Toward a Dynamic Understanding of Staffing: Nursing Home Workforce Resilience During Pandemic Disruptions, Post-Pandemic Staffing, and the Role of State Staffing Policies

Abstract

Nursing shortages and increased workforce demand have overwhelmed long-term care facilities during and after the COVID-19 pandemic. Conventional staffing measures quantify point-in-time workforce levels associated with quality of care but do not assess facilities' resilience to absorb workforce losses, recover from repeated disruptions, adapt recruitment strategies, or sustain workforce growth over time.

We address these cross-sectional shortcomings by developing and assessing a dynamic workforce resilience index that measures remaining staffing functionality and various measures of staffing resilience, and compare changes in nursing type compositions (registered nurses (RNs), licensed practical/vocational nurses (LPN/LVNs), and certified nursing assistants (CNAs)) and employment composition (facility-employed and contract staff) across successive COVID-19 waves. We further include sequential disruptions and variation in staffing regulation history, implementation strength, and labor market conditions across six selected states as a policy experiment. We then develop and evaluate workforce resilience indices, demonstrating their descriptive and predictive power for interpreting facility workforce adaptation.

Preliminary findings indicate that the growth-adjusted workforce resilience index captures persistent workforce deficits by accounting for increasing staffing needs, outperforming a fixed-baseline index. Due to a common shortage of RNs, states with long-standing minimum staffing mandates maintained workforce resilience primarily through stable permanent employment and sustained CNA staffing, whereas states with more flexible staffing policies relied more heavily on contract staff during periods of severe workforce shortages.

The proposed workforce resilience framework offers a practical approach for measuring organizational resilience beyond conventional staffing indicators. By incorporating workforce composition and expected workforce growth, it enables policymakers to evaluate the long-term effectiveness of staffing management and regulation, identify emerging workforce vulnerabilities, and design more resilient workforce strategies for future public health emergencies.

Supplementary Statement

Background

The COVID-19 pandemic exposed substantial variation in nursing home workforce stability across states and highlighted the importance of maintaining an adequate nursing workforce during prolonged public health emergencies. Skilled nursing facilities (SNFs) experienced successive disruptions, including multiple COVID-19 waves, severe labor shortages, emergency staffing waivers, and evolving state staffing regulations. Although conventional workforce indicators measure cross-sectional staffing levels or hours per resident day, they provide limited insight into how facilities adapt their workforce composition to sustain staffing capacity during prolonged and dynamic labor market disruptions. In particular, little is known about how different state staffing regulations influence facilities' reliance on permanent versus contract staff and how these workforce strategies contribute to workforce resilience over time.

Objective

This study develops a dynamic workforce resilience framework to evaluate how state staffing regulations influence nursing home workforce adaptation during prolonged labor market disruptions. We introduce two complementary Workforce Resilience Indices (WR1 and WR2) that jointly measure staffing resilience using workforce quantity and employment composition by distinguishing permanent facility employees from contract staff. Using this framework, we compare workforce resilience across states with different staffing regulations and examine how regulatory environments shape recruitment and retention strategies for registered nurses (RNs), licensed practical/vocational nurses (LPN/LVNs), and certified nursing assistants (CNAs).

Methods

Using CMS Payroll-Based Journal (PBJ) Staffing and Employee Detail data, we constructed weekly workforce measures for total nursing staff, facility-employed staff, contract staff, RNs, LPN/LVNs, and CNAs across six states from 2020 through 2024. Workforce resilience was evaluated across five sequential periods: the Baseline (2020w14–2020w17), COVID-19 First Wave (2020w18-2020w52), Vaccine Introduction and Delta (2021w1-2021w52), Omicron and Endemic Management (2022w1-2023w39), and Post-COVID Management (2023w40-2024w51).

The analysis compared workforce resilience across states with different staffing-regulation histories, implementation strengths, and labor-market conditions. For each workforce category, resilience was measured as the proportion of expected staffing functionality maintained over a specified disruption and recovery period:

$$WR_{ki} = 1 - \frac{\int_{t_{si}}^{t_{ri}} [P_k(t) - O(t)]\, dt}{\int_{t_{si}}^{t_{ri}} P_k\,(t)\, dt} = \frac{\int_{t_{si}}^{t_{ri}} O(t)\, dt}{\int_{t_{si}}^{t_{ri}} P_k\,(t)\, dt}, k \in \{1,2\}$$

where $O(t)$ denotes observed staffing at week t, $P_k(t)$ denotes the expected staffing trajectory under baseline model k, and t_{si} and t_{ri} represent the starting and end of disruption-recovery period i. The numerator of the loss term captures the cumulative staffing deficit relative to the expected trajectory, while the denominator represents total expected staffing functionality during the same period. An index of 1 indicates that expected staffing was fully maintained, values below 1 indicate cumulative workforce loss, and values above 1 indicate staffing above the expected level.

Under the fixed-baseline model, expected staffing remained equal to the average workforce observed during the four-week pre-pandemic baseline:

$$P_1(t) = P_0$$

and the corresponding resilience index was:

$$WR_{1i} = 1 - \frac{\int_{t_{si}}^{t_{ri}} [P_0 - O(t)]\, dt}{\int_{t_{si}}^{t_{ri}} P_0\ dt}$$

To account for workforce growth that would have been expected in the absence of the pandemic, the growth-adjusted trajectory was defined as:

$$P_2(t) = P_0(1 + 0.000755)^t,$$

producing the growth-adjusted resilience index:

$$WR_{2i} = 1 - \frac{\int_{t_{si}}^{t_{ri}} [P_0(1 + 0.000755)^t - O(t)]\, dt}{\int_{t_{si}}^{t_{ri}} P_0\,(1 + 0.000755)^t\, dt}$$

The weekly growth rate of 0.0755%, approximately 4% annually, was based on CMS projections of nursing staffing needs using 2019 as the baseline for the expected 2020–2024 workforce trajectory.

