

¹ **Supporting Information for**

² **Adaptive metrics for an evolving pandemic**

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

⁴ **Alyssa Bilinski, Joshua A. Salomon, and Laura Hatfield**

⁵ **Corresponding Author: Alyssa Bilinski.**

⁶ **E-mail: alyssa_bilinski@brown.edu**

⁷ **This PDF file includes:**

⁸ Supporting text

⁹ Figs. S1 to S12

10 **Supporting Information Text**

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

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

11 **B. Optimal Threshold Selection.** We first specify a weight wt such that we consider false positives to be a factor of wt as costly
 12 as false negatives. For example, if $wt = 3$, we consider 3 false positives as costly as 1 false negative; 2 false positives would be
 13 less costly than 1 false negative. Denote the probability that an outcome of interest occurs given observed indicators for an
 14 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, this will decrease
 15 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
 16 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
 17 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 logistic relationship between the probability of a high outcome ($Pr(Y_{i,w+3})$) and a synthetic hospitalization indicator ($X_{H,i,w}$):

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

18 where ϵ_{iw} are *i.i.d* draws from a logistic distribution with mean 0 and scale parameter σ . We then draw $Y_{i,w+3}$ from a
 19 binomial distribution with the corresponding probability.

20 We vary simulations across 3 main dimensions:

22 **1. Indicator prevalence:** We first use empirical hospitalization data for simulations, drawing synthetic outcomes according
 23 to 1. To build intuition, we then use two stylized scenarios, one in which prevalence is constant over quarters and one in
 24 which waves are even more pronounced.

- 25 (a) Empirical: We use true state-level hospitalization data from Q3 2021 through Q4 2022.
 26 (b) Constant: We draw $X_{H,i,w}$ from a *Unif*(2, 20) distribution for state-times from Q3 2021 through Q4 2022.
 27 (c) Sharp waves: We alternate each quarter between drawing hospitalizations from a $N(5, 1)$ distribution and a $N(15, 1)$
 28 distribution for each state-time from Q3 2021 through Q4 2022.

29 **2. Relationship between inputs and outputs:** The optimal cutoff for a metric with neutral weighting is $-\beta_0/\beta_1$. We
 30 vary this as displayed in Figure S11:

- 31 (a) Constant: 10 hospitalizations per 100,000 population
 32 (b) Linear increase: linearly increasing from 5 to 15 hospitalizations per 100,000 over the study period
 33 (c) Logistic increase: increasing from 5 to 15 hospitalizations per 100,000 over the study period per a logistic model
 34 with a sharp increase at week 25
 35 (d) Non-monotonic: optimal cutoff increases and then decreases

36 For illustration, we set $\beta_1 = 3, \sigma = 1$ and use the first quarter (synthetic Q3 2021) as training data. For each scenario,
 37 we simulate 50 draws. As in the main text, we select the best-performing static metric during training data and compare
 38 performance in terms of predictive accuracy to adaptive metrics, averaging over draws. Results are displayed in Figure S12.

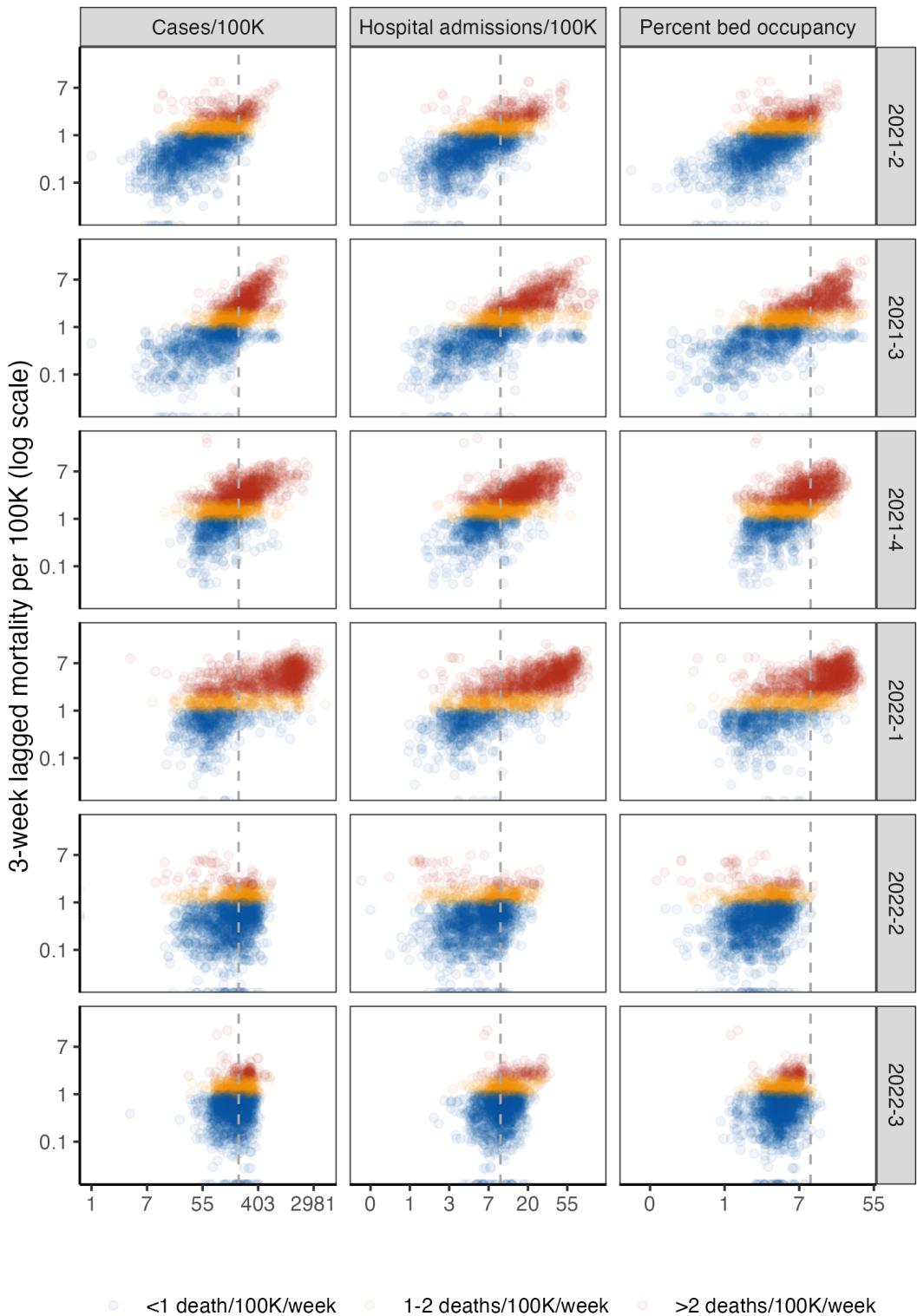


Fig. S1. County-level lagged mortality vs. indicator levels by quarter. Columns indicate different indicators (weekly cases per 100,000 population, new hospital admissions per 100,000, and percentage of inpatient beds occupied by COVID-19 patients), and rows indicate quarters. The x-axis displays indicator 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. Colors show mortality outcome level. The vertical gray dotted lines indicate thresholds from CDC Community Levels for each indicator (≥ 200 cases/100K/week and ≥ 10 new admissions/100K/week or $\geq 10\%$ COVID-19 bed occupancy.)

