# Hospital Discharge and Readmissions Before and During the COVID-19 Pandemic for California Acute Stroke Inpatients

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*Background:* Acute stroke therapy and rehabilitation declined during the COVID-19 pandemic. We characterized changes in acute stroke disposition and readmissions during the pandemic. *Methods:* We used the California State Inpatient Database in this retrospective observational study of ischemic and hemorrhagic stroke. We compared discharge disposition across a pre-pandemic period (January 2019 to February 2020) to a pandemic period (March to December 2020) using cumulative incidence functions (CIF), and re-admission rates using chi-squared. *Results:* There were 63,120 and 40,003 stroke hospitalizations in the pre-pandemic and pandemic periods, respectively. Pre-pandemic, the most common disposition was home [46%], followed by skilled nursing facility (SNF) [23%], and acute rehabilitation [13%]. During the pandemic, there were more home discharges [51%, subdistribution hazard ratio 1.17, 95% CI 1.15-1.19], decreased SNF discharges [17%, subdistribution hazard ratio 0.70, 95% CI 0.68-0.72], and acute rehabilitation discharges were unchanged [CIF, $p<0.001$]. Home discharges increased with increasing age, with an increase of 8.2% for those ≥85 years. SNF discharges decreased in a similar distribution by age. Thirty-day readmission rates were 12.7 per 100 hospitalizations pre-pandemic compared to 11.6 per 100 hospitalizations during the pandemic [$p<0.001$]. Home discharge readmission rates were unchanged between periods. Readmission rates for discharges to SNF (18.4 vs. 16.7 per 100 hospitalizations, $p=0.003$) and acute rehabilitation decreased (11.3 vs. 10.1 per 100 hospitalizations, $p=0.034$). *Conclusions:* During the pandemic a greater proportion of patients were discharged home, with no change in readmission rates. Research is needed to evaluate the impact on quality and financing of post-hospital stroke care.

**Keywords:** Acute stroke—ischemic stroke—subarachnoid hemorrhage—intracerebral hemorrhage—COVID-19 pandemic—hospital discharge—readmissions—rehabilitation



## Introduction

Stroke is a leading cause of death and disability in the United States, with approximately 795,000 new strokes occurring annually, including acute ischemic stroke (AIS), intracerebral hemorrhage (ICH), and subarachnoid hemorrhage (SAH).[1] The Coronavirus Disease 2019 (COVID-19) pandemic has impacted all levels of care for stroke patients, such as delays in initial presentation, reduction in acute therapies, limitations of in-patient resources, delays or lack of initiation of secondary stroke prevention therapy, and limitations in rehabilitation services after hospital discharge. Published data regarding stroke

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presentations and outcomes during the COVID-19 pandemic have been varied.[2-6]

We sought to characterize differences in acute stroke inpatient admissions and disposition during the COVID-19 pandemic compared to the time period preceding the pandemic by performing a retrospective review of acute stroke admissions in the state of California. Our hypothesis was that an increasing frequency of home discharges took place during the pandemic, with no change in readmission rates among these patients.

## Methods

We used the California State Inpatient Database (SID) from the Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project to perform a retrospective longitudinal observational study examining the impact of the COVID-19 pandemic on acute inpatient care. The University of Rochester Medical Center Research Subjects Review Board approved the study.

### *Data Source*

The California SID includes a complete enumeration of all-payer administrative claims data on hospital discharges from all non-federal acute care hospitals within the state of California in each year. The California SID is capable of tracking patients longitudinally, across hospitals admissions to understand interhospital transfers and hospital readmissions. The California SID also has the capability of linking American Hospital Association data to further understand hospital characteristics. Other available data include patient demographics (age, sex, race, insurance payor, median household income for ZIP), primary and secondary diagnoses (ICD-10-CM codes), and detailed disposition. Race and ethnicity in California SID are directly reported by HCUP partner organizations and consolidated by HCUP to uniform values which combined race and ethnicity into a single variable. In HCUP methodology, ethnicity took precedence over race. For example, if a patient was identified as Black and Hispanic, they were assigned to Hispanic. Additionally, HCUP consolidates some race categories (i.e., Asian and Native Hawaiian or Pacific Islander). We used up to 36 secondary diagnoses to calculate the Elixhauser comorbidity index calculated from up to 31 categories of disease for each admission with the v2021.1 AHRQ Elixhauser Comorbidity Software.[7] Comorbidities relevant to stroke pathology (hypertension, diabetes mellitus, obesity, heart failure, and atrial fibrillation) were separately delineated.

### *Timeframe*

The California SID contains data for hospital discharges which occurred between January 1st and December 31st of a calendar year. Admission and discharge month and year are known for all patients contained within the database. The specific date of admission and discharge is not known. The timeframe for the study was January 2019 to December 2020. Individuals admitted within the timeframe of the study but discharged after December 2020 are not contained within these data. For the purpose of this study, the beginning of the COVID-19 pandemic was considered to be March 2020. Given the first confirmed case of community transmission in California was identified on February 26, 2020,[8] followed by a revision of US Centers for Disease Control and Prevention criteria for testing patients suspected of having COVID-19 infection on February 28, 2020,[9] which led to increased use of testing in California. Furthermore, a State of Emergency was declared in California on March 4, 2020.[10] Since our dataset is limited to granularity by admission month, we used March 1, 2020 as the beginning of the pandemic period. Assignment to the pre-pandemic and pandemic period were performed using the variable for admission month.

