Impact of a Data-Informed Universal Masking Policy on Hospital-Acquired COVID-19, Influenza, and RSV Infections in King County, Washington: A Controlled Interrupted Time-Series Analysis

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Abstract

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Hospital-acquired respiratory viral infections (HAIs), including COVID-19, influenza, and respiratory syncytial virus (RSV), contribute to increased patient morbidity and healthcare burden. Universal masking has been shown to reduce respiratory virus transmission in healthcare settings, but masking mandates have fallen out of favor in the years following the COVID-19 pandemic. In response, the Northwest Healthcare Response Network (NWHRN) created a data-informed masking policy that "turns on" when respiratory virus transmission risk is high, and "off" when transmission risk is low. This study evaluated the impact of this data-informed hospital masking policy on HAIs in King County, Washington. We conducted a controlled interrupted time series analysis (CITS) using hospitalization data from the Washington Respiratory Virus Hospitalization Surveillance Network (RESP-NET) during the 2024–2025 respiratory virus season. The masking policy was activated on November 23, 2024, when emergency department visits for COVID-19, influenza, or RSV exceeded a predefined alert threshold. Hospital-acquired infections were compared with community-acquired infections (CAIs), which served as a control group. Among 3,374 laboratory-confirmed COVID-19, influenza, and RSV hospitalizations, 168 were classified as HAIs. No significant immediate change in the HAI-to-CAI ratio was observed following policy implementation (RR = 0.98, 95% CI: 0.31–3.08). The weekly HAI-to-CAI ratio declined by 9% per week after implementation compared to the pre-intervention period, although this decrease was not statistically significant (95% CI: 0.72–1.13). Although inconclusive, our findings suggest that data-informed masking policies may mitigate respiratory virus transmission in healthcare settings while minimizing the need for prolonged masking mandates. Further evaluation of this policy using data from multiple seasons and larger geographic areas is warranted to further assess its effectiveness.

Introduction

Hospital-acquired respiratory viral infections (HAIs), such as COVID-19, influenza, and respiratory syncytial virus (RSV), are respiratory infections acquired within healthcare settings that contribute to patient morbidity, mortality, and healthcare system burden[1,2]. In the US, approximately 18,000 HAIs are caused by respiratory infections annually[2, 3].

Hospital masking policies, both masking of patients and staff in all areas and masking of staff only, can mitigate the transmission of respiratory infections in hospital settings[4-6]. A 2024 meta-analysis found masking was an effective method of reducing respiratory virus transmission within hospital and community settings and that higher masking adherence was associated with decreased transmission[7]. These findings highlight the potential effectiveness of masking interventions in mitigating HAIs. As COVID-19 has become more controlled, with a steep decrease in infections and mortality, broad masking mandates have fallen out of favor, with critics often citing the negative impact on communication and adverse effects such as discomfort, headaches, and skin irritation[8]. While these side effects are important to consider, the total removal of hospital masking policies is regressive. Pak et. al. found that discontinuation of universal masking and SARS-CoV-2 testing was associated with a 25% increase in hospital-onset respiratory viral infections, and reinstating masking amongst healthcare workers was associated with a 33% decrease in hospital-acquired infections[9]. This research demonstrates that a hospital masking policy can be an effective method of mitigating HAIs during periods of high transmission risk.

In 2022, the Northwest Healthcare Response Network (NWHRN) created a multidisciplinary masking workgroup to develop masking recommendations for hospital networks across three counties in Washington State (King, Pierce, and Snohomish). NWHRN is a coalition of hospitals, clinics, emergency responders, and public health agencies that collaborates on emergency preparedness and health system resilience. The NWHRN publishes an annual Healthcare Worker Consensus Statement that aims to use the most up-to-date epidemiologic data to guide health system policies and reduce hospital-acquired respiratory infections. This statement was developed in the context of evolving respiratory virus epidemiology following the emergency phase of the COVID-19 pandemic. Unlike influenza and RSV, which typically demonstrate predictable seasonal peaks, COVID-19 transmission patterns have remained more variable and difficult to predict. In addition, healthcare-seeking behavior and respiratory virus testing practices have changed substantially since the pandemic, making reliance on individual disease-specific thresholds less practical. With these considerations in mind, inspired by the research done by Pak et. al., the masking workgroup adopted a flexible, data-informed approach to universal masking in hospital settings that can be "turned off" when respiratory transmission risk is low, thus avoiding the various detriments associated with a static masking policy, but can "turn on" when risk is high, helping mitigate HAIs when most needed.