Because staffing was observed weekly, the integrals were operationalized as discrete sums:

$$WR_{ki} = 1 - \frac{\sum_{t=t_{si}}^{t_{ri}} [P_k(t) - O(t)]}{\sum_{t=t_{si}}^{t_{ri}} P_k(t)} = \frac{\sum_{t=t_{si}}^{t_{ri}} O(t)}{\sum_{t=t_{si}}^{t_{ri}} P_k(t)}$$

Separate indices were estimated for the total nursing workforce, facility-employed staff, contract staff, and each nursing occupation (RNs, LPNs/LVNs, and CNAs) allowing comparisons of cumulative workforce loss and recovery across employment arrangements, nurse types, disruption periods, and state policy environments.

Interpretation for the Workforce Resilience

This formulation measures cumulative resilience over each disruption-recovery period, rather than resilience at a single week. The original measure,

$$WR_k(t) = \frac{O(t)}{P_k(t)}$$

can still be retained as the **weekly resilience trajectory**, while the integral-based WR_{ki} summarizes the entire resilience curve for period i. This gives two complementary measures:

- **Weekly $WR_k(t)$:** shows when staffing declined and recovered.
- **Integrated WR_{ki}:** summarizes the magnitude and duration of workforce loss across the full period

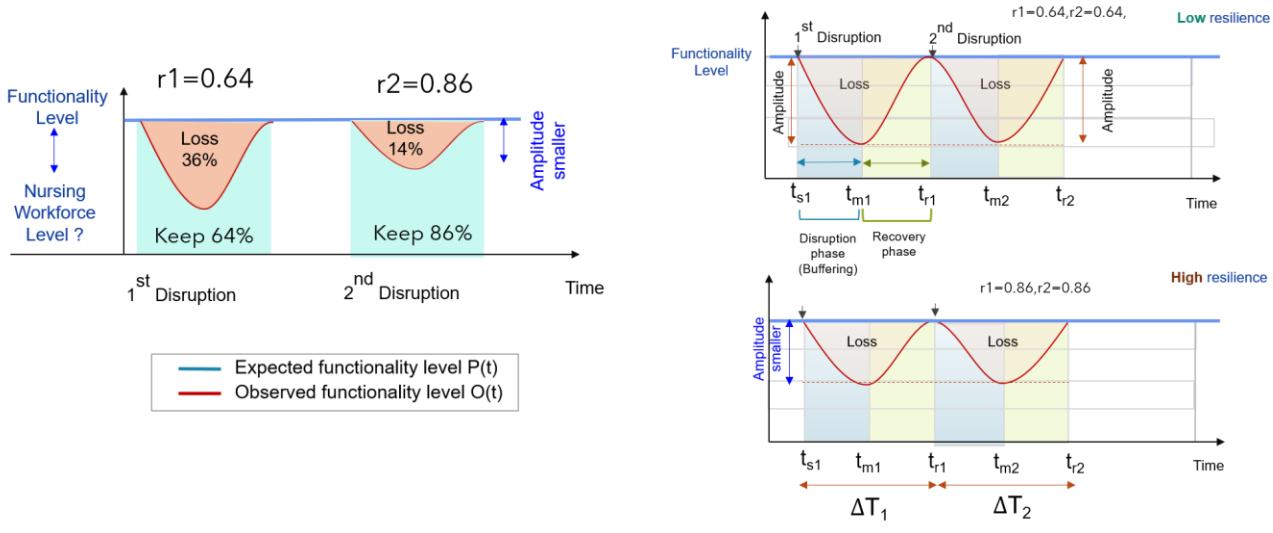


Figure 1. Conceptual Illustration of Workforce Resilience Measured by the Area Under the Staffing Functionality Curve

Table 1. The Judgement of Resilience Values

Resilience value	Interpretation
1.00	Observed staffing exactly matched predicted staffing
0.90	Observed staffing reached 90% of predicted staffing
0.75	Observed staffing reached 75% of predicted staffing
>1.00	Observed staffing exceeded predicted staffing

State Staffing Policy Comparison

We selected six states representing diverse staffing policy histories and workforce environments to investigate whether differences in staffing governance are associated with distinct workforce resilience trajectories and adaptation strategies.

Table 2 summarizes the history, implementation strength, and minimum staffing standards of nursing home staffing regulations across the six study states. The selected states represent substantial variation in the timing of staffing policy adoption, regulatory enforcement, quantitative staffing requirements, and workforce governance. California and Florida established minimum staffing standards before the COVID-19 pandemic, whereas New York implemented major staffing reforms during the pandemic. In contrast, Texas, Missouri, and Virginia primarily relied on needs-based staffing requirements with less prescriptive statewide minimum staffing standards. Together, these differences provide a heterogeneous policy environment for evaluating workforce resilience.

We hypothesize that differences in staffing regulation history, implementation timelines, regulatory enforcement, and workforce environments contribute to variation in workforce resilience across states. Specifically, states with earlier and more comprehensive staffing regulations may demonstrate greater resilience by maintaining permanent staffing, reducing cumulative workforce loss, and recovering more rapidly during successive COVID-19 disruptions. Conversely, states with more flexible or needs-based staffing policies may rely more heavily on contract staffing or exhibit different workforce adaptation strategies under labor shortages. Ongoing analyses will further examine how state-specific policy reforms, implementation milestones, and workforce conditions correspond to the observed resilience trajectories and the long-term effectiveness of staffing governance.