### *Inclusion and Exclusion Criteria*

We selected acute care hospitalizations for adult (age ≥18 years) patients admitted from January 1, 2019 to December 31, 2020 with acute ischemic stroke, intracerebral hemorrhage, or subarachnoid hemorrhage in California using ICD-10-CM primary diagnosis codes I63, I61, and I60, respectively. Observations with missing data for key variables (e.g., sex, race and ethnicity, and disposition) were excluded. Due to the need to identify single patients, this study required an encrypted patient identifier, which allows for the tracking of patients across multiple hospitalizations while adhering to privacy regulations. Observations with missing encrypted patient identifiers were excluded [**Supplement Figure S1**]. For stroke hospitalizations, there were no observations with missing data for other covariates analyzed within the study.

### *Outcome Measures*

We defined the pre-pandemic period as January 1, 2019 to February 29, 2020, and the pandemic period as March 1, 2020 to December 31, 2020. We classified discharge disposition into home, skilled nursing facility (SNF), acute rehabilitation including long-term acute care hospital (LTCH), interhospital transfer, death, and other. We examined disposition during the pre-pandemic and pandemic periods, stratified by age, race, and sex descriptively. We additionally examined readmission rates during pre-pandemic and pandemic periods, stratified by discharge disposition. We defined a readmission as any admission within 30 days of index hospitalization discharge.[11] Primary etiology of readmissions was examined using AHRQ Clinical Classifications Software Refined (CCSR) diagnostic categories. We further identified

admissions related to COVID-19 using CCSR diagnosis category INF012.

### *Statistical Analysis*

We used a cumulative incidence function (CIF) for each discharge disposition to investigate disposition differences between the pre-pandemic and pandemic periods, where alternative dispositions were treated as competing risks. Fine-Gray models were used to calculate subdistribution hazard ratios adjusted for age, race and ethnicity, stroke type, Elixhauser comorbidity index, insurance payer, and median income for household ZIP.[12-14] To evaluate differences in cumulative incidence of dispositions between pre-pandemic and pandemic periods, we used the *K*-sample test statistic.[15]

We compared categorical and continuous variables before and during the pandemic period using chi-squared and Wilcoxon Rank Sum tests, respectively. We performed multivariable logistic regression analysis predicting readmission stratified by initial hospital disposition (i.e., Home, SNF, Acute Rehab/LTCH, Transfer) controlling for age, race and ethnicity, stroke type, Elixhauser comorbidity index, insurance payer, median income for household ZIP, and length of stay of the index hospitalization in days. Individuals who died during the initial hospitalization were no longer at risk for readmission and therefore excluded from readmission analyses.

CIFs and Fine-Gray subdistribution hazard ratios were computed using the cmprsk v2.2-11 library in R version 4.1.2 (Vienna, Austria). All other analyses were performed using Stata version 16.0 (College Station, TX). Statistical significance was two-sided and set *a priori* at $p<0.05$.

## Results

There were 121,119 adult acute care stroke hospitalizations admitted across 347 hospitals before and during the pandemic in California. After applying our inclusion/exclusion criteria, there were 103,123 acute stroke admissions in our primary analysis and 11,697 readmissions within 30 days included in our readmissions analysis [**Supplement Figure S1**]. There were 63,120 stroke hospitalizations occurring in the pre-pandemic period and 40,003 stroke hospitalizations during the pandemic period. There were 51,064 (81%) ischemic stroke, 9,243 (15%) ICH, and 2,813 (4%) SAH during the pre-pandemic and 32,522 (81%) ischemic stroke, 5,839 (15%) ICH, and 1,642 (4%) SAH during the pandemic. Age, sex, race and ethnicity, insurance, Elixhauser Comorbidity Index, and median household income were similar in the pre-pandemic and pandemic periods (Table 1). Notable differences included age ≥85 years (18.5% pre-pandemic vs. 17.6% pandemic, $p<0.05$), Elixhauser comorbidity index ≥5 (42.4% pre-pandemic vs 44.6% pandemic, $p<0.05$), and Medicare insurance payer (63.4% pre-pandemic vs. 62.6% pandemic, $p<0.05$).

### *Disposition*

In the pre-pandemic period, most admissions resulted in discharge to home (46%), followed by SNF (23%), and acute rehabilitation or LTCH (13%) (Fig. 1**A**). During the pandemic, the distribution of dispositions shifted with more discharges home (51%) and less to SNF (17%), while discharges to acute rehabilitation or LTCH remained the same.

The increase in discharges to home, and decrease in discharge to SNF, were driven primarily by older age groups (Table 2). For example, 59% of 18−54 year old admissions resulted in discharge home prior to the pandemic and 61% were discharged home during the pandemic, compared to 31% of ≥85-year-old admissions resulting in discharge home before the pandemic and 39% during the pandemic (Fig. 1**B**). There were no differences in sex and race and ethnicity for discharges before and during the pandemic (Table 2).

