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Comorbidity of Type 2 Diabetes and Dementia among Hospitalized Patients in Los Angeles County: Hospitalization Outcomes and Costs, 2019–2021

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Abstract: Hospitalizations for diabetes and dementia can impose a significant health and economic toll on older adults in the United States. This study sought to examine differences in hospitalization characteristics and outcomes associated with diabetes and dementia, separately and together, using 2019–2021 discharge record data from the California Department of Health Care Access and Information. The sampled group were residents of Los Angeles County who were aged 50+ at the time of the study. The multivariable linear regression analysis showed that compared to those with no diabetes or dementia, patients with diabetes alone exhibited the highest total charges, while those with comorbid diabetes and dementia exhibited lower charges ($p < 0.05$). The multinomial logistic regression found that patients with comorbid diabetes and dementia had the highest odds of having a length of stay of 7+ days (Adjusted Odds Ratio = 1.49; 95% Confidence Interval (CI) = 1.44–1.53). A matched case–control analysis revealed that comorbid diabetes and dementia were associated with significantly lower odds of hypertensive disease than diabetes alone (Matched Odds Ratio = 0.81; 95% CI = 0.67–0.97). Collectively, these results highlight the complex factors that may influence the variable hospitalization outcomes that are common occurrences in these three distinct disease profiles. Study findings suggest a need to consider these complexities when developing policies or strategies to improve hospitalization outcomes for these conditions.

Keywords: diabetes; Alzheimer's disease; dementia; hospitalization

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1. Introduction

Approximately 37 million Americans (11.3% of the United States [US] population) have diabetes [1]. The disease is the eighth leading cause of death nationwide and in 2021 alone was responsible for 103,294 deaths [2]. The vast majority (90–95%) of Americans with diabetes have type 2 diabetes, a condition that inhibits the body from processing blood sugar due to insulin resistance [3]. Type 2 diabetes (hereafter referred to as 'diabetes') most often develops in people over the age of 45; its prevalence increases with age [3,4].

In the US, more than 25% of adults over the age of 65 have diabetes [5]. This higher prevalence in this population has been attributed to age-related changes in organ function and body composition. Among older adults, diabetes has historically been associated with an increased risk of vascular complications, including coronary heart disease, stroke, diabetic kidney disease, retinopathy, and peripheral neuropathy [6]. In recent years, research has identified emerging complications affecting older adults with diabetes, such as various cancers, infections, and diseases of the liver, and dementia and cognitive impairment [6].

Dementia is an umbrella term for changes in cognition due to physiological conditions such as Alzheimer's disease, vascular dementia, and various other illnesses affecting the brain [6]. Numerous studies have found that individuals with diabetes are at an increased risk for developing dementia [6,7]. Furthermore, they have also shown that diabetics with mild cognitive impairment have an increased risk of progressing to dementia [6]. Clinical pathways that may contribute to this relationship include impaired insulin signaling, inflammation, and hypoglycemia [7].

Research has dedicated considerable attention to the burden and cost of diabetes-related hospital care with a focus on potentially avoidable hospitalizations (PAHs) for ambulatory-care-sensitive conditions. Diabetes hospitalization costs have been increasing over the past two decades, which has been attributed, in part, to PAHs for uncontrolled diabetes, short- and long-term diabetic complications, and lower extremity amputations [8]. From 2001 to 2014, the national cost of PAHs related to diabetes increased from USD 4.5 billion to USD 5.9 billion. The majority (75%) of this increase was due to a rise in diabetes-related PAHs, with the remainder being attributed to an increase in mean cost per admission.

Hospitalizations also played a significant role in driving the healthcare costs of dementia over the years [9,10]. Lin and colleagues found that in 2013 alone, the total cost of hospitalizations for Medicare beneficiaries with dementia was USD 4.7 billion [10]. They also found that nearly one in ten of these patients were hospitalized for a potentially avoidable condition, and that nearly one in five had an unplanned readmission within 30 days. A state-wide matched analysis of Medicare costs in Tennessee by Husaini and colleagues found that hospitalization costs were 14% higher among dementia patients as compared to patients without dementia; those with dementia also had a significantly higher frequency of diabetes (36% vs. 32%, $p < 0.001$) [9].

Individuals with both diabetes and dementia are known to be at an increased risk for PAHs. A 2017 study by Lin et al., which examined Medicare claims data, found that patients with dementia were more likely to have PAHs for short- and long-term diabetic complications than patients without dementia [11]. Another study by Zaslavsky et al. found that incident dementia was associated with increased rates of hospitalization among individuals with diabetes, both for diabetic complications and non-diabetic complications, such as dehydration or urinary tract infections [12]. While there is a growing body of research focused on the risk for and outcomes of PAHs among individuals with comorbid diabetes and dementia, few studies have provided in-depth comparisons of the demographic and health characteristics of patients with diabetes, with dementia, and with diabetes and dementia together. To the best of our knowledge, no studies have examined the differences in cost and duration of hospitalization and costs for individuals with these three distinct health profiles.