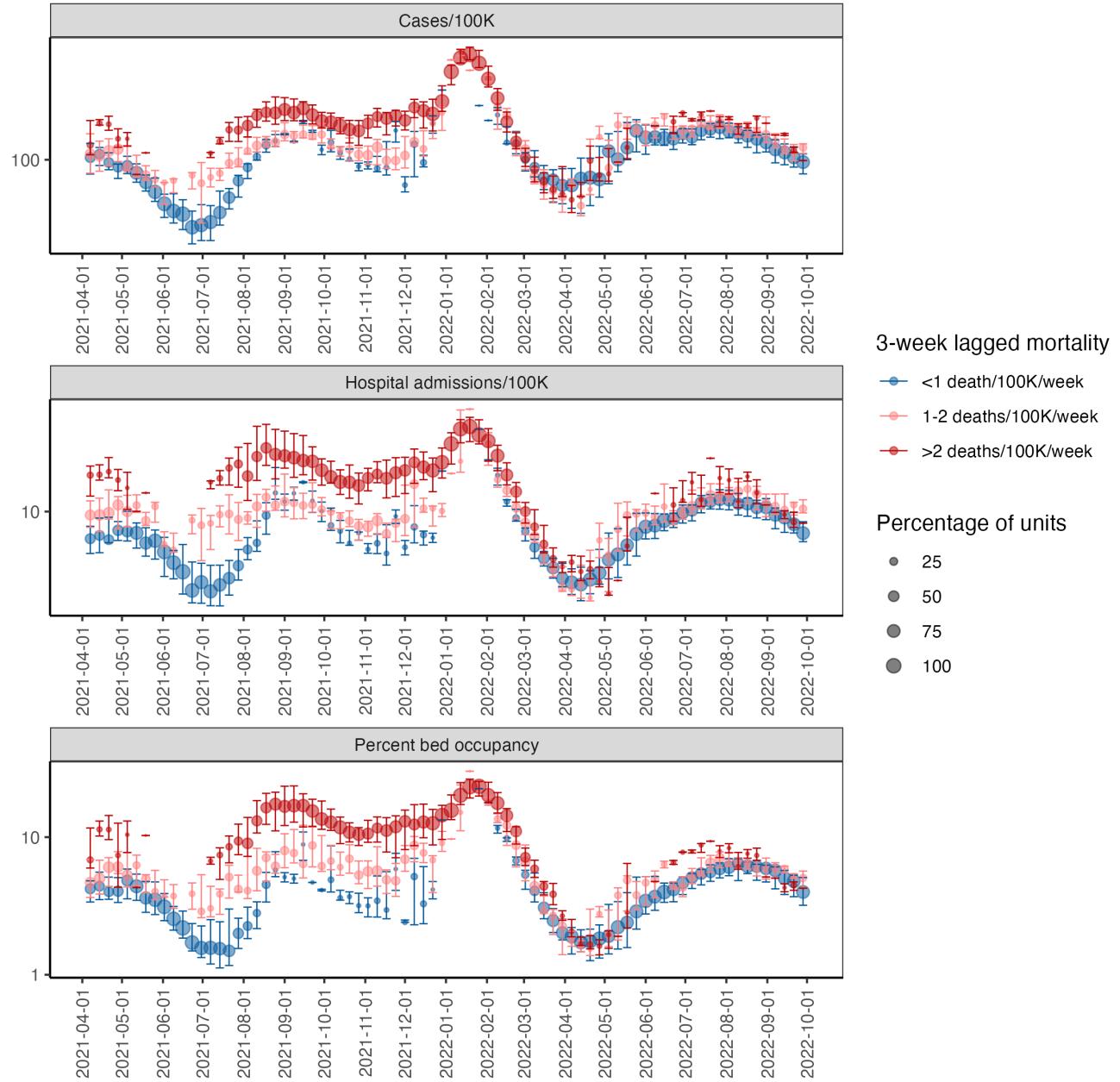


Fig. S2. Indicators by lagged mortality (state). Indicators vary across rows. The x-axis displays time and the y-axis displays the median (point) and interquartile range (bars) of each indicator by future mortality status.