To account for competing risks in discharge disposition, we demonstrate a cumulative incidence function and calculate subdistribution hazard ratios [SHR] adjusted for covariates showing an increase in discharge to home (SHR 1.17, 95% CI 1.15-1.19) and decline in discharge to SNF (SHR 0.70, 95% CI 0.68-0.72) and interhospital transfer (SHR 0.88, 95% CI 0.83-0.93) (CIF, $p<0.001$ for all) (Fig. 2 **and Supplement Table S1**).

### *Readmissions*

The overall 30-day hospital readmission rate for acute stroke before the pandemic was 12.7 per 100 hospitalizations compared to 11.6 per 100 hospitalizations during the pandemic. The primary diagnosis for 30-day hospital readmissions following acute stroke before and during the pandemic are shown in **Supplement Figure S2**. The most common reasons for readmission following acute stroke included ischemic stroke, sepsis, hemorrhagic stroke, and renal disorders. Sepsis was the only primary diagnosis for readmission which increased in the pandemic period compared to pre-pandemic ($p=0.01$). Among all 30-day hospital readmission, ~2% were readmitted with a primary diagnosis of COVID-19. COVID-19 readmission was most common among discharges to SNF.

The readmission rate for those discharged to home (11.0 vs. 10.9 per 100 hospitalizations, adjusted Odds Ratio [aOR] 0.95, 95% CI 0.90-1.01) and interhospital transfer (11.8 vs. 11.7 per 100 hospitalizations, aOR 0.99, 95% CI 0.82-1.18) were unchanged (Fig. 3). However, the readmission rate for those discharged to SNF (18.4 vs. 16.7 per 100 hospitalizations, aOR 0.88, 95% CI 0.81-0.95) and acute rehabilitation or LTCH (11.3 vs. 10.1 per 100 hospitalizations, aOR 0.87, 95% CI 0.78-0.97) decreased during the pandemic compared to before the pandemic [Figure 3]. In an unadjusted subgroup analysis, 30-day

**Table 1.** *Acute stroke hospitalization characteristics before and during the COVID-19 pandemic*

| Hospitalization Characteristics | Pre-Pandemic* | | During Pandemic*,† | |
|---|---|---|---|---|
| Age in yrs, n (%) | | | | |
| 18-54 | 9,130 | (14.5) | 5,877 | (14.7) |
| 55-64 | 12,165 | (19.3) | 8,013 | (20.0) |
| 65-74 | 15,227 | (24.1) | 9,690 | (24.2) |
| 75-84 | 14,898 | (23.6) | 9,400 | (23.5) |
| ≥85 | 11,700 | (18.5) | 7,023 | (17.6) |
| Race and Ethnicity, n (%) | | | | |
| Asian or Pacific Islander | 8,206 | (13.0) | 5,064 | (12.7) |
| Black | 6,499 | (10.3) | 4,043 | (10.1) |
| Hispanic | 14,507 | (23.0) | 9,257 | (23.1) |
| White | 30,804 | (48.8) | 19,415 | (48.5) |
| Other‡ | 3,104 | (4.9) | 2,224 | (5.6) |
| Sex, n (%) | | | | |
| Female | 30,341 | (48.1) | 19,049 | (47.6) |
| Male | 32,779 | (51.9) | 20,954 | (52.4) |
| Stroke Type, n (%) | | | | |
| Acute Ischemic | 51,064 | (80.9) | 32,522 | (81.3) |
| ICH | 9,243 | (14.6) | 5,839 | (14.6) |
| SAH | 2,813 | (4.5) | 1,642 | (4.1) |
| Elixhauser Comorbidity Index§, n (%) | | | | |
| 0-1 | 4,358 | (6.9) | 2,570 | (6.4) |
| 2 | 8,295 | (13.1) | 4,843 | (12.1) |
| 3 | 11,838 | (18.8) | 7,251 | (18.1) |
| 4 | 11,850 | (18.8) | 7,506 | (18.8) |
| ≥5 | 26,779 | (42.4) | 17,833 | (44.6) |
| Comorbidities, n (%) | | | | |
| Hypertension | 53,950 | (85.5) | 34,111 | (85.3) |
| Diabetes mellitus | 24,883 | (39.4) | 15,916 | (39.8) |
| Obesity | 8,800 | (13.9) | 6,035 | (15.1) |
| Heart failure | 11,569 | (18.3) | 7,522 | (18.8) |
| Atrial fibrillation | 16,124 | (25.5) | 10,206 | (25.5) |
| Insurance Payer, n (%) | | | | |
| Medicare | 40,032 | (63.4) | 25,050 | (62.6) |
| Private | 11,123 | (17.6) | 7,071 | (17.7) |
| Medicaid | 9,762 | (15.5) | 6,473 | (16.2) |
| Other‖ | 2,195 | (3.5) | 1,405 | (3.5) |
| Household Income#, n (%) | | | | |
| 1st Quartile | 16,814 | (27.4) | 10,333 | (25.8) |
| 2nd Quartile | 15,384 | (25.0) | 10,056 | (25.1) |
| 3rd Quartile | 15,675 | (25.5) | 9,652 | (24.1) |
| 4th Quartile | 13,571 | (22.1) | 8,573 | (21.4) |
| Length of Stay, mean (SD) | 5.44 | (7.54) | 5.22 | (6.89) |

Abbreviations: ICH − intracerebral hemorrhage; SAH − subarachnoid hemorrhage.