To address this gap in the literature, we analyzed Los Angeles County hospital discharge data from 2019 to 2021 to better understand the factors affecting hospitalizations of individuals with diabetes, with dementia, and with both conditions together (comorbidity). This study sought to (1) describe the differences in demographic and hospitalization characteristics and outcomes, including costs, between these groups; (2) examine the factors that may influence total charges and hospital length of stay; and (3) compare the odds of diabetic complications for individuals with comorbid diabetes and dementia versus those with only diabetes.

2. Materials and Methods

2.1. Data Source and Study Population

Hospitalizations were examined using patient discharge data (PDD) for the years 2019–2021 derived from the California Department of Health Care Access and Information

(HCAI) [13]. HCAI maintains non-public, limited data sets consisting of patient-level inpatient discharge data collected from all state-licensed hospitals in California. Licensed hospitals include general acute care, acute psychiatric, chemical dependency recovery, and psychiatric health facilities. PDD contains demographic, clinical, payer, and facility data for all inpatient records. HCAI datasets do not contain any direct identifiers (i.e., name, address, social security number); additional safeguards are typically implemented to ensure that dataset information could not be used to personally identify individuals (e.g., avoiding cell counts smaller than 12).

All hospitalizations of Los Angeles County residents aged 50 years and older at the time of admission were included in the present analysis (n = 1,472,688), reflecting 47% of all hospitalization records during the study period (n = 3,160,404). The analysis sample was stratified into four mutually exclusive groups based on disease status: (i) diabetes, (ii) dementia, (iii) diabetes and dementia, and (iv) no diabetes or dementia. Disease status was classified using the International Classification of Diseases, Tenth Revision, Clinical Modifications (ICD-10-CM) codes (see Supplemental Table S1) [14]. Diagnosis of diabetes and/or dementia was established based on the listing of a diabetes or dementia ICD-10-CM code as (a) the chief cause of admission of the patient for hospital care or (b) a coexisting condition at the time of admission that developed during the hospital stay, or that affected the treatment received and/or the length of stay of the hospitalization. Individuals with dementia were defined as having one of the following relevant diagnoses: Alzheimer's disease, vascular dementia, dementia in other diseases classified elsewhere, unspecified dementia, Huntington's disease, Parkinson's disease, other secondary Parkinsonism, frontotemporal dementia, Pick's disease, other frontotemporal neurocognitive disorder, senile degeneration of the brain not elsewhere classified, and/or neurocognitive disorder with Lewy bodies.

2.2. Variables

To understand the characteristics of hospitalizations by disease status, descriptive and univariate statistics were generated for the following variables: length of stay—the total number of days from admission to discharge date; total charges—the total charges for services rendered based on the hospital's full established rates, in US dollars; age; sex; race/ethnicity; year of hospital admission; disposition—the consequent arrangement or event ending the patient's stay in the hospital; type of care—the licensure of the bed occupied by the patient; expected source of payment—the entity or organization expected to pay the greatest share of the patient's bill such as Medicare or private coverage; type of admission, such as emergency or elective; and source of admission—site where the patient originated such as a non-healthcare facility of different hospital facility.

Length of stay, total charges, and age were examined as continuous variables. Race/ethnicity was categorized as White, Black, Hispanic, Asian, and Other (inclusive of Other, American Indian/Alaskan Native, Native Hawaiian or Other Pacific Islander, and Multiracial). Disposition was categorized in alignment with categories established in the Agency for Healthcare Research and Quality's Healthcare Cost & Utilization Project as routine discharge, transfer to a short-term hospital, transfer to other (inclusive of skilled nursing facilities (SNF), intermediate care facilities (ICF), and other types of facilities), home healthcare, against medical advice, and died [15]. The type of care was categorized as acute care or other types of care (inclusive of skilled nursing care/intermediate care, psychiatric care, chemical dependency recovery care, and physical rehabilitation care) for this analysis. The expected source of payment was categorized as Medicare, Medi-Cal (California's Medicaid program), private coverage, and other (inclusive of workers' compensation, county indigent programs, other government, other indigent, self-pay, or other). The type of admission was categorized as emergency, urgent, elective, or trauma. Finally, the source of admission was categorized as non-healthcare facility, clinic/physician's office, different hospital facility, SNF/ICF/assisted living facility (ALF), or other (inclusive of court/law enforcement sites, one distinct unit to another distinct unit of the same hospital, ambulatory surgery centers, hospices, and designated disaster alternate care sites). Additionally, because the study period coincided with the onset and peak of the coronavirus disease 2019 (COVID-19) pandemic, which had a significant impact on hospitalizations across the US, diagnosis of COVID-19 was also examined [16–18].