This strategy aimed to align masking recommendations with broader respiratory illness surveillance approaches and to rapidly identify increases in community respiratory illness burden. By using objective respiratory illness metrics to guide implementation, the approach sought to balance the benefits of reducing hospital-acquired respiratory infections with the practical considerations associated with prolonged universal masking policies.

To our knowledge, this data-informed approach to universal masking has not previously been evaluated. If effective, the data-informed approach would provide a flexible and adaptive strategy for reducing respiratory virus transmission in hospital settings. The goal of this study is to evaluate the impact of this data-informed masking policy on hospital acquired COVID-19, influenza, and RSV infections in King County, WA.

Methods

Study Design and Setting

We used a controlled interrupted time series (CITS) study design to examine the effect of the masking policy on hospital-acquired COVID-19, flu, and RSV infections (HAI). Traditional interrupted time series measure the effect of a policy change by comparing the outcome measure before and after the policy is introduced. In this study, we examined the immediate impact ("level change") and impact over time ("trend change") in HAI counts after the masking policy was activated. In a CITS, a control group is included to account for competing interventions and policies (e.g., reduced community activity when COVID-19, influenza, and RSV incidence is high, seasonal vaccination in response to rising incidence, etc.) that are introduced around the same time the policy was activated that could also explain changes in the outcome of interest.

In this study, we will include "community-acquired" COVID-19, influenza, and RSV infections (CAIs) as our control group, which are defined as any COVID-19, influenza, and RSV infection that occurred prior to a patient being hospitalized. While the masking policy will likely impact HAIs, we expect there to be no effect on CAIs, because these infections would occur *before* patients are admitted to the hospital. Including this control group allowed us to compare trends in the HAI group to trends in a similar population in every way *except* for the hospital masking policy.

Data Sources and Study Population

All data were sourced from the Washington Respiratory Virus Hospitalization Surveillance Network (RESP-NET), a statewide surveillance network that monitors laboratory-confirmed hospitalizations associated with influenza, COVID-19, and RSV[10, 11]. WA RESP-NET identifies eligible hospitalizations using multiple complementary surveillance systems, including syndromic surveillance, electronic laboratory reporting, and routine reports from hospitals across Washington State. The integration of these data sources helps ensure that nearly all

RESP-NET-eligible hospitalizations are identified, making RESP-NET one of the most comprehensive sources of respiratory virus hospitalization data in the state. This approach is particularly valuable for RSV surveillance because positive RSV laboratory results are not routinely reportable through mandatory disease reporting systems. Nearly all major hospital networks in Washington participate in RESP-NET reporting, except for Kaiser Permanente and the Department of Veterans Affairs; however, hospitalizations from these systems may still be identified through syndromic surveillance and electronic laboratory reporting. We included all hospitalizations among King County residents reported to RESP-NET.

Intervention

The intervention of interest in this study is the universal masking policy outlined in the NWHRN 2024-2025 Healthcare Worker Masking Consensus Statement[12]. This masking policy, which is applied to all patients, visitors, and staff in patient care areas, is implemented when COVID-19, influenza, and RSV emergency department (ED) visits cumulatively surpass a predefined alert threshold. The alert threshold was calculated separately for COVID-19, influenza, and RSV ED visits using the Moving Epidemic Method (MEM)[13]. The MEM calculates a "baseline" respiratory disease activity level for each season per infection, defined as the lowest activity week. Weekly ED counts are then compared to this baseline. The alert threshold for influenza and RSV is calculated by taking the arithmetic mean of the highest activity weeks from the 2017 to 2024 seasons and calculates a single-tailed 95th percentile confidence interval.

Due to the abnormal seasonal patterns caused by the COVID-19 pandemic, the 2020-2021 and 2021-2022 seasons were not implemented in the calculation of the baseline or alert threshold for influenza or RSV. Relatedly, the calculation of a COVID-19 baseline and alert threshold was implemented in a different manner due to its recent emergence in the United States and its unclear seasonal pattern. Instead, an algorithm that identifies "peaks" and "waves" are used to continuously update a working model of COVID-19's seasonal pattern, which is then used to determine the baseline and alert threshold. This model defines a "peak" as the highest percent visit of ED visits for COVID-19 following a consistent increase in ED visits for 3 weeks. The start of a new wave is defined as the lowest ED activity week between two weeks. Per the Healthcare Worker Masking Consensus statement, once one condition surpassed the alert threshold, the masking policy would be "activated" for the entire hospital and consequently each respiratory infection would be impacted, allowing us to use one timepoint marking the beginning of the intervention.