*The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020.

†P-values were excluded from the table as all comparisons using the chi-squared test were statistically significant with $p<0.001$.

‡"Other" race and ethnicity includes individuals not categorized by the California State Inpatient Database, which include those identified as multiple races, other race not classified, or unknown. Individuals identified as Native American and Alaskan Native are included within this group for confidentiality reasons due to fewer than 10 records within the sample.

§Elixhauser comorbidity index is a measure of comorbidity for use with large administrative datasets with higher numbers representing the presence of more comorbidities, accounting for up to 31 categories of disease.

‖"Other" insurance payer includes self-pay, no charge, Worker's Compensation, Civilian Health and Medical Program of the Uniformed Services or Veterans Affairs, Title V, and other government programs.

#Household income quartiles were assigned based on the median income of the patient's ZIP Code, where the first quartile is the lowest income and fourth quartile is the highest income.

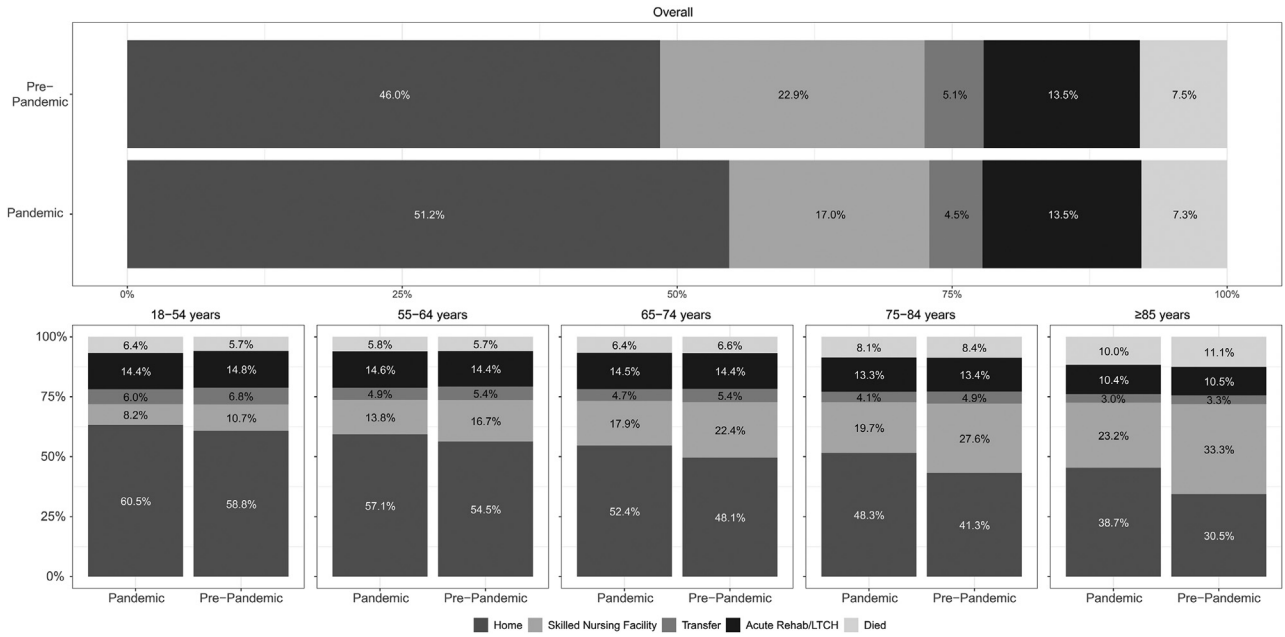


**Fig. 1.** ***Acute stroke discharge disposition before and during the COVID-19 pandemic.***

Abbreviations: LTCH − long-term acute care hospital

Percentages of discharges to each disposition among discharges within the period specified for (A) all stroke patients and (B) by age group. The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020.