Table 2. Nursing Home Staffing Requirement across Six States

State	Policy & Regulation Strength	Minimum Staffing Standard
California (CA)	**Strongest** • Early quantitative standard (2000) • Active audit & penalty enforcement (2018)	• **2000:** 3.2 HPRD • **2018:** Staffing audit & financial penalties • **2022:** COVID workforce waiver • **2024:** Increased to **3.5 HPRD**
Florida (FL)	**Strong** • Early quantitative staffing standard (2001)	• **3.6 HPRD** direct care • **2.0 CNA HPRD** (≥1 CNA:20 residents) • **1.0 Licensed Nurse HPRD** (≥1 LN:40 residents)
New York (NY)	**Strong** • Late Adopter 2021, Pandemic-era staffing reform	• **2021:** 3.5 HPRD • **2.2 CNA HPRD** • **1.1 Licensed Nurse** (RN+LPN/LVN) **HPRD**
Texas (TX)	**Moderate** • Partial staffing regulation	• Licensed nurse requirement (~0.4 HPRD) • No statewide total HPRD
Missouri (MO)	**Weak** • Needs-based staffing	• No statewide minimum HPRD • "Sufficient staffing" requirement
Virginia (VA)	**Weak** • Needs-based staffing	• No statewide minimum HPRD • Licensed nurse coverage required

Note: HPRD, nursing service hours per resident day; RN, registered nurse; LPN/LVN, licensed practical/vocational nurse; CNA, certified nursing assistant.

Results

The proposed workforce resilience framework revealed substantial heterogeneity in workforce adaptation that was not captured by conventional staffing measures alone. Under the fixed-baseline measure (WR1), workforce resilience declined from 1.000 at baseline to its lowest level during the Delta wave (0.928) before recovering to approximately baseline in the post-COVID period (1.014). In contrast, the growth-adjusted measure (WR2) revealed persistent workforce deficits, with resilience remaining well below expected levels during Omicron (0.857) and the post-COVID period (0.865). See Table S1. Compared with the fixed-baseline index (WR1), the growth-adjusted index (WR2) consistently identified larger workforce deficits after accounting for expected workforce growth, demonstrating that apparent recovery toward pre-pandemic staffing levels often masked unrealized workforce expansion.

Employment-type analyses further showed that nursing homes adopted distinct recruitment and retention strategies under different state regulatory environments. The average number of nurses per facility and workforce resilience respectively show in Figure S1 and Figure S2.

States with long-standing minimum staffing mandates demonstrated different adaptation pathways despite sharing similar regulatory frameworks. California maintained workforce resilience primarily through stable facility-employed staff and sustained CNA staffing while relying minimally on contract nurses. Despite persistent RN shortages, contract RN utilization remained consistently low throughout the pandemic, suggesting that facilities emphasized retaining permanent employees rather than expanding agency staffing. Florida also maintained high CNA resilience throughout the study period, consistent with strong incentives created by minimum CNA staffing requirements, although growth-adjusted overall workforce and RN resilience remained below expected levels.

New York, representing pandemic-era staffing policy reforms, exhibited a markedly different workforce adaptation strategy. Facilities substantially expanded contract staffing during the Delta and Omicron periods before gradually rebuilding their permanent workforce, indicating that contract staff served as a temporary workforce buffer during severe labor shortages.

In contrast, Texas, Missouri, and Virginia, which primarily rely on needs-based staffing standards, generally experienced larger declines in growth-adjusted workforce resilience and greater dependence on contract staffing following successive disruptions. Compared with states implementing more prescriptive staffing regulations, these states demonstrated lower overall workforce resilience and slower recovery toward expected staffing trajectories.

Across all six states, workforce adaptation also differed by nursing occupation. RN resilience remained constrained by persistent labor market shortages, whereas CNA resilience was consistently higher in states with stronger staffing mandates, suggesting that staffing regulations influenced facilities' recruitment priorities and workforce composition. These findings indicate that workforce resilience reflects not only staffing availability but also how facilities strategically allocate permanent and contract workers under different regulatory and labor market conditions.

Conclusions

This study introduces a dynamic workforce resilience framework that extends conventional staffing measures by integrating workforce quantity, employment composition, and expected workforce growth.

By distinguishing between permanent and contract employment, the proposed Workforce Resilience Indices quantify how nursing homes adapt their workforce under different regulatory environments and prolonged labor market disruptions.

Our findings suggest that state staffing regulations influence not only staffing levels but also facilities' workforce adaptation strategies, including the balance between permanent and contract employment and occupation-specific recruitment priorities. The proposed resilience framework therefore provides policymakers with a practical monitoring tool for identifying emerging workforce vulnerabilities, evaluating the effectiveness of staffing regulations and workforce policies, and supporting evidence-based workforce planning to strengthen long-term care preparedness during future public health emergencies and other prolonged workforce disruptions.

Reference Results:

Table S1. Workforce Resilience (Overall and by States)

WR1: Fixed-baseline workforce resilience

Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	**1.000**	**0.971**	**0.928**	**0.953**	**1.014**
RN	1.000	1.028	0.982	0.961	1.066
LPN/LVN	1.000	0.987	0.967	1.032	1.064
CNA	1.000	1.153	1.149	1.254	1.296

WR2: Growth-adjusted workforce resilience (Weekly growth: 0.0755%)

Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	**1.000**	**0.958**	**0.886**	**0.857**	**0.865**
RN	1.000	1.014	0.938	0.864	0.909
LPN/LVN	1.000	0.974	0.923	0.928	0.908
CNA	1.000	1.138	1.097	1.128	1.106

California — WR1: Fixed-baseline workforce resilience

Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	1.000	0.966	0.963	1.001	1.093
RN	1.000	1.010	0.986	0.948	1.050

LPN/LVN	1.000	0.997	1.014	1.098	1.185
CNA	1.000	0.962	0.975	1.021	1.120

California — WR2: Growth-adjusted workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	0.953	0.919	0.902	0.933
RN	1.000	0.997	0.942	0.855	0.896
LPN/LVN	1.000	0.984	0.968	0.990	1.011
CNA	1.000	0.949	0.931	0.920	0.955

New York — WR1: Fixed-baseline workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	1.015	0.960	1.005	1.076
RN	1.000	1.049	1.024	1.041	1.114
LPN/LVN	1.000	1.025	0.972	1.014	1.066
CNA	1.000	1.037	0.982	1.067	1.142

New York — WR2: Growth-adjusted workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	1.001	0.917	0.900	0.918

RN	1.000	1.035	0.978	0.932	0.950
LPN/LVN	1.000	1.012	0.928	0.909	0.910
CNA	1.000	1.023	0.938	0.955	0.974

Florida — WR1: Fixed-baseline workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	0.949	0.917	0.918	0.953
RN	1.000	0.987	0.909	0.901	1.006
LPN/LVN	1.000	0.958	0.959	1.079	1.082
CNA	1.000	1.704	1.908	2.042	2.161