Study Periods

The 2024-25 respiratory virus season in King County, WA started on October 1, 2024 and ended on April 5th, 2025. In this study, we included all RESP-NET hospitalizations that occurred during this time period. The masking policy was "activated" on November 23, 2024. Thus, the "pre-policy" period includes all hospitalizations from October 1, 2024 to November 23, 2024 and the "post-policy" period includes all hospitalizations from November 24, 2024 to April 5, 2025.

Outcome Measures

The outcome of interest is the weekly count of COVID-19, influenza, and RSV hospitalizations due to HAI divided by the weekly count of hospitalizations due to CAI (HAI-to-CAI ratio).
HAI were defined as RESP-NET hospitalizations where the first positive lab report occurred at least 3 days after the first date of admission and before the last discharge date. CAI were

defined as RESP-NET hospitalizations where the date of first positive lab report occurred up to 14 days before or less than 4 days after the first admission date[12].

Statistical Analyses

We tabulated and compared characteristics of the HAI and CAI group before and after the masking policy was activated. Additionally, the data was visually inspected via plot graph to check for the assumption of linearity in a CITS analysis.

Individual patient hospitalizations were aggregated into weekly counts. For each week, we calculated the ratio of HAI hospitalizations to CAI hospitalizations and plotted this data for the entire study period. There are two main metrics we evaluated for this study: the initial change in the ratio of HAI to CAI cases immediately following the implementation of the masking policy, and the change in the ratio over time following the intervention. We hypothesized that the ratio between the HAI and CAI groups would decrease both immediately (i.e. “level change”) following intervention implementation and continue to decrease overtime (i.e. “trend change”) as HAI cases will decrease while CAI cases continue to increase. To estimate the level and trend changes, we fit a Poisson regression model, including terms for time since the start of observation (week), intervention period (pre-/post-masking policy), and time since the intervention period (time after):

$$Y_t = \beta_0 + \beta_1 Week_t + \beta_2 Intervention_t + \beta_3 TimeAfter_t$$

Y_t represents the HAI-to-CAI ratio:

$$Y_t = \frac{HAI\ weekly\ count}{CAI\ weekly\ count}$$

Y_t represents the weekly ratio of HAI cases to CAI cases Using this model, we estimated the level change (β_2) and the trend change (β_3) and calculated 95% confidence intervals. Wald’s test was used to assess the statistical significance of these estimates, using an alpha of 0.05.

Results

During the 2024-2025 respiratory virus season, there were 3,374 laboratory-confirmed cases for COVID-19, influenza, and RSV is King County, WA. Of these, 22.9% were COVID-19, 53.7% were influenza, and 23.4% were RSV. In the pre-intervention period, 9.3% (39 of 418) of cases were categorized as HAI compared to 4.3% (129 of 2,956) in the post-intervention period.

COVID-19 was the most prevalent infection type in the pre-intervention period for both the HAI group (81% of cases) and CAI group (90% of cases), but influenza was the most prevalent infection type in the post-intervention period for the HAI group (53% of cases) and CAI group (60% of cases) (**Table 1**). Comparing characteristics of cases in the HAI group and CAI group, the average length of stay among the HAI group was higher in both the pre- and post-intervention time periods compared to the CAI group. Race, ethnicity, and sex were similar between the HAI and CAI groups while the age distributed differed, with few cases < 19 years old in the HAI group compared to the CAI group (**Table 1**).

Figure 1 displays the observed HAI and CAI counts by week. During the pre-intervention period, CAI weekly counts were higher than weekly HAI counts; on average, the CAI and HAI weekly counts generally did not change during the pre-intervention period. In the post-intervention period, both HAI and CAI weekly counts increased each week. CAI cases increased steadily, reaching a high of 270 cases in week 19. HAI weekly counts generally increased each week, eventually reaching a high of 12 HAI cases in weeks 16 and 17.

