wolf (0.5x FN)				Better safe than sorry (0.5x FP)				
	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	Training	Training MR	Test	Test MR	
	Adaptive: CHO	89	2	69	4	87	0	77	4	92	1	65	
Adaptive: CHOZ	89	1	72	0	88	0	78	2	92	1	72	1	
Adaptive: CHOD	89	2	71	2	88	0	79	1	92	1	66	6	
Adaptive: HZ	89	0	72	1	88	0	78	3	93	0	72	1	
Simplified adaptive: HZ	88	4	70	4	87	2	76	5	92	1	71	1	
Community Levels	85	10	65	8	86	3	70	15	85	20	60	20	
Z	83	6	70	4	85	1	68	12	80	13	71	5	
CHO	88	3	66	9	87	0	70	19	89	10	63	12	
HO	88	4	66	10	87	0	69	21	89	10	63	11	
CH	89	1	52	26	87	0	64	28	91	3	61	13	
H	89	2	49	33	87	1	62	31	92	2	61	13	
C	89	1	48	32	87	2	48	39	92	1	57	21	
Prevalence	88		35		88		35		88		35		
Adaptive: CHO	80	3	86	1	77	4	90	0	85	1	83	3	
Adaptive: CHOZ	81	0	86	0	78	1	90	1	85	0	85	0	
Adaptive: CHOD	80	2	86	1	78	1	90	0	86	0	84	1	
Adaptive: HZ	80	3	86	2	78	3	89	3	85	0	84	2	
Simplified adaptive: HZ	78	7	86	2	78	2	90	0	82	9	84	2	
Community Levels	80	2	73	23	77	5	71	33	84	3	75	13	
Z	71	7	81	10	74	4	79	15	67	14	83	10	
CHO	80	1	77	17	79	0	87	6	85	1	76	16	
HO	80	1	77	21	78	1	86	9	85	1	76	16	
CH	80	1	67	37	79	1	86	8	84	0	72	22	
H	80	2	65	40	77	3	83	14	84	1	71	23	
C	79	4	62	31	77	5	79	15	84	2	55	38	
Prevalence	75		15		75		15		75		15		

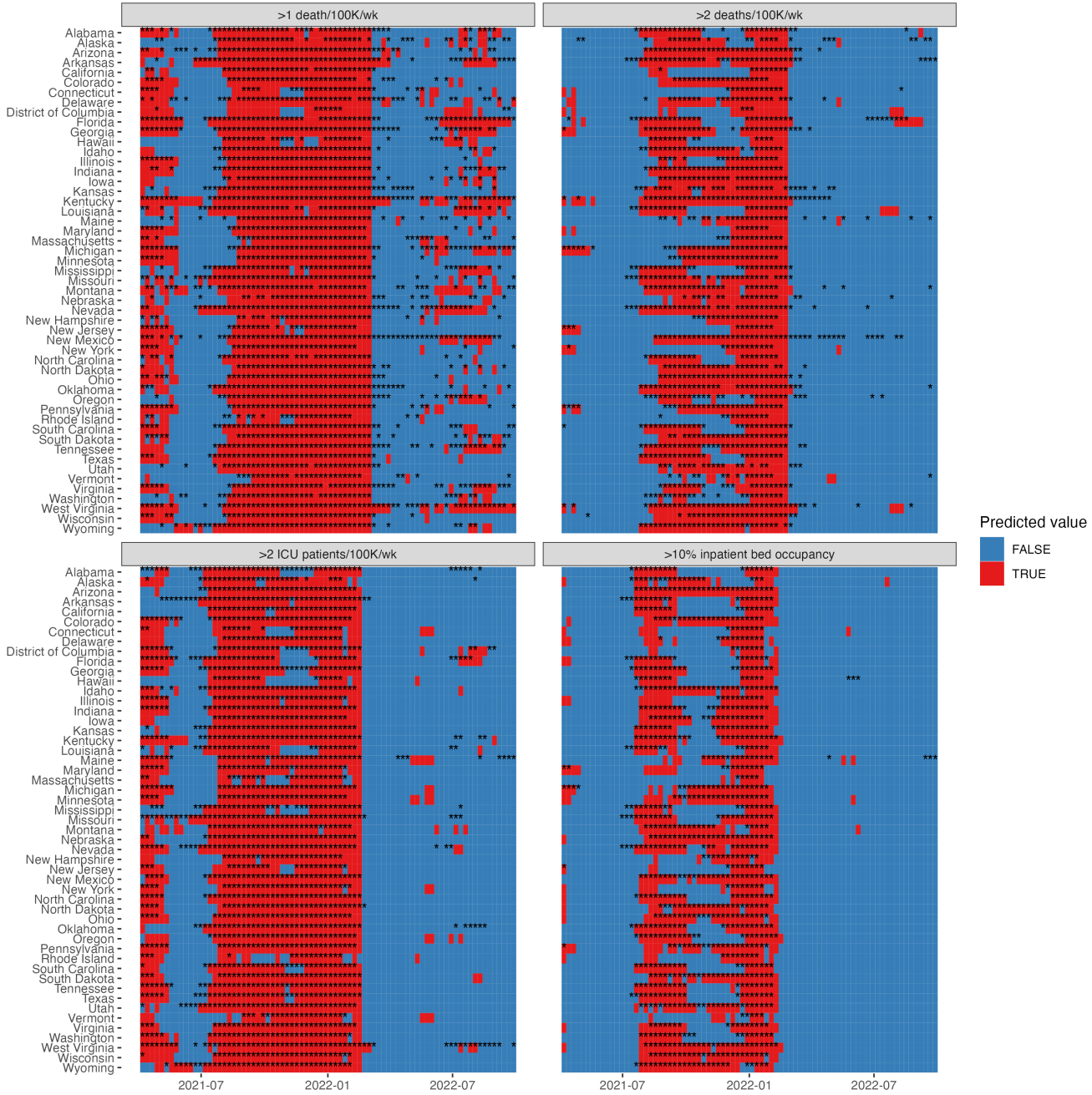
Fig. S12. Head-to-head comparison results (omicron training set). The top plots display results from state-level analyses, middle from HSA-level analyses, and bottom from county-level analyses, all weighted for population. Metrics are displayed on the left, with training data from December 15, 2021-February 15, 2022 and test data from February 16-September 30, 2022. Cells report weighted accuracy and maximum regret (MR) over training and test periods. Rows vary outcomes, and columns vary preferences for false positives versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the population-weighted proportion of high location-weeks in a given time period.



**Fig. S13.** Simulation scenarios. We vary the optimal cutoff for hospitalization to classify a location-week as "high" over time in different scenarios. The constant scenario assumes a static relationship between indicators and outcomes, while other scenarios assume a changing relationship.



**Fig. S14.** Simulation results. Columns vary the relationship between the input indicator and outcome over time (Figure S13) and rows vary prevalence of hospitalizations and corresponding high outcomes. Metrics are varied in the y-axis, and 3-week-ahead predictive accuracy is displayed in cells.



**Fig. S15.** Predicted and actual values of primary and secondary outcomes at the state level over time. Colors indicate predicted values, while asterisks indicate true values. Predictions are taken from the best-performing adaptive model in the training period, corresponding to those presented in Figure 4.