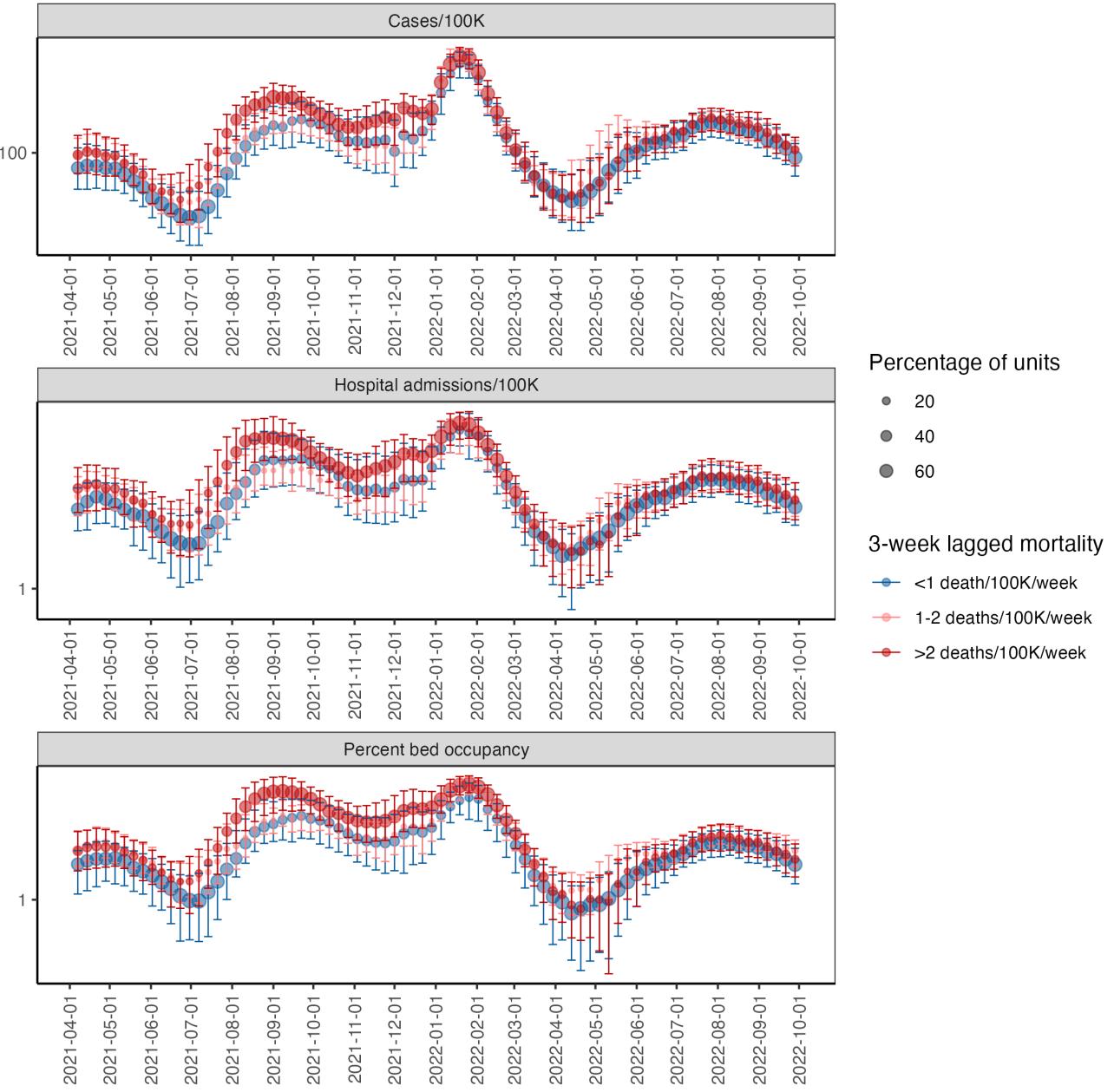


Fig. S3. Indicators by future mortality (county). Indicators vary across rows. The x-axis displays time and the y-axis displays the median (point) and interquartile range (bars) of each indicator by future mortality status.

States

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			$\geq 1 \text{ death}/100K/\text{wk}$		
	Training	Training MR	Test	Training	Training MR	Test	Training	Training MR	Test			
Adaptive: CHOZ	88	3	83	5	88	5	87	2	90	2	80	10
Adaptive: CHO	88	3	80	10	87	5	86	2	90	3	75	14
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	83	15	56	52	84	19	68	45	88	8	69	26
C	86	5	45	60	86	9	41	67	90	2	62	33
Prevalence	68	46	41	67	68	50	41	73	68	49	41	65
Adaptive: CHOZ	88	6	92	3	88	5	93	3	88	8	92	5
Adaptive: CHO	87	7	93	3	87	6	94	2	87	8	93	3
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	2	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	4	91	10	87	9	79	38
C	88	8	70	39	90	4	62	55	88	7	68	42
Prevalence	36	91	23	94	36	91	23	95	36	92	23	92

HSAs

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			$\geq 1 \text{ death}/100K/\text{wk}$		
	Training	Training MR	Test	Training	Training MR	Test	Training	Training MR	Test			
Adaptive: CHOZ	83	1	77	1	83	1	81	1	86	1	78	0
Adaptive: CHO	80	4	73	6	81	3	80	2	84	5	70	11
Adaptive: HZ	82	3	77	0	83	1	81	1	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	32	48	47	66	35	48	56	66	35	48	47
Adaptive: CHOZ	84	1	88	0	86	2	91	1	85	1	88	0
Adaptive: CHO	82	4	88	0	84	5	91	1	83	5	87	2
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	76	26	86	37	79	26	88	37	74	26	84

Counties

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			$\geq 1 \text{ death}/100K/\text{wk}$		
	Training	Training MR	Test	Training	Training MR	Test	Training	Training MR	Test			
Adaptive: CHOZ	77	0	75	0	79	0	80	1	81	0	75	0
Adaptive: CHO	76	2	73	3	78	3	80	2	79	4	70	7
Adaptive: HZ	76	4	75	1	78	2	80	2	79	5	75	0
Simplified adaptive: HZ	75	4	74	4	76	5	80	3	79	4	75	1
Community Levels	67	19	69	9	76	7	73	15	57	36	65	21
Z	73	6	72	4	74	14	71	12	73	14	73	6
CHO	74	7	70	9	78	3	73	19	70	17	68	12
HO	74	7	70	9	78	3	73	19	70	17	68	12
CH	75	3	57	31	78	2	68	27	78	4	66	12
H	74	8	56	31	77	3	67	29	79	4	66	12
C	75	4	54	33	77	4	54	39	79	3	63	20
Prevalence	59	36	45	51	59	42	45	58	59	38	45	48
Adaptive: CHOZ	81	1	86	0	84	0	88	1	82	0	85	0
Adaptive: CHO	79	4	86	1	82	4	89	0	80	4	84	2
Adaptive: HZ	80	3	86	2	83	1	88	2	81	3	85	1
Simplified adaptive: HZ	79	3	86	1	83	3	89	0	79	4	84	1
Community Levels	80	3	75	23	82	3	72	34	79	9	77	13
Z	77	5	80	11	78	12	78	16	77	8	81	10
CHO	80	4	83	6	83	1	85	8	79	5	80	11
HO	80	4	83	6	83	2	88	1	80	4	74	22
CH	80	5	82	8	83	1	84	11	79	4	74	23
H	80	4	82	9	82	3	87	2	79	5	66	28
C	80	4	65	32	83	3	71	27	35	69	26	79
Prevalence	35	71	26	82	35	76	26	85	35	69	26	79

Fig. S4. Head-to-head comparison results. The top plots display results from state-level analyses and the bottom plots display results from county-level analyses, both 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 positive versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the proportion of high location-weeks in a given time period. Weighted accuracy by quarter, including for intensive care usage, is presented in Figures S5-S7.