2.3. Total Charges

A multiple linear regression model was constructed for total charges incurred for all services rendered during the patient's hospitalization. To satisfy the normality assumption for linear regression modelling, the dependent variable was log-transformed, and 1 was subsequently added to stabilize the log-transformed variable to account for instances of zero values for total charges. The total charge variable was regressed on disease status, age, sex, race/ethnicity, year of hospital admission, disposition, type of care, expected source of payment, type of admission, source of admission, and COVID-19 diagnosis.

Best subsets, backwards, and stepwise selection algorithms were utilized with the Akaike information criterion (AIC), Bayesian information criterion (BIC), and adjusted R-squared noted for all approaches to determine the best-fitted model; the practical and clinical relevancy of the variables to be included were also considered. In the model building, all three algorithms selected all variables of interest for inclusion in the final model. The model was then checked for potentially influential outliers utilizing statistical measures of influence; based on the results, no observations were deleted. The normality of residuals was also assessed using a histogram overlayed with a kernel density and normal plot. Finally, homoskedasticity was assessed using the studentized residuals vs. fitted values plot. No violations of any model assumptions were detected.

Discharge records with any missing or invalid data for the log total charge variable or any of the covariates were excluded from the analysis. The total sample size included in the final linear model was $n = 1{,}450{,}843$. Parameter estimates and 95% confidence intervals (CIs) were generated, and the statistical significance threshold was set at $p < 0.05$.

2.4. Length of Stay

A multinomial logistic regression model was built for length of stay, which was categorized by quartiles: 0–1 days, 2–3 days, 4–6 days, and 7+ days. Despite the ordinal nature of the length of stay variable, it was analyzed as a non-ordered multinomial variable due to a violation of the proportional odds assumption. Length of stay was regressed on disease status, age category (50–59 years, 60–69 years, 70–79 years, 80–89 years, and 90+ years), sex, race/ethnicity, year of hospital admission, disposition, type of care, expected source of payment, type of admission, source of admission, and COVID-19 diagnosis.

Forward and backward selection algorithms were used to test variable selection. The model fit was assessed using objective functions like likelihood ratio test measures, AIC, and BIC; as with the multiple linear regression model, the practical and clinical relevancy of identified variables were also considered. In the model building, both algorithms selected all variables of interest for inclusion in the final model. Model checking included an assessment of multicollinearity by measuring Cramer's V for each pair of categorical variables. The absence of complete separation was ascertained by checking standard errors and parameter estimates for extremely large and/or infinite values. No violations of any multinomial logistic models were detected.

Discharges that had any missing or invalid data for the length of stay variable or any of the covariates were excluded from the analysis. The total sample size included in the final multinomial model was $n = 1{,}450{,}843$. Adjusted odds ratios (AORs) and 95% CIs were generated, and the statistical significance threshold was set at $p < 0.05$.

2.5. Matched Case–Control Analysis

To explore the differences in odds of diabetic complications experienced by those with comorbid diabetes and dementia compared to those with diabetes alone, a 1:4 matched, nested case–control analysis was employed. From the pool of discharge records with complete data (n = 1,450,843), cases (those with diabetes and dementia) and controls (those with diabetes alone) were selected and matched based on the year of hospital admission, sex, age, and race/ethnicity. The final matched sample size consisted of 1492 cases and 5968 controls.

Univariate and descriptive statistics for cases and controls were examined for length of stay, total charges, age, sex, race/ethnicity, year of hospital admission, dispositions, type of care, expected sources of payment (categorized as Medicare, Medi-Cal, and other), type of admission (categorized as emergency, urgent, and other), and source of admission.

Conditional logistic regression models were employed to assess the likelihood of hospitalization for five diabetic complications for cases compared to controls. Complications examined included the following: ophthalmic complications; kidney complications; neurological complications; hypertensive diseases; and lower-extremity amputations (based on ICD-10-Procedural Coding System classification; see Supplemental Table S1). Matched odds ratios (MORs) and 95% CIs were generated for each model; the statistical significance threshold was set at $p < 0.05$.

After evaluating for potential confounders, no sizable impacts to the crude MOR estimates were detected; therefore, regression models were unadjusted. Model checking included an assessment of the linearity between the log odds of the diabetic complications and age; outlier influence assessment and case-wise deletion procedures; and confirmation of the efficiency of the matching process.

All statistical analyses were conducted using SAS analytical software version 9.4 (SAS Institute Inc., Cary, NC, USA). This study was considered exempt as non-human-subject research by the Los Angeles County Department of Public Health Institutional Review Board.