There was no significant level change in average weekly HAIs from the pre-intervention to the post-intervention period (**Table 2,** RR: 0.98, 95% CI: 0.31, 3.08). During the pre-intervention period, HAIs per 100 CAIs decreased by 0.25% per week (95% CI: -20.5, 24.5). This decrease grew to 9.6% per week in the post-intervention period (95% CI: -22.6, 5.5). This represents a 9% weekly reduction in the count of HAIs per 100 CAIs during the post-intervention period compared to the pre-intervention period. However, this decrease was not statistically significant.

During the pre-intervention period, the HAI-to-CAI ratio remained generally stable, but declined sharply in the post-intervention period (**Figure 2**). **Table 3** shows the predicted weekly HAI case counts per 100 CAI cases at specific time points during the study period. At the start of the pre-intervention period, the predicted HAI cases per 100 CAI cases was 11 (95% CI; 5, 24), compared to a predicated case count of 10 HAI cases per 100 CAI cases (95% CI; 5, 20) at the start of the post-intervention period. At the peak of the respiratory virus season (i.e., when CAI cases are highest), this ratio fell to 3 HAI cases per 100 CAI cases (95% CI; 1, 8).

Discussion

In this study, we leveraged data from a statewide respiratory virus hospitalization surveillance network to examine the impact of a flexible hospital masking policy on hospital-acquired respiratory infections. Using hospitalized community-acquired respiratory infections as a comparison group (cases that would not be directly impacted by a hospital-based masking policy since those infections were acquired outside of the hospital), we found that there was a 9% per week decrease in the ratio of hospital-acquired cases to community-acquired cases after the masking policy was in place, though this decrease was not statistically significant (95% CI; 0.72, 1.13). We did not observe an immediate change in the ratio of HAI to CAI cases after the masking policy was implemented. Although inconclusive, these findings suggest that a data-informed masking policy may mitigate transmission of respiratory infections within hospital settings.

Our findings are generally consistent with prior research evaluating masking policies within healthcare settings, though most of the other studies observed larger decreases in hospital acquired infections. Munigala et al. observed a 34% reduction in monthly HAI cases within a single hospital setting between 2019 and 2022 after a masking policy was implemented. A study conducted by Ehrenzeller et al. also showed a 44%-53% reduction in hospital acquired influenza and RSV following implementation of a masking policy.

There are a number of differences between our study and the Munigala and Ehrenzeller studies. Our study was assessing the implementation of a flexible, data-driven masking policy that used real-time data to determine when respiratory virus infection was at increased risk. The masking policies assessed in Munigala et al. and Ehrenzeller et al. were static policies, having been implemented at pre-determined timepoints. Additionally, these studies were conducted during the COVID-19 pandemic when masking, social distancing, and various other interventions were implemented and were strongly enforced.

These differences in intervention and the wider context may partially explain the attenuated effects of our study. Notably, our analysis assessed the impact of a hospital masking policy, not masking itself. Insofar as masking fatigue may play a role in policy adherence, it is possible that by the time of the 2024-2025 respiratory season (when our study was conducted), the adherence to the masking policy was less complete compared to the early years of the COVID-19 pandemic. A notable strength of our research is that we studied the impact of this masking policy across various healthcare systems within a county, while the Munigala et al. and Ehrenzeller et al. studies were only implemented within a single hospital setting.

The findings of this study have implications for the future of healthcare system policy. Previous work has shown the effectiveness of hospital masking policy, but little research has focused on the timeliness of implementing such a policy. This study is one of the first to evaluate the effectiveness of a flexible masking policy that is activated when respiratory virus transmission risk is high and is deactivated when risk is low. This strategy may be a pragmatic way forward to help mitigate hospital acquired infections while also minimizing the need for masking, which is linked to increased patient discomfort, communication issues with hospital staff, and trouble breathing[9].

There are several strengths of this analysis. Firstly, RESP-NET is a robust, population-based surveillance system that collects data on respiratory virus testing and hospital admission dates, which allowed us to determine whether cases acquired their infection within the hospital or in the community. Our use of hospitalizations for community-acquired infections as a control group allowed us to compare whether the trends we observed in the HAI group were likely attributable to the masking policy or external factors.