States																	
Neutral																	
Don't cry wolf (0.5x FN)																	
Better safe than sorry (0.5x FP)																	
Adaptive: CHOZ																	
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			
81	90	92	85	84	80	83	88	85	83	88	91	87	84	87	87		
80	90	93	85	83	73	80	88	84	81	88	92	87	83	87	87		
Adaptive: CHO	80	90	93	85	83	73	80	88	84	81	88	92	87	83	87	87	
Adaptive: HZ	80	92	94	85	84	81	83	89	86	82	93	92	88	87	88	87	
Simplified adaptive: HZ	75	89	94	82	81	83	82	86	84	73	89	93	84	85	85	85	
Community Levels	71	72	50	75	79	59	71	64	68	81	81	66	83	80	55	72	
Z	72	78	91	82	81	80	81	80	81	66	85	91	77	81	80	79	
CHO	79	90	87	87	75	42	68	86	77	80	92	90	89	75	26	63	
HO	79	90	87	87	75	42	68	85	77	79	92	90	89	75	26	63	
CH	76	93	93	88	48	31	56	87	72	81	92	85	86	36	17	47	
H	66	91	94	90	49	31	56	83	70	85	93	75	87	79	39	68	
C	76	89	93	80	24	29	45	86	65	81	92	85	84	23	17	41	
Prevalence	35	75	94	78	17	29	41	68	55	35	75	94	78	17	29	41	
Adaptive: CHOZ	96	86	82	87	96	93	92	88	90	96	86	83	88	97	95	93	
Adaptive: CHO	95	84	81	87	96	96	93	87	90	95	84	83	88	97	98	94	
Adaptive: HZ	95	87	88	87	97	95	93	90	91	96	89	88	86	97	95	93	
Simplified adaptive: HZ	93	83	86	90	97	96	94	87	91	94	87	87	87	89	98	92	
Community Levels	96	88	81	87	85	60	77	88	83	96	89	84	89	80	47	72	
Z	92	81	77	71	95	96	87	83	85	91	86	78	66	95	96	86	
CHO	96	89	81	86	84	59	76	89	83	96	90	84	89	87	49	75	
HO	95	88	82	88	96	91	91	88	90	94	89	87	90	95	98	91	
CH	96	89	80	86	66	57	70	88	79	95	89	86	90	95	98	90	
H	94	88	82	88	95	90	91	88	90	92	89	87	90	90	95	89	
C	96	89	80	86	66	57	70	88	79	96	89	84	88	55	43	62	
Prevalence	5	47	56	61	3	5	23	36	29	5	47	56	61	3	5	23	36
Adaptive: CHOZ	75	92	90	86	92	94	91	86	88	77	92	92	82	92	91	90	88
Adaptive: CHO	78	92	90	90	94	94	93	87	90	81	92	91	87	94	95	93	87
Adaptive: HZ	76	88	95	86	98	94	93	86	89	77	90	92	82	98	95	93	87
Simplified adaptive: HZ	80	81	92	74	99	94	89	85	87	84	84	90	68	99	95	87	87
Community Levels	68	58	53	91	86	61	79	60	70	76	83	93	77	99	93	87	86
Z	76	83	93	77	99	94	90	84	87	82	92	91	87	94	96	92	88
CHO	81	79	91	73	82	27	61	84	72	82	86	93	64	76	3	48	87
HO	80	79	91	73	82	27	61	83	72	83	89	88	72	23	0	27	87
CH	77	92	95	67	41	7	38	88	63	83	85	76	77	80	19	59	81
H	67	93	93	65	40	6	37	84	61	83	89	88	68	10	0	22	87
C	75	93	94	55	11	5	24	87	56	83	89	88	68	10	0	22	87
Prevalence	37	89	92	45	1	5	17	73	45	37	89	92	45	1	5	17	73