**Table 2.** *Changes in acute stroke discharge disposition during the COVID-19 pandemic by age, race, and sex*

| | Home | SNF | Transfer | Acute Rehab/LTCH | Died | Other* |
|---|---|---|---|---|---|---|
| | **Percent Change Disposition Within Group,† Pandemic vs. Pre-Pandemic‡** | | | | | |
| Overall | +5.1 | -5.8 | -0.6 | +0.02$^{NS}$ | -0.2$^{NS}$ | +1.5 |
| Age, yrs | | | | | | |
| 18-54 | +1.7 | -2.5 | -0.8$^{NS}$ | -0.4$^{NS}$ | +0.7$^{NS}$ | +1.2 |
| 55-64 | +2.6 | -2.9 | -0.5$^{NS}$ | +0.2$^{NS}$ | +0.1$^{NS}$ | +0.6 |
| 65-74 | +4.3 | -4.5 | -0.7 | +0.1$^{NS}$ | -0.2$^{NS}$ | +1.0 |
| 75-84 | +7.0 | -7.9 | -0.8 | -0.1$^{NS}$ | -0.3$^{NS}$ | +2.0 |
| ≥85 | +8.2 | -10.1 | -0.3$^{NS}$ | -0.1$^{NS}$ | -1.1 | +3.4 |
| Race and Ethnicity | | | | | | |
| Asian or Pacific Islander | +5.3 | -7.6 | -0.4$^{NS}$ | -0.2$^{NS}$ | +0.9$^{NS}$ | +2.0 |
| Black | +5.3 | -5.5 | -0.7$^{NS}$ | -0.9$^{NS}$ | +0.4$^{NS}$ | +1.4 |
| Hispanic | +6.3 | -6.5 | -0.8 | -0.1$^{NS}$ | -0.2$^{NS}$ | +1.3 |
| White | +4.7 | -5.3 | -0.4 | +0.5$^{NS}$ | -0.7 | +1.4 |
| Other§ | +3.6 | -3.5 | -1.0$^{NS}$ | -0.6$^{NS}$ | -0.3$^{NS}$ | +1.8 |
| Sex | | | | | | |
| Female | +6.5 | -7.0 | -0.6 | -0.6 | -0.2$^{NS}$ | +1.9 |
| Male | +3.9 | -4.7 | -0.6 | +0.5$^{NS}$ | -0.3$^{NS}$ | +1.1 |

Abbreviations: SNF − skilled nursing facility; LTCH − long-term acute care hospital

NS = not significant

*"Other" disposition category includes those discharged to hospice care or those who left against medical advice.

†Each cell represents the absolute percent change in the share of discharge disposition for each detailed disposition option (e.g., home, SNF, transfer). For example, among patients 18-54 years of age there were 58.8% discharged home in the pre-pandemic period compared to 60.5% discharged home in the pandemic period, or +1.7% absolute percent change. All absolute percent changes are statistically significant $p<0.05$ unless indicated.

‡The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020.

§"Other" race and ethnicity includes individuals not categorized by the California State Inpatient Database, which include those identified as multiple races, other race not classified, or unknown. Individuals identified as Native American and Alaskan Native are included within this group for confidentiality reasons due to fewer than 10 records within the sample.

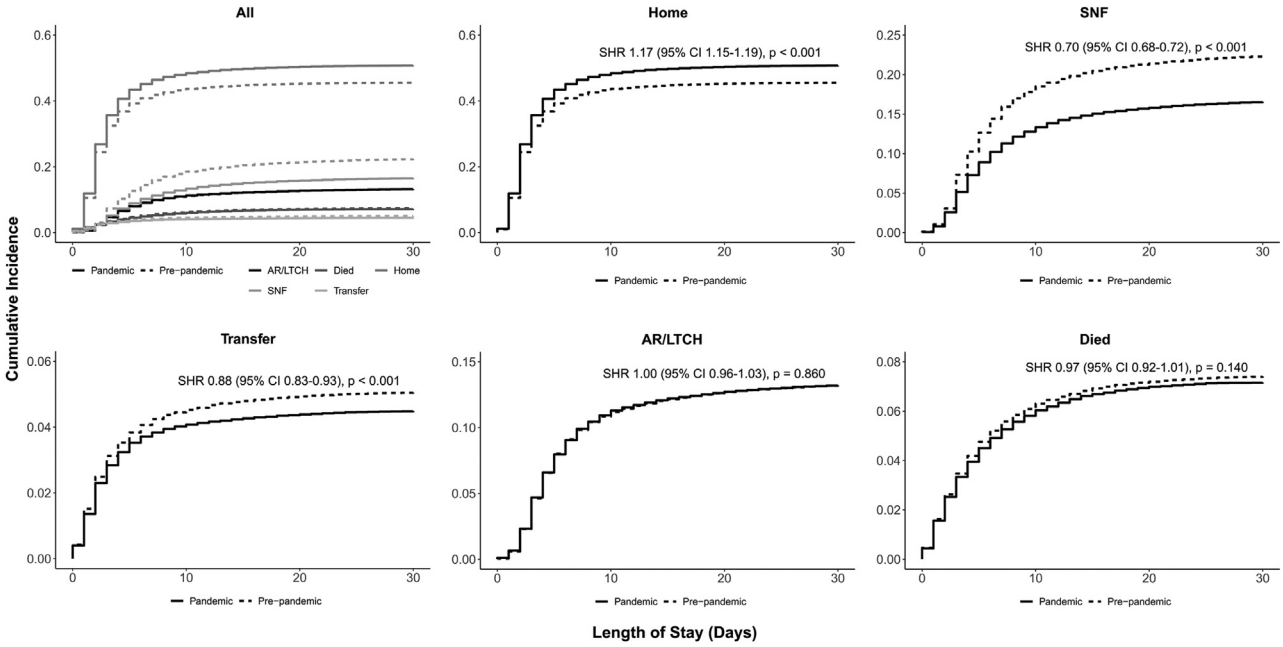


**Fig. 2.** ***Cumulative incidence for acute stroke disposition before and during the COVID-19 pandemic.***

Abbreviations: AR/LTCH – Acute rehabilitation/long-term acute care hospital; SNF – skilled nursing facility

Cumulative incidence functions (CIF) representing incidence of disposition as a function of length of stay, accounting for each possible disposition as a competing risk. Length of stay was truncated at 30 days for visualization purposes only. The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020. CIF is displayed for (A) all stroke, and by individual disposition: (B) home, (C) SNF, (D) transfer, (E) AR/LTCH, and (F) Died

readmission rates by age, race and ethnicity, and sex were unchanged with few exceptions (Table 3).