Florida — WR2: Growth-adjusted workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	0.936	0.876	0.831	0.813
RN	1.000	0.974	0.869	0.814	0.858
LPN/LVN	1.000	0.945	0.915	0.976	0.923
CNA	1.000	1.679	1.821	1.845	1.843

Virginia — WR1: Fixed-baseline workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**

Overall	1.000	1.047	0.974	1.017	1.106
RN	1.000	1.031	0.968	0.973	1.072
LPN/LVN	1.000	0.994	0.973	1.027	1.084
CNA	1.000	1.665	1.428	1.496	1.575

Virginia— WR2: Growth-adjusted workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	1.033	0.931	0.911	0.943
RN	1.000	1.017	0.924	0.871	0.914
LPN/LVN	1.000	0.981	0.930	0.920	0.925
CNA	1.000	1.642	1.365	1.341	1.344

Missouri — WR1: Fixed-baseline workforce resilience

Workforce	**Baseline**	**COVID-19 First Wave**	**Vaccine + Delta**	**Omicron + Endemic**	**Post-COVID**
Overall	1.000	0.963	0.883	0.911	0.971
RN	1.000	1.009	0.971	0.954	0.988
LPN/LVN	1.000	0.987	0.941	0.944	0.971
CNA	1.000	0.960	0.876	0.933	1.011

Missouri— WR2: Growth-adjusted workforce resilience

Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	1.000	0.950	0.843	0.816	0.829
RN	1.000	0.996	0.928	0.855	0.843
LPN/LVN	1.000	0.974	0.898	0.846	0.828
CNA	1.000	0.947	0.836	0.835	0.862

Texas — WR1: Fixed-baseline workforce resilience

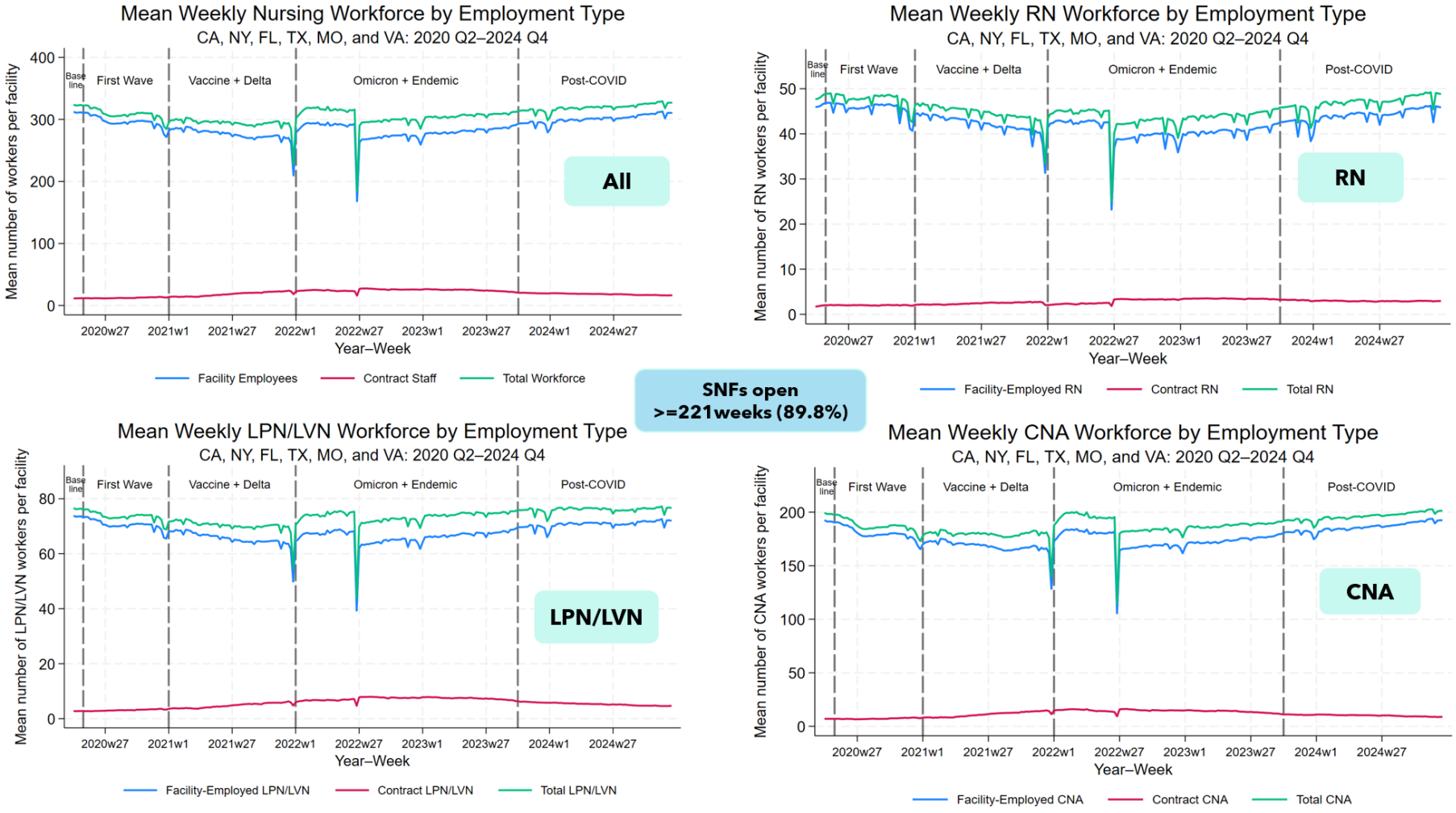
Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	1.000	0.952	0.882	0.887	0.922
RN	1.000	1.076	1.019	0.998	1.131
LPN/LVN	1.000	0.972	0.922	0.927	0.934
CNA	1.000	0.942	0.870	0.893	0.930

Texas— WR2: Growth-adjusted workforce resilience

Workforce	Baseline	COVID-19 First Wave	Vaccine + Delta	Omicron + Endemic	Post-COVID
Overall	1.000	0.940	0.842	0.795	0.786
RN	1.000	1.062	0.973	0.894	0.964
LPN/LVN	1.000	0.959	0.881	0.830	0.797
CNA	1.000	0.930	0.831	0.800	0.793

Figure S1-1. Weekly Mean Nursing Workforce by Employment Type Across Six States, 2020–2024

Weekly mean numbers of facility-employed, contract, and total nursing staff per skilled nursing facility (SNF) for the overall nursing workforce and by nurse type (RN, LPN/LVN, and CNA) across six study states, 2020–2024.