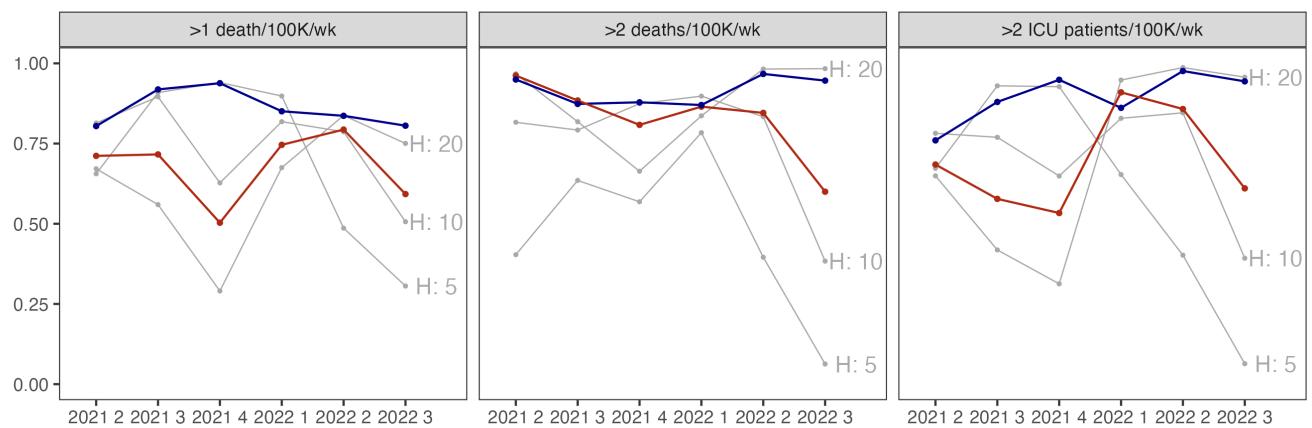
HSAs

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: CHOZ	76	87	86	84	74	71	77	83	80	79	87	83	83	82	77	81	83	82	79	89	90	89	74	72	78	86	82								
Adaptive: CHO	72	86	84	82	73	66	73	80	77	76	84	83	84	82	75	80	81	81	74	87	89	86	63	62	70	84	77								
Adaptive: HZ	76	84	87	84	74	72	77	82	80	79	86	84	83	83	77	81	83	82	78	87	91	89	74	72	78	86	82								
Simplified adaptive: HZ	73	84	86	84	73	72	76	81	78	72	85	83	84	80	77	80	80	80	78	86	90	88	74	72	78	85	81	>1 death/10Kwk							
Community Levels	63	72	56	71	71	62	68	64	66	75	81	70	80	75	64	73	75	74	51	64	42	62	67	61	63	52	58								
Z	72	78	83	82	72	72	75	78	77	68	84	83	79	71	72	74	78	76	76	73	83	86	73	71	77	77	77								
CHO	70	82	72	78	72	59	70	75	72	78	85	80	83	78	59	73	81	77	62	78	65	73	67	60	66	68	67								
HO	70	82	72	78	72	59	70	75	72	78	85	80	83	78	59	73	81	77	62	78	65	73	67	60	66	68	67								
CH	73	85	83	82	49	41	58	81	69	77	85	81	83	43	30	52	81	66	73	88	83	81	59	59	66	81	74								
H	70	84	84	84	49	41	58	80	69	79	85	85	87	82	72	51	68	81	74	74	88	85	83	59	59	67	82	74							
C	72	82	84	78	32	39	50	79	64	76	84	81	82	29	28	46	80	63	74	87	88	81	51	59	64	83	73								
Prevalence	44	70	84	79	27	39	48	66	57	44	70	84	79	27	39	48	66	57	44	70	84	79	27	39	48	66	57								
Adaptive: CHOZ	89	84	79	82	93	90	88	84	86	92	84	82	83	95	94	91	86	88	87	85	82	84	91	88	88	85	86								
Adaptive: CHO	88	82	76	82	93	90	88	82	85	92	81	79	83	95	93	91	84	87	87	81	83	83	88	87	83	85									
Adaptive: HZ	89	81	80	81	93	90	88	83	86	92	80	77	81	80	95	94	90	85	88	87	81	83	83	87	84	85									
Simplified adaptive: HZ	88	80	77	80	92	90	87	82	85	90	85	75	80	80	77	57	73	85	79	87	85	70	78	83	74	78	>2 deaths/10Kwk								
Community Levels	89	85	75	81	80	66	76	83	79	83	80	76	71	88	88	82	80	81	85	76	76	75	89	88	84	79	82								
Z	83	80	76	71	88	88	82	80	81	91	87	79	77	67	88	88	81	81	91	83	79	81	87	71	80	82	81								
CHO	87	83	76	80	89	71	80	82	81	91	84	80	83	93	84	86	85	86	85	83	79	81	84	86	87	83									
HO	89	83	73	78	91	85	85	82	83	91	84	80	83	93	84	86	85	86	85	84	76	80	88	76	81	82	81								
CH	87	83	77	81	78	56	72	82	77	92	85	78	83	92	92	82	85	85	85	85	84	78	80	81	65	75	82	79							
H	89	83	73	78	98	81	83	83	82	90	84	80	83	91	79	84	84	84	83	83	78	80	81	64	75	82	78								
C	88	84	73	80	62	57	66	82	74	92	86	77	82	69	67	73	85	79	85	84	75	80	62	57	66	82	74								
Prevalence	13	42	56	62	7	10	26	37	32	13	42	56	62	7	10	26	37	32	13	42	56	62	7	10	26	37	32								
Adaptive: CHOZ	78	84	84	84	96	93	91	82	87	81	84	81	97	94	91	83	87	80	85	85	85	85	88	96	92	83	88								
Adaptive: CHO	79	83	81	84	96	92	91	81	86	80	83	81	90	95	90	82	86	83	85	87	88	89	95	90	91	83	87								
Adaptive: HZ	78	80	83	82	97	93	91	80	85	79	82	84	80	98	94	90	82	86	80	81	84	86	96	92	91	82	87								
Simplified adaptive: HZ	79	79	83	74	97	92	88	80	84	82	75	83	82	68	98	93	86	80	83	75	84	75	96	92	88	80	84	>2 ICU patients/10Kwk							
Community Levels	74	61	61	85	85	68	80	66	73	82	73	82	81	59	74	76	75	76	67	49	50	89	89	77	85	55	70								
Z	79	80	82	76	97	92	89	80	84	76	84	83	69	97	92	86	81	84	81	75	81	84	96	93	91	79	85								
CHO	77	72	77	76	89	61	75	75	75	82	79	72	87	52	70	81	76	73	64	72	84	91	71	82	70	76									
HO	77	72	77	76	89	61	75	75	75	81	79	72	68	87	50	68	81	75	73	64	72	83	91	71	82	70	76								
CH	74	84	85	67	47	15	43	81	62	82	81	82	85	66	35	0	33	83	58	79	83	88	77	65	43	62	83	72							
H	69	86	85	64	46	15	42	80	61	82	80	79	75	76	36	62	80	71	77	85	88	76	64	43	61	83	72								
C	77	79	83	71	37	19	42	80	61	80	82	84	62	16	0	23	82	52	76	86	86	68	46	40	51	83	67								
Prevalence	31	81	76	40	3	8	17	63	40	31	81	76	40	3	8	17	63	40	31	81	76	40	3	8	17	63	40								

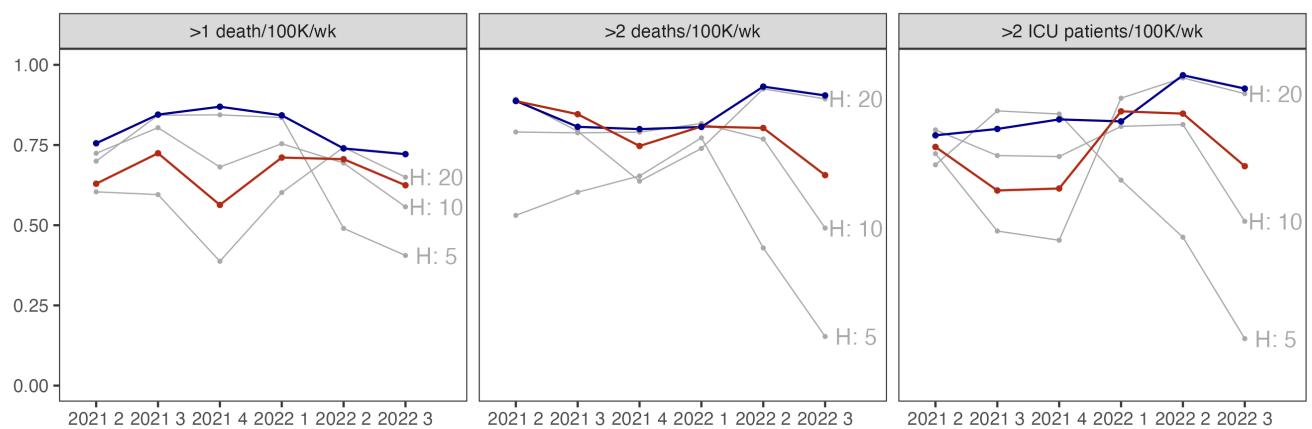
Fig. S6. HSA-level results by quarter. Metrics are displayed on the left, with training data from Q3-Q4 2021 and test data from Q1-Q3 2022. Cells report weighted accuracy. Preferences for false positive versus false negatives varying across columns (with "neutral" corresponding to unweighted accuracy)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