## Discussion

We performed a retrospective observational analysis examining the impact of the COVID-19 pandemic on disposition following an inpatient admission for acute stroke. We found an overall decrease in acute stroke admissions during the pandemic, and an increase in home discharges and corresponding decrease in discharges to SNF. Thirty-day readmission rates were not different for patients discharged home, while there was a decrease in 30-day readmission rates for patients discharged to SNF and acute rehabilitation or LTCH.

The incidence of stroke hospitalizations in California during the pandemic decreased compared to the pre-pandemic period, with 4,509 stroke admissions per month pre-pandemic and 4,000 stroke admissions per month during the pandemic. This decrease in stroke presentations is consistent with previous publications.[3,4,6,16,17] Furthermore, the pandemic may be marked by more medically complex patients as demonstrated by greater Elixhauser comorbidity index scores. The reasons for the decrease in stroke presentations remains unclear, but potential explanations include a decrease in the number of mild stroke presentations (e.g., patients remaining at home in an attempt to avoid COVID-19 exposure in the hospital), delays in presentation of major strokes leading to death outside the hospital, and missed stroke diagnoses. Mild stroke presentations have been reported to be lower during the pandemic lockdown period.[4,16]

During the pandemic period, there was a significant increase in the frequency of patients discharged home, and corresponding decrease in the frequency of patients discharged to SNF. This change in discharge practice patterns was driven by older adults; however, shifts toward home discharge were consistent across sex, race and ethnicity subgroups. This increase in the rate of discharge to home is particularly notable given the higher complexity of stroke patients admitted in the pandemic period, as measured by Elixhauser index. Limited data is published regarding changes in stroke discharge disposition during the pandemic. One small study found no significant difference in disposition.[3] Two recent studies found patients admitted with COVID-19 and acute ischemic stroke were more likely to have discharge destination other than home.[18,19] However, the overall rate of acute ischemic stroke in COVID-19 patients is relatively low; approximately 1%.[19] These studies did not specifically examine discharge destinations for the stroke population during the pandemic period.

Potential explanations for a shift toward home discharges following an inpatient admission for stroke include[1] decreased availability of SNF beds during the pandemic,[2] patient preferences for home discharge to