Note: Vertical dashed lines indicate transitions between the five study periods: Baseline (2020w14–2020w17), COVID-19 First Wave, Vaccine + Delta, Omicron + Endemic Management, and Post-COVID Management. Results are based on facilities reporting staffing data for ≥221 weeks (89.8%) between 2020 Q2 and 2024 Q4. Total workforce equals the sum of facility-employed and contract staff.

Figure S1-2. Weekly Mean Nursing Workforce by Employment Type in California and New York, 2020–2024

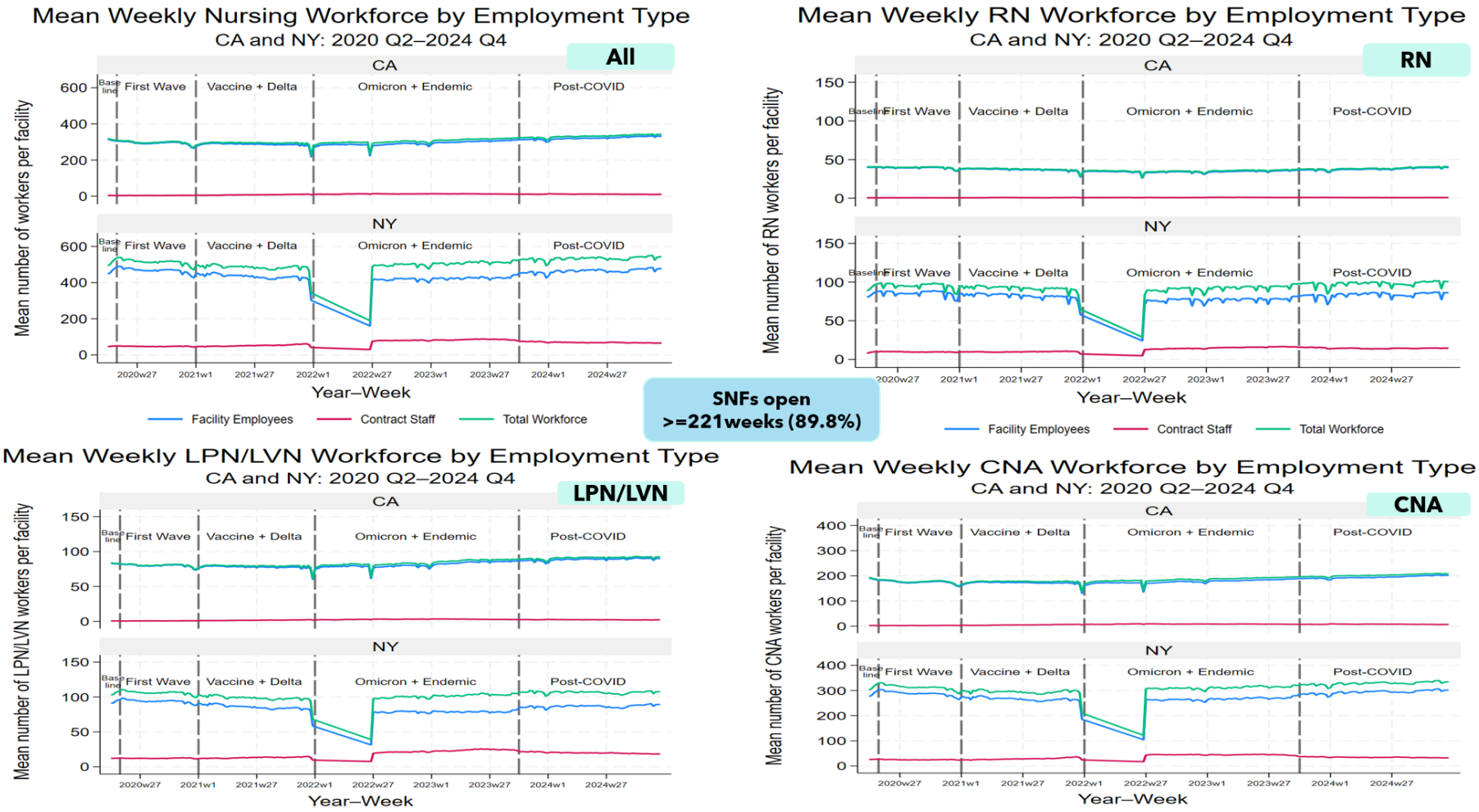


Figure S1-3. Weekly Mean Nursing Workforce by Employment Type in Florida and Virginia, 2020–2024