Counties																												
Neutral																												
	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: CHOZ	73	81	79	81	76	69	75	77	76	79	82	78	80	83	78	80	79	80	75	84	84	86	73	67	75	81	78	
Adaptive: CHO	71	79	77	78	75	67	73	76	75	78	79	78	79	83	77	80	78	79	79	83	84	83	66	61	70	79	75	
Adaptive: HZ	72	77	79	80	75	69	75	76	75	78	80	77	79	83	78	80	78	79	79	74	79	84	86	73	67	75	79	77
Simplified adaptive: HZ	69	77	77	80	72	69	74	75	74	75	77	76	81	80	78	80	76	78	73	80	84	85	72	67	75	79	77	
Community Levels	68	72	60	72	72	62	69	67	68	78	78	71	79	76	63	73	76	74	59	66	48	65	68	62	65	57	61	
Z	69	75	76	77	72	67	72	73	73	65	80	76	74	71	67	71	74	72	72	70	76	80	72	67	73	73	73	
CHO	72	77	72	78	73	60	70	74	72	78	79	77	81	79	59	73	78	75	66	76	67	74	68	62	68	70	69	
HO	72	77	72	78	73	60	70	74	72	78	80	77	81	73	51	68	78	73	72	83	80	80	61	57	66	78	72	
CH	70	78	80	51	38	57	75	66	65	76	79	76	81	72	49	67	77	72	71	83	82	82	61	57	66	79	71	
H	65	77	78	81	50	38	56	74	65	78	80	74	79	44	39	54	77	66	72	82	82	79	53	57	63	79	71	
C	71	79	75	77	43	42	54	75	64	78	80	74	79	44	39	54	77	66	72	82	82	79	53	57	63	79	71	
Prevalence	37	63	75	74	25	35	45	59	52	37	63	75	74	25	35	45	59	52	37	63	75	74	25	35	45	59	52	
Adaptive: CHOZ	86	81	76	79	91	89	86	81	84	91	83	78	79	94	92	88	84	86	84	83	79	81	88	86	85	82	84	
Adaptive: CHO	85	79	72	78	91	88	86	79	82	90	79	76	80	94	92	89	82	85	81	83	75	79	88	85	84	80	82	
Adaptive: HZ	86	79	75	77	91	89	86	80	83	91	82	78	78	94	92	88	83	86	84	80	79	80	88	86	85	81	83	
Simplified adaptive: HZ	85	79	73	78	91	88	86	79	82	88	81	77	80	94	92	89	83	86	84	79	75	80	87	86	84	79	82	
Community Levels	86	82	73	78	80	66	75	80	78	88	81	77	80	78	58	72	82	77	84	83	70	77	82	73	77	79	78	
Z	81	79	73	68	86	85	80	77	79	79	82	82	73	64	86	85	78	78	83	75	72	71	87	85	81	77	79	
CHO	86	81	72	77	90	83	83	80	82	90	83	77	80	92	84	85	83	84	83	81	74	78	86	75	80	79	79	
HO	86	81	72	77	90	83	83	80	82	90	83	76	80	94	91	88	83	86	82	81	74	78	86	74	80	79	79	
CH	86	82	71	76	89	81	82	80	81	90	83	77	80	91	81	84	83	84	82	81	75	78	80	64	74	80	77	
H	86	81	72	77	89	80	82	80	81	90	81	75	79	93	90	87	82	85	80	81	76	79	80	63	74	79	77	
C	86	81	72	77	62	57	65	80	72	90	83	75	79	69	65	71	83	77	82	81	74	77	62	58	66	79	72	
Prevalence	15	40	50	57	9	12	26	35	30	15	40	50	57	9	12	26	35	30	15	40	50	57	9	12	26	35	30	
Adaptive: CHOZ	78	83	84	84	97	93	91	81	86	81	83	84	81	97	94	91	83	87	80	84	85	88	96	92	92	83	87	
Adaptive: CHO	79	82	81	84	96	92	91	81	86	80	82	84	81	97	95	90	82	86	77	84	86	88	95	90	91	82	87	
Adaptive: HZ	78	80	83	82	97	93	91	80	85	79	80	82	84	98	94	90	82	86	80	81	84	86	96	92	91	82	86	
Simplified adaptive: HZ	79	79	83	74	97	92	88	80	84	82	75	82	82	98	93	86	80	83	81	75	84	75	96	92	88	80	84	
Community Levels	75	60	61	86	85	69	80	65	73	82	73	82	82	61	75	76	75	76	67	48	49	89	89	78	85	55	70	
Z	79	80	82	76	97	92	89	80	84	83	79	82	83	97	92	86	81	84	81	75	81	84	96	93	91	79	85	
CHO	77	72	77	76	89	61	75	75	75	78	81	79	82	87	50	69	81	75	73	64	72	84	91	71	82	70	76	
HO	77	72	77	76	89	61	75	75	75	78	81	79	82	87	50	68	81	75	73	64	72	83	91	71	82	70	76	
CH	74	84	85	67	48	16	44	81	62	81	82	84	67	36	0	34	82	58	82	83	87	88	78	65	44	62	82	
H	69	86	85	64	46	15	42	80	61	82	80	89	62	76	36	62	80	71	77	85	88	76	64	43	61	83	72	
C	77	78	82	71	37	20	43	79	61	79	82	83	62	17	0	24	81	53	75	86	85	69	47	40	52	82	67	
Prevalence	31	81	76	40	3	8	17	63	40	31	81	76	40	3	8	17	63	40	31	81	76	40	3	8	17	63	40	

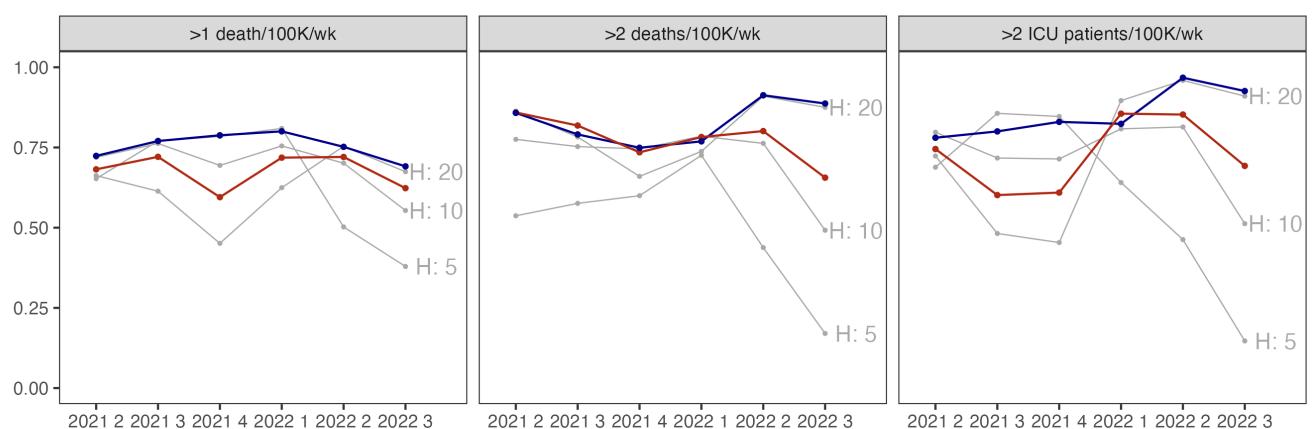
States



HSAs



Counties



— Adaptive — Community Levels

Fig. S8. Weighted accuracy by metric. 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 row threshold. The red line indicates CDC Community Level and the blue line an adaptive metric (HZ).