The results of this study are limited by insufficient sample size and data availability. We used only data from one respiratory virus season from just one county. During the study period, there were only 168 HAI case patients and small weekly changes in case counts would greatly increase the variance of our model estimates. In addition, there are a limited number of timepoints in the pre-intervention period. Respiratory virus transmission is rare in the spring and summer months and the alert threshold is crossed early in the respiratory virus season. These factors limit the power to detect a significant difference in an interrupted time series analysis.

Future analyses should focus on including multiple respiratory viral seasons and multiple jurisdictions, which would increase the study sample size and mitigate some of these limitations. In addition, since COVID-19, influenza, and RSV may have different incubation periods, it is possible that some cases may have been misclassified as “community acquired” when they were really “hospital acquired”, and vice versa. Lastly, this study only assessed the impact of the masking policy on three respiratory diseases, which may underestimate the full impact of the policy on hospital-acquired respiratory infections.

Future research into data-informed masking policies should focus on validating these findings using data from multiple seasons and across multiple counties. Additionally, future studies should examine the role of masking adherence (both among healthcare workers and patients) on the effectiveness of the policy. Prior research has shown that healthcare workers may be a significant source and spread of hospital-acquired infection[15].

In conclusion, through the work of the NWHRN, a novel methodology towards hospital masking was developed for Washington State, which we assessed using the 2024-2025 respiratory virus seasons community and hospital acquired infection data within King County. This research showed the potential for such a policy to mitigate hospital acquired infections when it is most important through a decrease in the ratio of HAI cases compared to CAIs after the policy was implemented.

Appendix

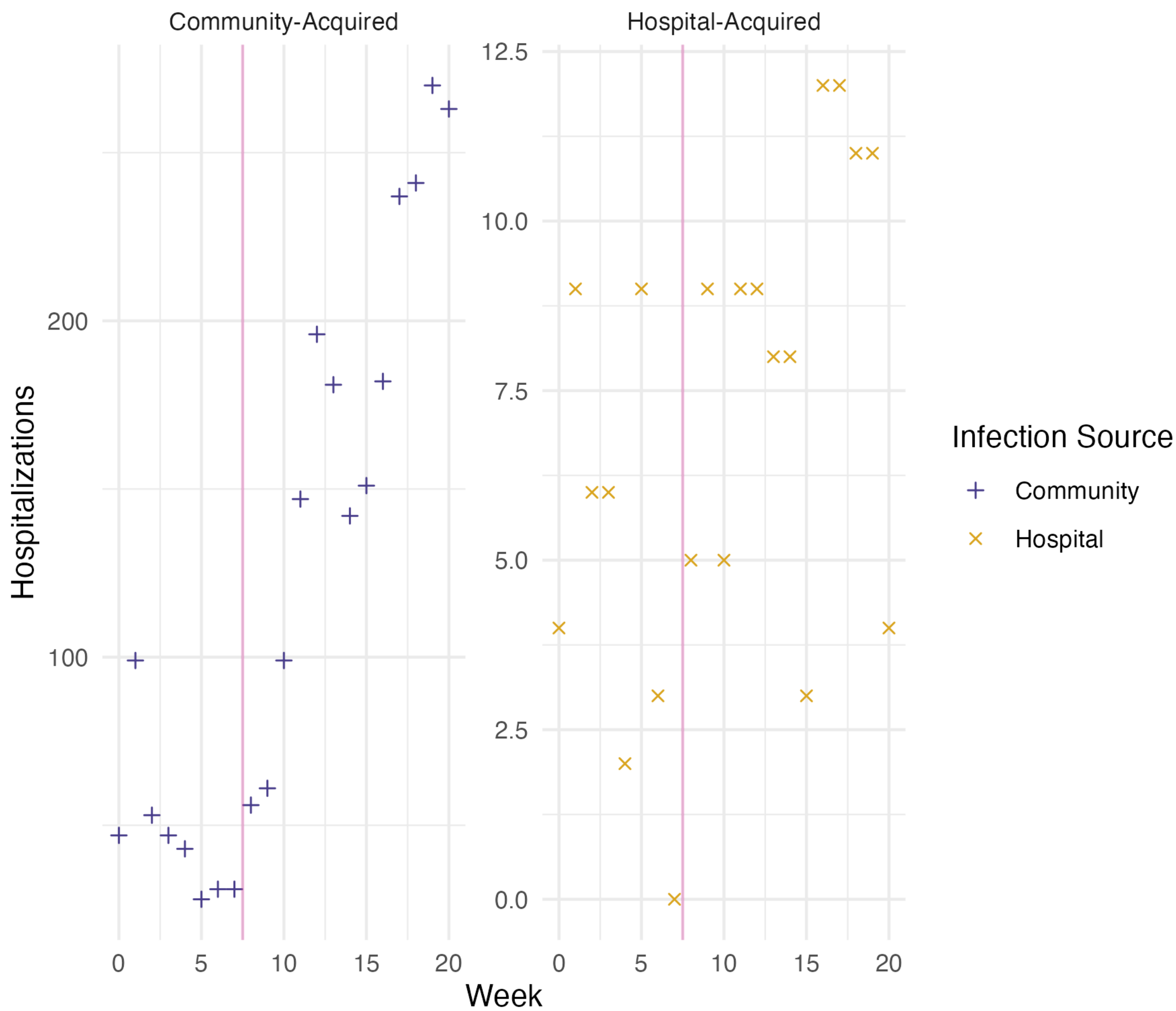
Table 1. Demographic Data of Study Population by Time-period, Study Group