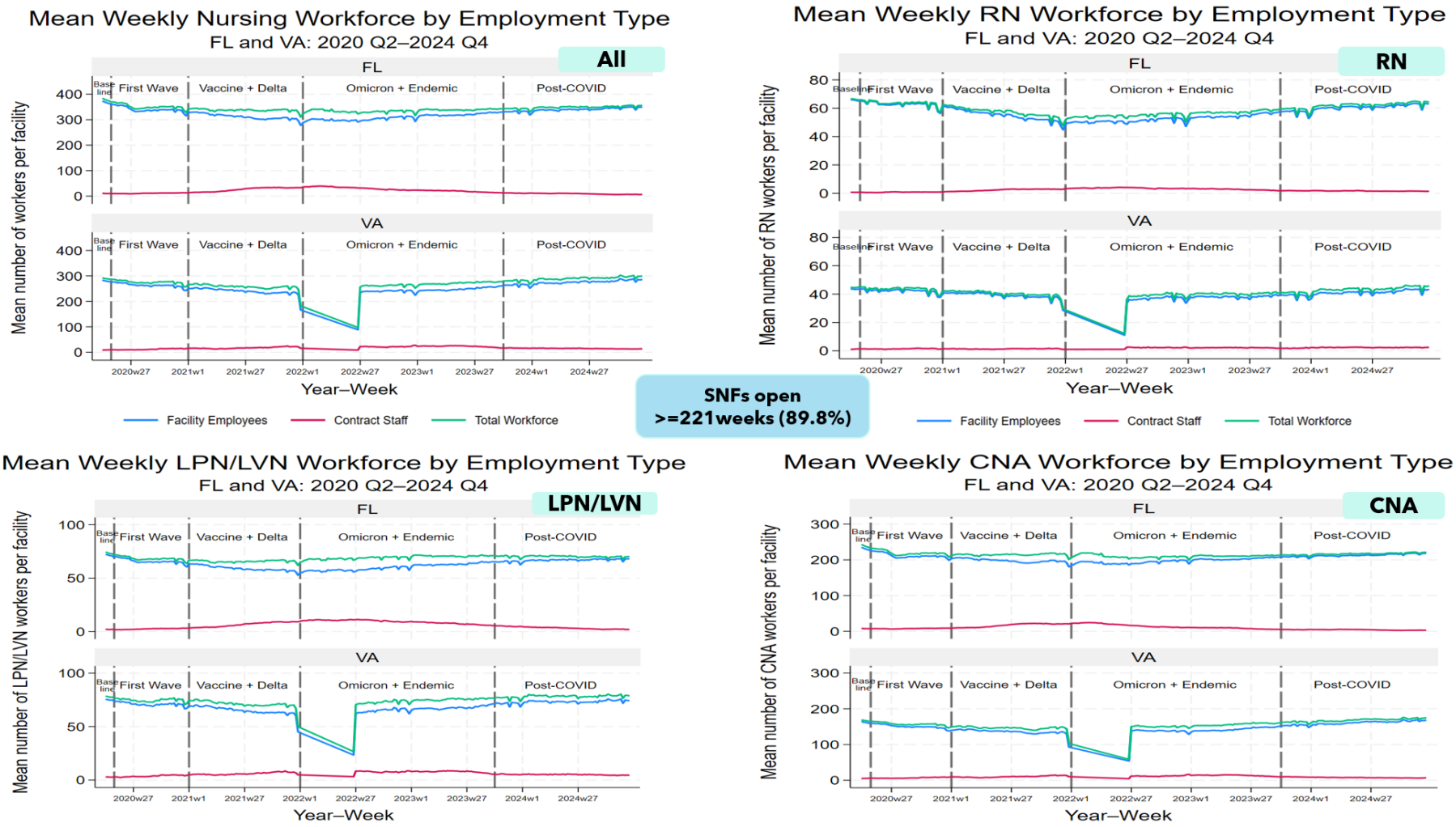


Figure S1-4. Weekly Mean Nursing Workforce by Employment Type in Missouri and Texas, 2020–2024