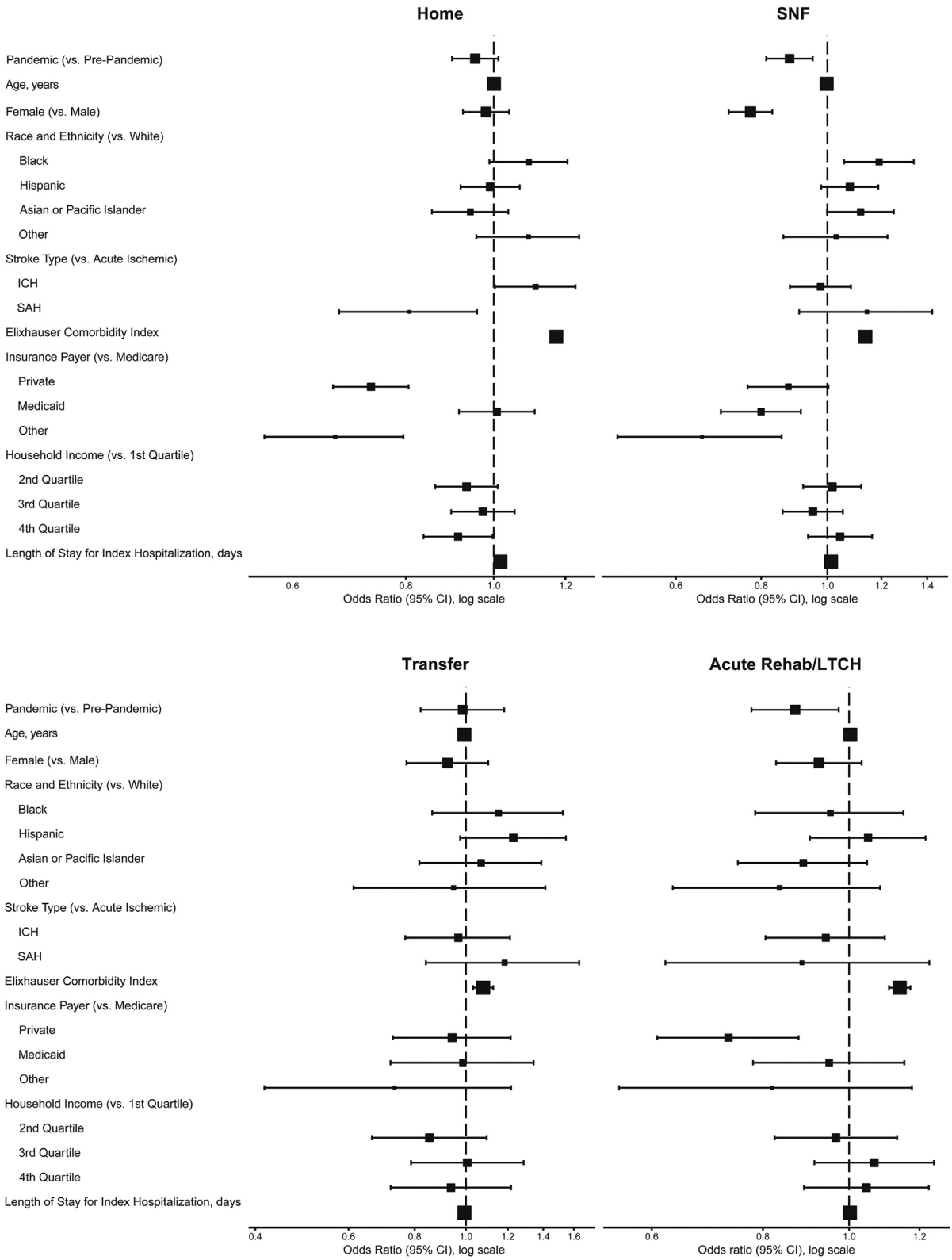


**Fig. 3.** ***Multivariate logistic regression predicting odds of readmission within 30 days of index hospitalization discharge.***

Abbreviations: SNF – skilled nursing facility; LTCH – long-term acute care hospital; ICH – intracerebral hemorrhage; SAH – subarachnoid hemorrhage

Home, SNF, Transfer, Acute Rehab/LTCH indicate the discharge disposition for the index acute stroke hospitalization. For example, acute stroke patients discharged to SNF during the pandemic period compared to pre-pandemic had lower odds of being readmitted within 30 days following discharge, while those discharged to home during the pandemic compared to pre-pandemic had no difference in odds of 30-day readmission. The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020.

**Table 3.** *Changes in acute stroke readmission rates during the COVID-19 pandemic by age, race, and sex*

| | Home | | SNF | | Transfer | | Acute Rehab/LTCH | | Other* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Pandemic | Pandemic† | Pre-Pandemic | Pandemic† | Pre-Pandemic | Pandemic† | Pre-Pandemic | Pandemic† | Pre-Pandemic | Pandemic† |
| | *Readmission Rate Per 100 Hospitalizations*‡ | | | | | | | | | |
| Age (years) | | | | | | | | | | |
| 18-54 | 10.0 | 9.4 | 18.3 | 15.5 | 11.9 | 12.1 | 9.3 | 9.3 | 19.6 | 18.7 |
| 55-64 | 10.2 | 10.2 | 17.8 | 18.7 | 12.5 | 14.0 | 10.2 | 8.1 | 16.0 | 16.1 |
| 65-74 | 10.8 | 10.8 | 19.4 | 17.1**S** | 11.7 | 12.9 | 10.2 | 10.8 | 9.6 | 7.0 |
| 75-84 | 11.9 | 12.0 | 20.2 | 18.0**S** | 11.0 | 9.3 | 13.4 | 11.9 | 4.4 | 4.3 |
| ≥85 | 12.8 | 12.3 | 16.0 | 13.9 | 12.3 | 8.5 | 13.4 | 10.0**S** | 1.7 | 1.2 |
| Race and Ethnicity | | | | | | | | | | |
| Asian or Pacific Islander | 9.6 | 10.2 | 18.8 | 16.5 | 12.4 | 9.6 | 9.9 | 8.4 | 4.1 | 3.4 |
| Black | 12.9 | 12.6 | 21.2 | 19.5 | 14.6 | 10.9 | 10.6 | 10.9 | 15.3 | 12.4 |
| Hispanic | 10.7 | 10.5 | 19.1 | 17.3 | 12.7 | 14.3 | 12.1 | 9.9 | 7.1 | 9.0 |
| White | 10.9 | 10.8 | 17.4 | 15.8 | 10.7 | 11.2 | 11.8 | 10.6 | 6.0 | 4.8 |
| Other§ | 12.1 | 12.0 | 18.1 | 17.3 | 9.6 | 12.5 | 8.9 | 9.8 | 8.4 | 8.1 |
| Sex | | | | | | | | | | |
| Female | 11.2 | 11.2 | 16.6 | 15.2 | 11.7 | 10.5 | 11.0 | 10.1 | 4.7 | 5.1 |
| Male | 10.8 | 10.6 | 20.5 | 18.2**S** | 12.0 | 12.6 | 11.5 | 10.1 | 9.6 | 7.9 |

Abbreviations: SNF − skilled nursing facility; LTCH − long-term acute care hospital; s = significant to $p<0.05$

*"Other" disposition category includes those discharged to hospice care or those who left against medical advice.