	Pre-policy		Post-policy	
Characteristic	**CAI**[1] N = 379[2]	**HAI**[1] N = 39[2]	**CAI**[1] N = 2,827[2]	**HAI**[1] N = 129[2]
Age				
0-4	26 (6.9%)	0 (0%)	377 (13%)	1 (0.8%)
5-17	5 (1.3%)	0 (0%)	187 (6.6%)	1 (0.8%)
18-49	56 (15%)	2 (5.1%)	458 (16%)	14 (11%)
50-65	64 (17%)	2 (5.1%)	488 (17%)	30 (23%)
66+	228 (60%)	35 (90%)	1,317 (47%)	83 (64%)
Race/Ethnicity				
American Indian/Alaskan Native	4 (1.1%)	0 (0%)	36 (1.3%)	2 (1.6%)
Asian	39 (10%)	3 (7.7%)	295 (10%)	14 (11%)
Black	36 (9.5%)	3 (7.7%)	351 (12%)	13 (10%)
Hispanic	24 (6.3%)	0 (0%)	174 (6.2%)	5 (3.9%)
Native Hawaiian/Pacific Islander	4 (1.1%)	0 (0%)	76 (2.7%)	0 (0%)
White	252 (66%)	31 (79%)	1,668 (59%)	90 (70%)
Multi/Other	5 (1.3%)	0 (0%)	13 (0.5%)	1 (0.8%)
Unknown	15 (4.0%)	2 (5.1%)	214 (7.6%)	4 (3.1%)
Sex				
Female	186 (49%)	19 (49%)	1,467 (52%)	69 (53%)
Male	193 (51%)	20 (51%)	1,360 (48%)	60 (47%)
Infection				
COVID-19	306 (81%)	35 (90%)	386 (14%)	45 (35%)
Influenza	34 (9.0%)	3 (7.7%)	1,707 (60%)	68 (53%)
RSV	39 (10%)	1 (2.6%)	734 (26%)	16 (12%)
Length of Stay				
	4 (2, 7)	14 (8, 27)	3 (2, 6)	14 (8, 25)