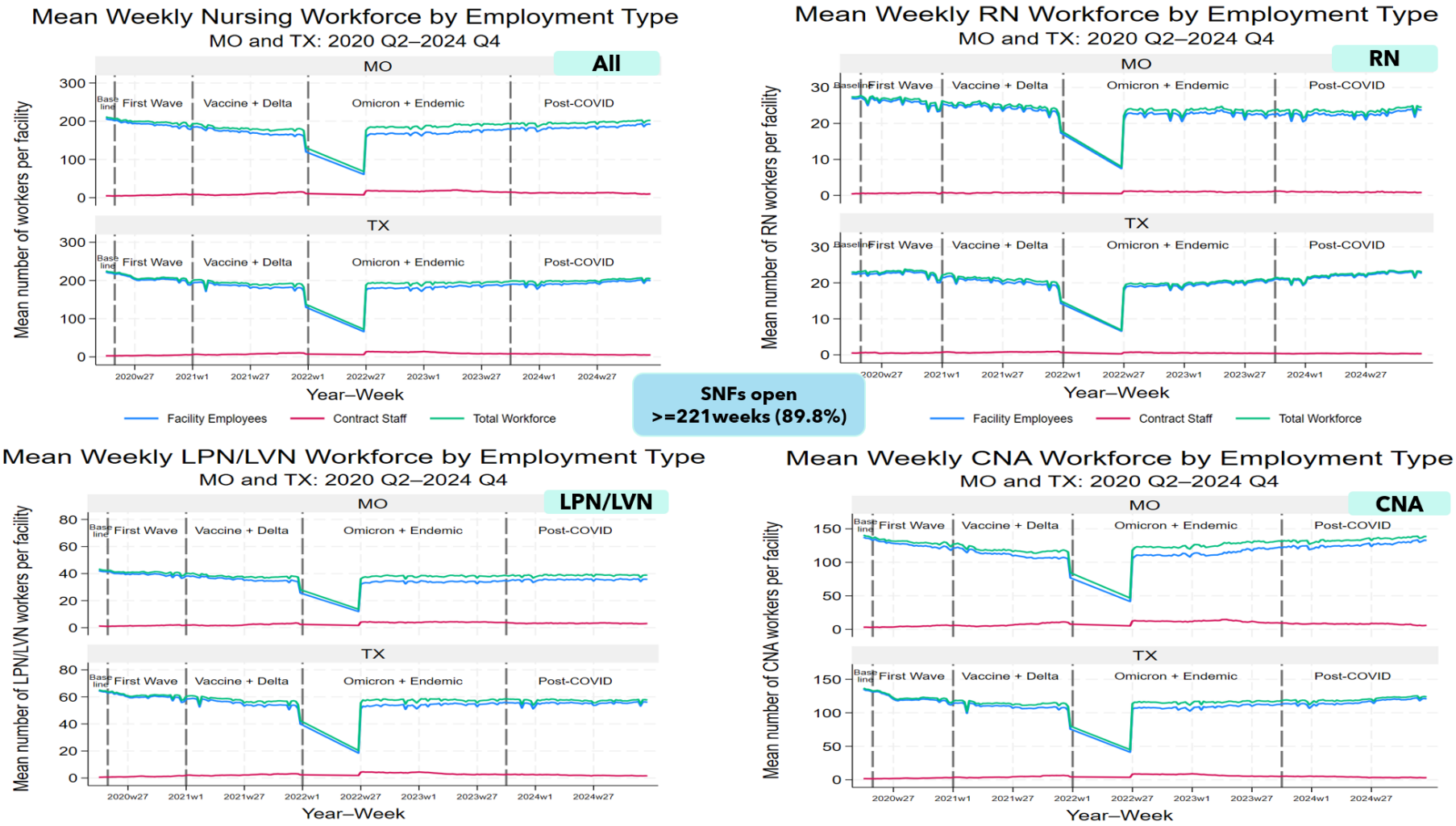


Figure S2-1. Weekly Workforce Resilience by Nurse Type Under Fixed- and Growth-Adjusted Baseline Assumptions

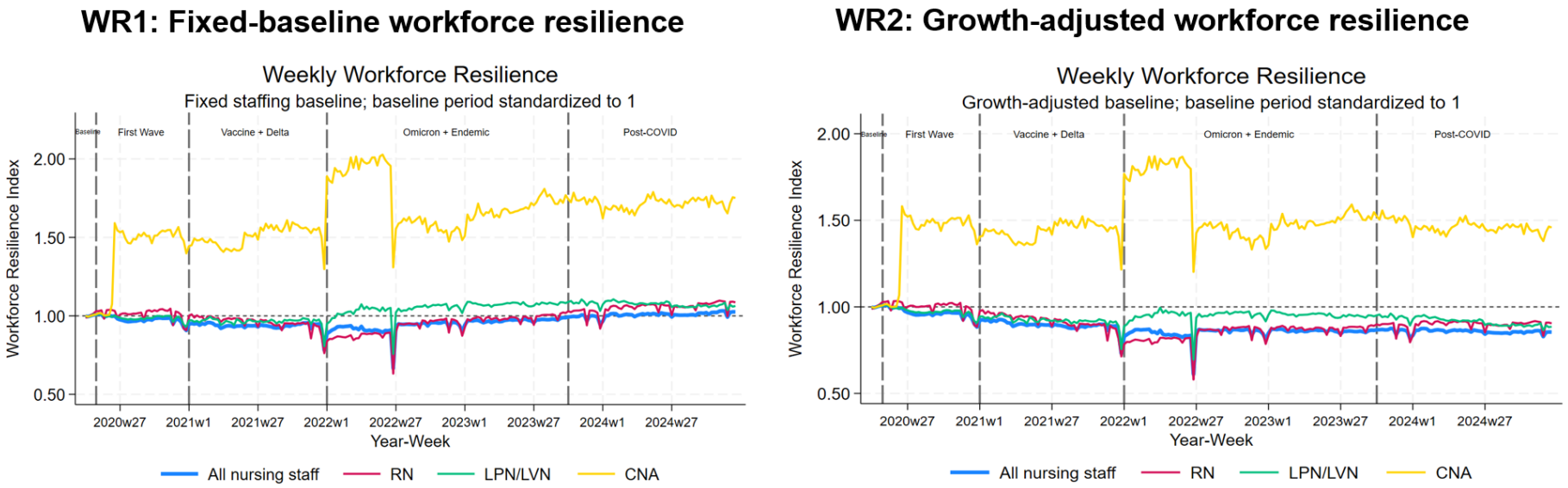


Figure S2-2. State-Level Weekly Total Nursing Workforce Resilience Under Fixed- and Growth-Adjusted Baseline Models, 2020–2024