†The pre-pandemic period is from January 1, 2019 to February 29, 2020 and the pandemic period is March 1, 2020 to December 31, 2020.

‡Each cell represents the 30-day readmission rate for index acute stroke hospitalizations occurring in the pre-pandemic or pandemic period. Significant change from pre-pandemic to pandemic period is marked by $^{s}$ for $p<0.05$. For example, male readmission rate following discharge to SNF was 18.2 per 100 hospitalizations during the pandemic, which was less than 20.5 per 100 hospitalizations in the pre-pandemic period.

§"Other" race and ethnicity includes individuals not categorized by the California State Inpatient Database, which include those identified as multiple races, other race not classified, or unknown. Individuals identified as Native American and Alaskan Native are included within this group for confidentiality reasons due to fewer than 10 records within the sample.

avoid exposure to COVID-19 in SNF, or[3] avoid strict visitor limitations at SNF during the pandemic period.

Despite the increased number of home discharges, 30-day readmissions for this population were unchanged compared to the pre-pandemic period. Furthermore, the rate of 30-day readmissions from SNF and acute rehabilitation or LTCH decreased. The primary readmission diagnoses were similar pre-pandemic and during the pandemic, with few exceptions. Readmissions for sepsis increased during the pandemic period which may be another marker of increased illness severity during the pandemic period as well as potential overlap with COVID-19 illness.

Our findings suggests that more patients can be discharged directly home than previously practiced, potentially without compromising quality, as measured by avoidance of 30-day readmission. This could possibly result in decreased direct healthcare costs, increased patient satisfaction, and provide support for increased insurance coverage of home and community-based services.[20] However, long-term functional outcomes in this patient population are unknown. In addition, it is possible that more patients were discharged home due to increased availability of family support during the pandemic, with family members more often acting as caregivers with shelter-in-place orders and the greater ability to work from home. Such availability of family support may wane over time as pandemic restrictions decline and fewer people work from home. Further research may focus on design and outcomes for rehabilitation at home programs for patients post-stroke.

## Limitations

Our study utilized the California SID, an administrative database. Diagnoses are based upon ICD-10 codes, and some coding errors may exist within the data. However, the sensitivity and positive predictive value of utilizing ICD-10 codes for identifying acute stroke are 99% and 93% (ischemic strokes) and 99% and 89% (hemorrhagic strokes), respectively.[21,22] Patients included in our cohort were selected based upon admission date. Individuals admitted within the timeframe of the study but discharged after December 2020 are not contained within these data. Patients admitted during the end of December 2020 or those with more prolonged hospitalizations that were discharged after December 2020 were not included in the analysis, leading to a net loss of patients admitted during the pandemic period, and potentially excluding some sicker patients with longer length of stay. Specific metrics such as stroke severity, radiographic and laboratory findings, and baseline and discharge functional status are not measured within the State Inpatient Database. Such data may provide more insight into specific findings; however, databases with these detailed clinical characteristics are limited in size. Data is limited to California inpatient admissions, which may limit generalizability to the population as a whole, especially since COVID-19 case rates varied by state. Data only capture inpatient death and therefore does not allow for the analysis of death following discharge to be considered as a competing risk with readmission. Furthermore, our analysis of 30-day readmission rates during the pandemic compared to a pre-pandemic period may be confounded by a generally higher threshold to send patients to the hospital at the height of the COVID-19 pandemic, which may skew our results in the direction of declining readmissions. Finally, we excluded 13% of acute stroke hospitalizations in our sample due to missing encrypted patient identifiers, which were needed to track patients over hospitalizations. Observations with missing patient identifiers were younger (mean age 63 vs. 70 years, $p<0.001$) and more often identified as Hispanic (42% vs. 23%, $p<0.001$) compared to those with known patient identifiers, raising the potential for bias in our results.

Despite these limitations, our study has a large number of observations in a diverse patient population that included patients with a broad mix of insurance payers, who sought care from a wide spectrum of hospital settings (e.g., large academic centers, urban community, or rural community hospitals). This allowed us to assess for potential differences in disposition and readmission for various patient characteristics across the pre-pandemic and pandemic periods.

## Conclusions

We confirmed our hypothesis that more acute stroke patients were discharged to home during the pandemic, as opposed to facility discharge, compared to the pre-pandemic period of our study. Furthermore, this shift toward home disposition did not result in increased hospital readmissions. Disruption in normal patterns of stroke care utilization by the COVID-19 pandemic may have forced health systems to address prior inefficiencies and costly care.[23,24] Further study is needed to identify changes in care patterns that arose during the pandemic, which may have resulted in unintended improvements without sacrificing the quality of care provided to stroke patients, and to better align payments policies with more cost-effective, patient-centered care.

Dr. George takes responsibility of the accuracy of the analysis, integrity of the study, and accountability for all aspects of the work.

## Author Contributions

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Interpretation of Data: Albert GP, McHugh DC, George BP, Roberts DE, Kelly AG, R Okwechime, Holloway RG

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## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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## Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jstrokecerebrovasdis.2023.107233.

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