[1] CAI, Community-acquired infections; HAI, Hospital-acquired infections

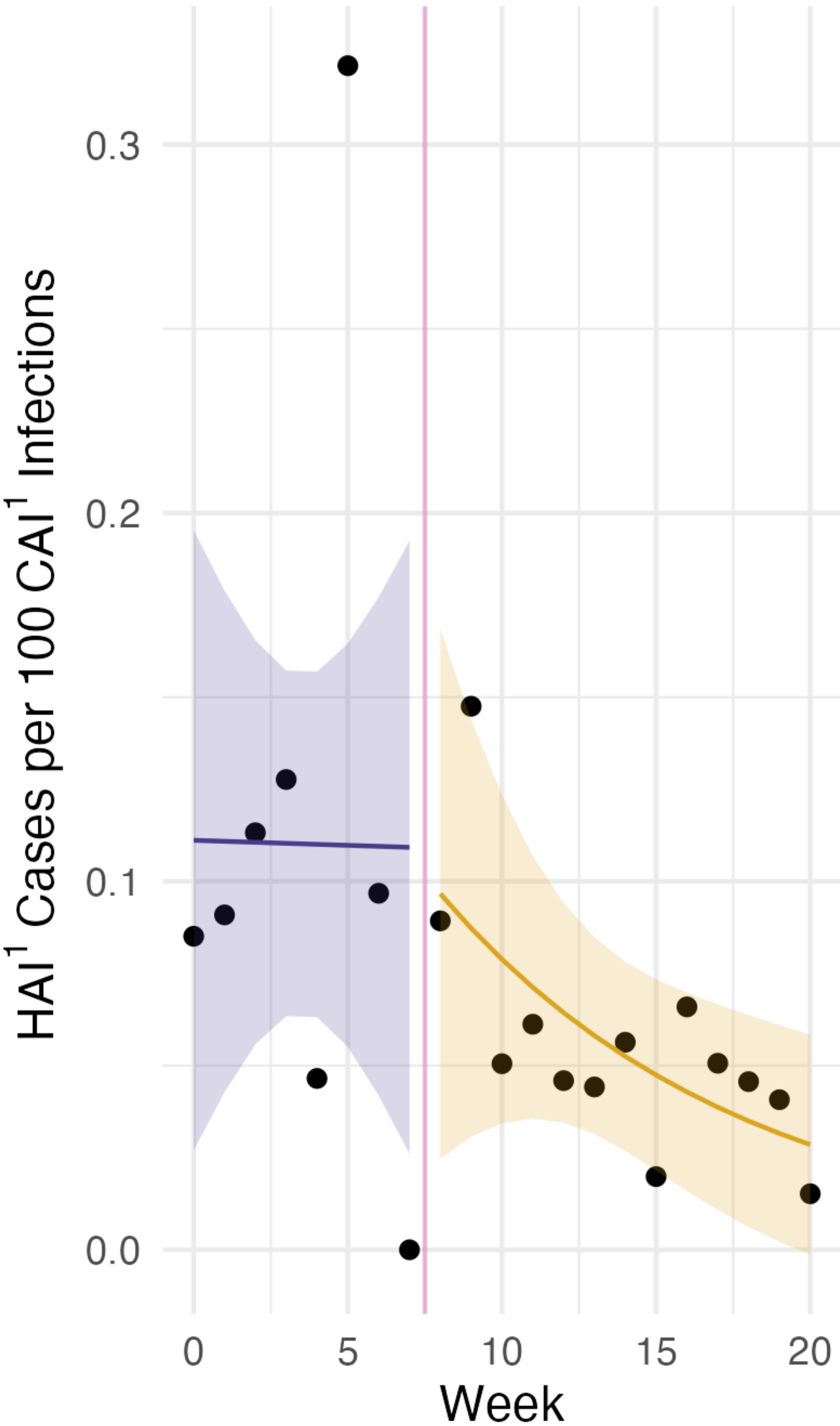
[2] n (%); Median (Q1, Q2)

Figure 1. Hospital and Community-Acquired Infection Counts by Week*



*Note: Different Y-scales

Figure 2. Weekly hospitalization counts for hospital-acquired COVID-19, influenza, and RSV infections per 100 community-acquired infections



[1] CAI, Community-acquired infections; HAI, Hospital-acquired infections

Table 2. Ratio Change of Hospital-acquired Infections

	Level Change		Trend Change	
Period	**Average weekly HAI[1] hospitalization per 100 CAI[1] (95% CI)**	**RR (95% CI)**	**Average % change in HAI[1] hospitalizations (per 100 CAI[1])**	**RR (95% CI)**
Pre-Intervention	11 (4, 28)	Ref.	-0.25 (-20.5, 24.45)	Ref.
Post-intervention	11 (2, 71)	0.98 (0.31, 3.08)	-9.67 (-22.64, 5.49)	0.91 (0.72, 1.13)

[1] CAI, Community-acquired infections; HAI, Hospital-acquired infections

Table 3. Predicted weekly counts of hospitalizations for hospital-acquired COVID-19, influenza, and RSV infections (per 100 community-acquired infections) during the 2024-2025 respiratory virus season

Time Point	**Predicted HAI weekly count (95% CI)**
Start of respiratory season, Week 0	11 (5, 24)
Start of post-intervention period, week 8	10 (5, 20)
Respiratory season "peak," Week 20	3 (1, 8)

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