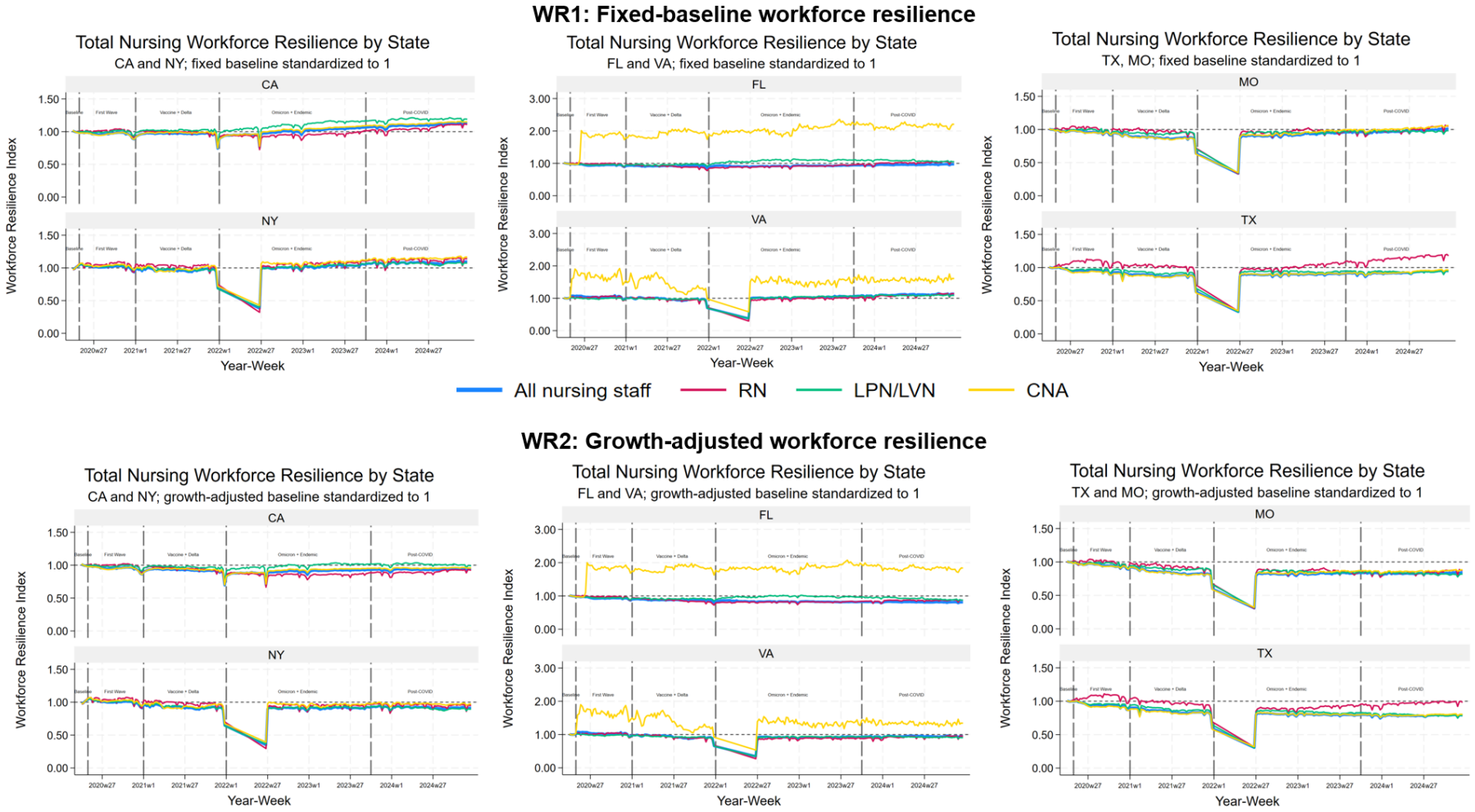


Figure S2-3. State-Level Facility-Employed Workforce Resilience: Weekly Trajectories Under Fixed- and Growth-Adjusted Baseline Models, 2020–2024

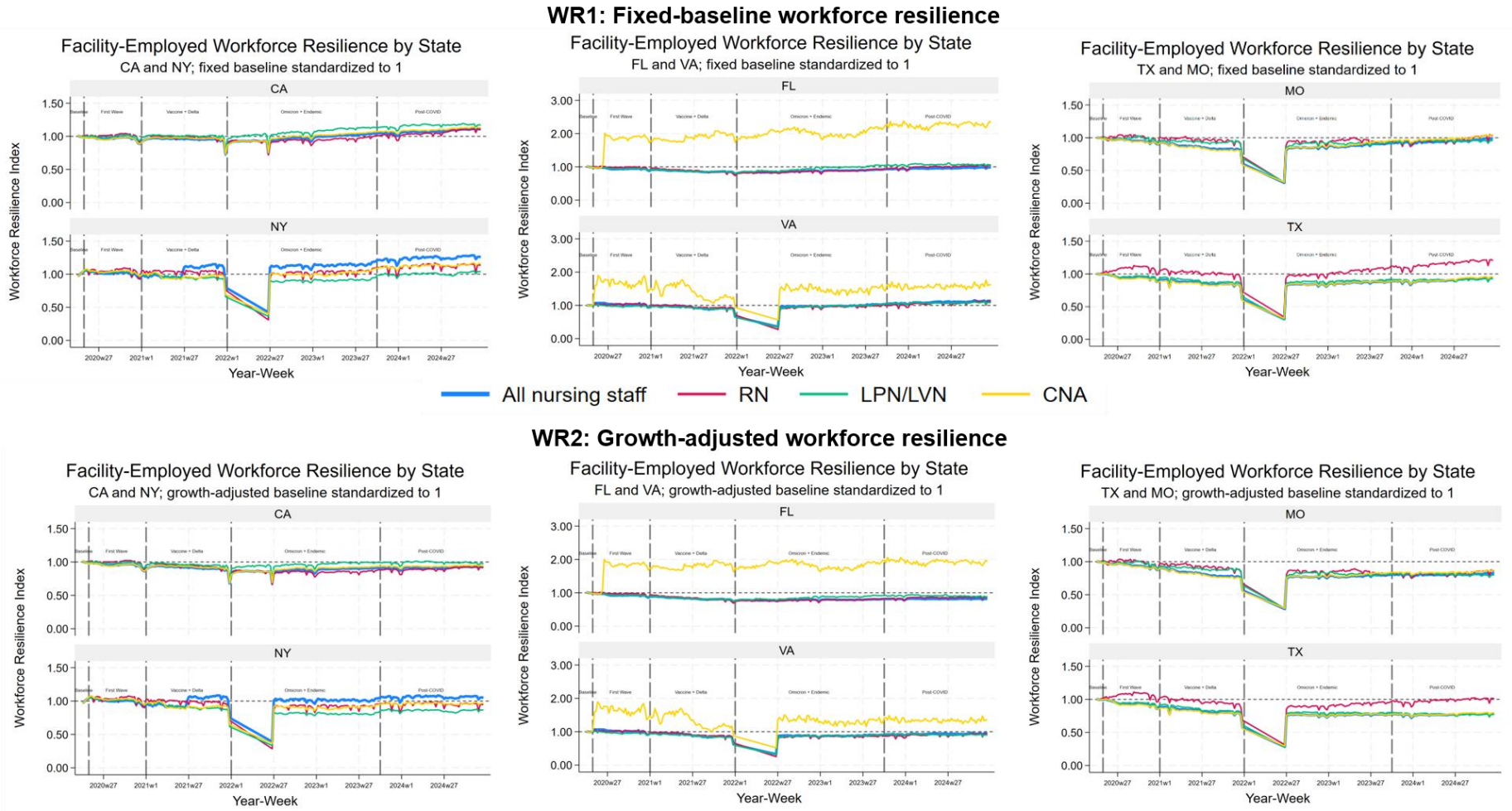


Figure S2-4. State-Level Contract/Agency Workforce Resilience: Weekly Trajectories Under Fixed- and Growth-Adjusted Baseline Models, 2020–2024