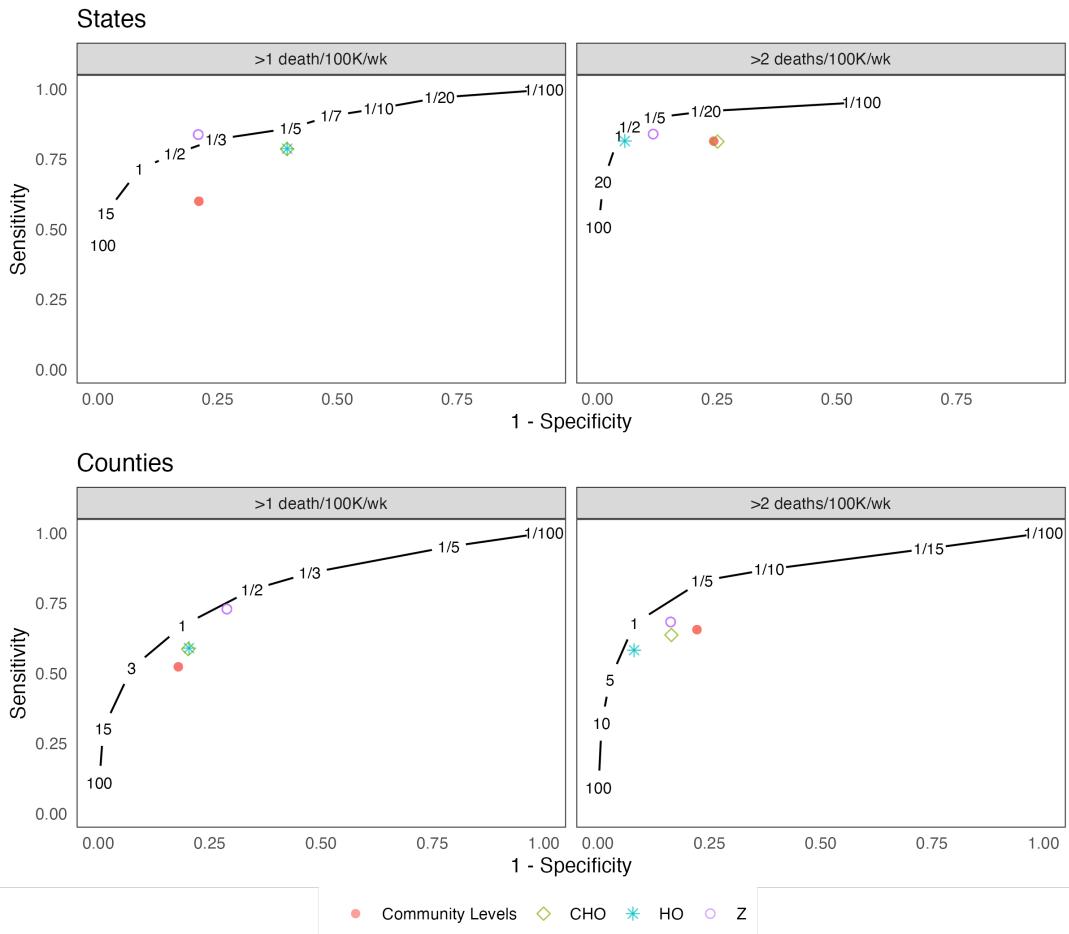


Fig. S9. Receiver operating characteristic (ROC) curves for the test period from January 1, 2022 to September 30, 2022. The black line indicates performance of the adaptive metric (HZ) across different values of wt , indicating the relative preference for false negatives over false positives. The top plot indicates states and the bottom plot counties.

States

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			≥ 1 death/100K/wk
	Training	Training	Test	Training	Training	Test	Training	Training	Test	
		MR	MR	MR	MR	MR	MR	MR	MR	
Adaptive: CHOZ	97	4	80	5	97	5	85	2	98	2
Adaptive: CHO	97	2	77	10	97	4	84	2	98	2
Adaptive: HZ	98	3	80	5	98	4	85	1	99	2
Simplified adaptive: HZ	98	4	79	8	98	3	82	5	99	2
Community Levels	92	20	66	24	95	12	68	29	90	26
Z	93	14	78	8	94	11	76	12	91	16
CHO	98	4	62	41	98	2	57	58	98	4
HO	98	4	62	41	98	2	57	58	98	4
CH	99	0	49	46	99	0	37	67	99	0
H	98	3	48	52	98	4	33	77	99	1
C	99	0	44	46	99	0	31	67	99	0
Prevalence	98	3	31	67	98	2	31	73	98	3
Adaptive: CHOZ	92	3	91	3	91	8	93	3	94	1
Adaptive: CHO	92	3	93	3	90	9	94	2	94	1
Adaptive: HZ	93	0	92	3	93	0	93	4	94	1
Simplified adaptive: HZ	92	2	94	0	92	2	94	2	93	2
Community Levels	92	5	73	36	91	9	68	51	93	4
Z	78	18	88	19	82	13	86	24	73	25
CHO	93	1	71	49	94	2	91	6	94	0
HO	93	2	91	5	93	0	91	10	94	0
CH	93	2	90	6	94	2	91	7	94	1
H	93	2	90	6	93	0	90	10	93	2
C	92	6	65	39	91	10	74	27	94	1
Prevalence	88	17	9	94	88	19	9	95	88	17

HSAs

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			≥ 1 death/100K/wk
	Training	Training	Test	Training	Training	Test	Training	Training	Test	
		MR	MR	MR	MR	MR	MR	MR	MR	
Adaptive: CHOZ	95	2	73	1	93	2	78	2	96	1
Adaptive: CHO	95	2	69	6	94	1	77	2	96	1
Adaptive: HZ	95	0	73	0	94	1	78	2	96	0
Simplified adaptive: HZ	94	2	72	1	93	3	77	3	96	1
Community Levels	89	15	63	13	92	6	68	13	86	26
Z	89	9	72	2	91	6	70	12	87	14
CHO	92	7	65	13	94	1	69	18	91	15
HO	92	7	65	13	94	1	69	18	91	15
CH	94	2	50	31	94	0	44	47	95	3
H	94	2	51	31	93	1	40	55	95	3
C	95	2	47	32	94	1	37	54	96	2
Prevalence	94	3	39	47	94	1	39	56	94	6
Adaptive: CHOZ	88	2	88	0	86	2	91	1	91	0
Adaptive: CHO	87	3	88	0	85	3	91	1	90	2
Adaptive: HZ	88	0	88	1	86	1	90	4	90	1
Simplified adaptive: HZ	85	8	87	2	85	5	91	1	87	10
Community Levels	87	4	73	24	86	3	70	37	88	6
Z	77	10	83	11	81	5	81	17	73	17
CHO	87	3	78	21	85	0	86	10	89	3
HO	87	3	78	21	85	0	86	10	89	3
CH	87	2	66	40	85	1	84	15	89	4
H	87	3	65	41	85	1	84	15	89	3
C	86	7	49	52	85	5	70	27	90	3
Prevalence	83	15	14	86	83	15	14	88	83	17

Counties

	Neutral			Don't cry wolf (0.5x FN)			Better safe than sorry (0.5x FP)			≥ 1 death/100K/wk
	Training	Training	Test	Training	Training	Test	Training	Training	Test	
		MR	MR	MR	MR	MR	MR	MR	MR	
Adaptive: CHOZ	90	0	72	0	89	1	78	1	93	0
Adaptive: CHO	90	2	70	3	89	0	78	2	93	0
Adaptive: HZ	90	0	71	1	89	1	78	2	93	0
Simplified adaptive: HZ	90	3	70	4	88	3	78	3	93	0
Community Levels	86	10	64	9	87	3	69	15	85	19
Z	83	7	69	4	86	3	67	12	81	13
CHO	89	4	66	9	89	1	69	19	89	9
HO	89	4	66	9	89	1	69	19	89	9
CH	90	2	50	31	88	1	63	29	92	2
H	90	2	50	31	88	1	63	29	92	1
C	90	1	47	33	88	3	36	53	93	0
Prevalence	89	3	36	51	89	2	36	58	89	7
Adaptive: CHOZ	82	0	86	0	80	1	90	1	86	0
Adaptive: CHO	81	1	86	1	79	3	90	0	86	0
Adaptive: HZ	81	1	86	2	80	2	89	2	86	0
Simplified adaptive: HZ	79	5	86	1	79	3	90	0	83	8
Community Levels	82	0	73	23	78	4	71	34	85	2
Z	71	7	81	11	75	5	79	16	68	14
CHO	81	0	77	21	80	1	87	6	85	0
HO	81	0	77	21	80	0	86	9	85	0
CH	81	0	66	38	79	2	86	8	85	0
H	81	1	65	40	79	2	83	13	85	0
C	80	4	62	32	77	6	78	15	85	2
Prevalence	76	15	15	82	76	18	15	85	76	18

Fig. S10. Head-to-head comparison results (omicron training set). The top plots display results from state-level analyses and the bottom plots display results from county-level analyses, both 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 positive versus false negatives, with "neutral" corresponding to unweighted accuracy. Prevalence indicates the proportion of high location-weeks in a given time period.

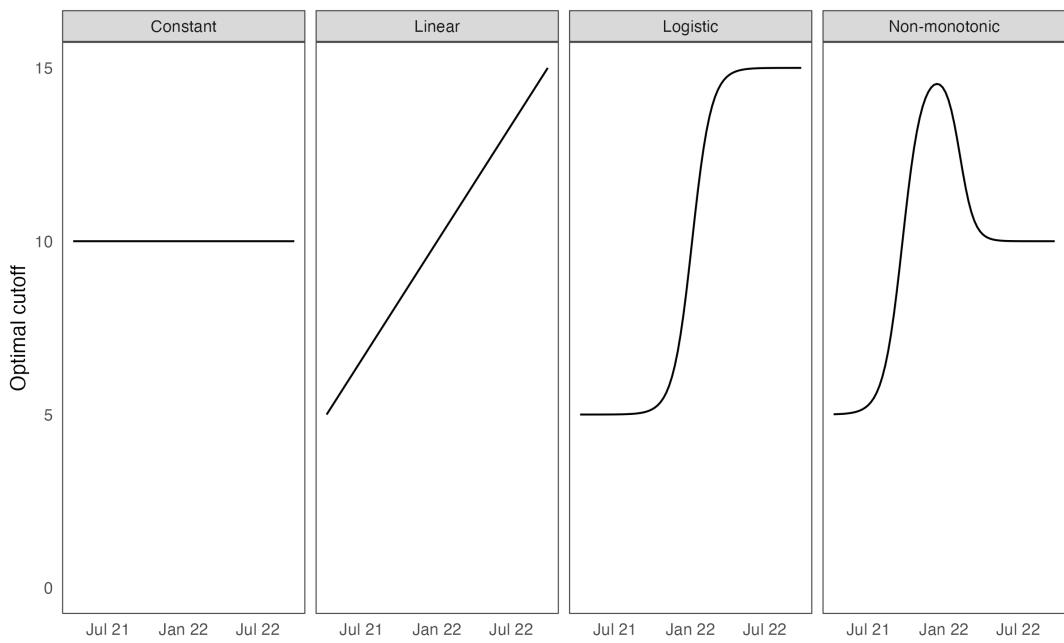


Fig. S11. Simulation scenarios. We vary the optimal cutoff for hospitalization to classify a location-week as "high" ($-\beta_0/\beta_1$) over time in different scenarios. The constant scenario assumes a static relationship between indicators and outcomes, while other scenarios assume a changing relationship.

		Constant							Linear							Logistic							Non-monotonic												
		21-3	21-4	22-1	22-2	22-3	Overall	Training	Test	21-3	21-4	22-1	22-2	22-3	Overall	Training	Test	21-3	21-4	22-1	22-2	22-3	Overall	Training	Test	21-3	21-4	22-1	22-2	22-3	Overall	Training	Test		
		Adaptive: HZ	97	96	91	92	92	94	97	93	96	95	90	97	94	95	96	94	97	93	91	98	96	95	97	95	94	92	90	92	92	92	94	92	
		Simplified adaptive: HZ	97	97	99	92	92	95	97	95	94	91	95	91	91	93	94	92	98	93	80	84	96	90	98	88	93	68	97	88	92	88	93	86	
		H	97	97	98	95	92	96	97	96	92	78	79	46	23	63	92	56	98	93	74	43	18	65	98	57	93	60	78	57	63	70	93	65	
		Z	79	81	73	85	70	78	79	77	80	82	73	93	83	82	80	83	82	91	74	96	87	86	82	87	80	79	70	84	70	77	80	76	
		Prevalence	63	70	62	18	60	54	63	52	73	75	60	7	19	47	73	40	81	90	55	3	14	49	81	41	75	57	58	18	60	54	75	48	
		Adaptive: HZ	96	96	96	96	96	96	96	96	95	95	95	95	95	95	95	95	96	93	87	96	96	94	96	93	91	89	92	96	96	93	91	93	
		Simplified adaptive: HZ	96	96	96	96	96	96	96	96	92	91	90	90	90	91	92	90	96	91	63	90	96	87	96	85	87	66	90	89	96	86	87	85	
		H	96	96	96	96	96	96	96	96	86	77	68	58	49	68	86	63	96	91	55	44	44	66	96	59	86	52	60	72	72	68	86	64	
		Z	51	51	51	50	50	51	51	51	59	53	50	51	56	54	59	52	72	65	53	59	60	62	72	59	62	54	53	50	50	54	62	52	
		Prevalence	56	56	56	55	56	56	56	56	70	61	51	41	32	51	70	46	83	75	38	28	28	50	83	42	70	35	44	55	55	52	70	47	
		Adaptive: HZ	78	78	77	78	78	78	78	78	100	77	78	86	63	81	100	76	100	73	84	100	71	86	100	82	100	78	78	77	80	77	83	100	78
		Simplified adaptive: HZ	10	8	12	9	8	9	10	9	100	0	57	41	29	45	100	32	100	20	83	100	50	71	100	63	100	5	7	100	5	43	100	29	
		H	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	93	100	80	83	100	50	82	100	78	100	100	93	100	100	98			
		Z	77	77	77	77	77	77	77	77	80	77	77	77	77	50	72	80	70	89	64	58	86	50	69	89	64	87	77	75	77	77	79	87	76
		Prevalence	100	0	100	0	100	60	100	50	100	0	100	0	71	54	100	43	100	20	83	0	50	51	100	38	100	0	93	0	100	59	100	48	

Fig. S12. Simulation results. Columns vary the relationship between the input indicator and outcome over time (Figure S11) and rows vary indicator (input) prevalence. Metrics are varied over the y-axis, and 3-week-ahead predictive accuracy is displayed in cells.