3. Results

During the 3-year study period, a total of 523,987 discharges (36.7%) were indicated as having diabetes and incurred a total of USD 62.5 billion in total charges; 32,376 of these discharges listed diabetes as the chief cause of admission. A total of 115,958 (8.1%) had dementia and incurred a total of USD 11.8 billion in total charges; of these, approximately 5% (n = 5849) listed dementia as the chief cause of admission. Approximately 5.5% of patients had both (n = 78,088) diabetes and dementia and incurred a total of USD 8.7 billion in hospital charges. The median length of stay and total charges were highest among those with comorbid diabetes and dementia—5 days and USD 71,398, respectively (Table 1). The median age at admission was found to be highest among patients with dementia alone (84 years). Differences by sex were most pronounced among those with dementia alone, with females being more frequently diagnosed with dementia (55.0%) as compared to males (45.0%). Race/ethnicity patterns varied significantly by disease status. For example, among those with diabetes alone, Hispanics comprised the largest group (43.6%), and among those with comorbid diabetes and dementia, those classified as Other made up the largest group (51.0%). Notably, disposition upon discharge varied substantially, with far fewer patients with dementia (alone or in conjunction with diabetes) having a routine discharge (e.g., 18.2% of those with dementia compared to 48.2% of those with diabetes). Across all disease categories, Medicare was the primary source of payment for the majority of inpatients and most admissions were characterized as emergency admissions originating from non-healthcare facility sources (e.g., patients' homes). The frequency of COVID-19 diagnoses was highest among individuals with comorbid diabetes and dementia (7.1%).

Multivariable linear regression revealed that individuals with diabetes alone exhibited 8.9% [$\exp(\beta_1) - 1 = \exp(-0.115) - 1$] higher total charges when compared to individuals without dementia or diabetes, while holding all other variables constant ($p < 0.0001$); see Table 2. Conversely, those with dementia or comorbid diabetes and dementia had lower total charges (-10.9% and -2.9%, respectively; $p < 0.0001$).

Table 1. Hospital Discharges by Disease Status, Los Angeles County, 2019–2021.

Characteristics	**Median [Range] or *N* (%)**				
	Diabetes (*n* = 523,987)	**Dementia (*n* = 115,958)**	**Diabetes + Dementia (*n* = 78,088)**	**No Diabetes or Dementia (*n* = 754,655)**	***p*-Value [1]**
Length of Stay (days)	4 [0–900]	4 [0–807]	5 [0–938]	3 [0–859]	<0.0001
Total Charges (USD)	$68,378 [$0–$10,795,377]	$65,297 [$0–$7,067,876]	$71,398 [$0–$5,087,514]	$63,641 [$0–$12,281,262]	<0.0001
Age (years)	68 [50–119]	84 [50–116]	82 [50–109]	67 [50–120]	<0.0001
Sex					<0.0001
Male	275,695 (52.6)	49,939 (45.0)	35,125 (49.8)	376,559 (49.9)	
Female	248,272 (47.4)	66,018 (55.0)	42,962 (50.2)	378,056 (50.1)	
Race/Ethnicity					<0.0001
White	134,014 (25.9)	56,118 (31.5)	323,871 (43.3)	321,829 (43.2)	
Black	69,370 (13.4)	13,498 (14.3)	97,841 (13.0)	96,996 (13.0)	
Hispanic	226,117 (43.6)	23,050 (31.5)	210,541 (28.0)	208,257 (28.0)	
Asian	55,107 (10.6)	13,771 (15.4)	70,157 (9.3)	69,715 (9.3)	
Other [2]	33,588 (6.5)	7821 (7.2)	48,595 (51.0)	48,213 (6.5)	
Year of Hospital Admission					<0.0001
2019	183,917 (35.1)	43,014 (37.1)	28,053 (35.9)	278,218 (36.9)	
2020	168,655 (32.2)	37,993 (32.8)	26,355 (33.8)	235,295 (31.2)	
2021	171,415 (32.7)	34,951 (30.1)	23,680 (30.3)	241,142 (31.9)	
Disposition					<0.0001
Routine	252,600 (48.2)	21,034 (18.2)	13,877 (17.8)	403,272 (53.5)	
Transfer to Short-Term Hospital	19,211 (3.7)	3499 (3.0)	2491 (3.2)	23,165 (3.1)	
Transfer Other [3]	95,661 (18.3)	54,486 (47.1)	37,166 (47.6)	119,420 (15.8)	
Home Healthcare	119,312 (22.8)	27,107 (23.4)	17,566 (22.5)	159,367 (21.1)	
Against Medical Advice	10,510 (2.0)	1215 (1.1)	850 (1.1)	17,591 (2.3)	
Died	26,531 (5.1)	8318 (7.2)	6109 (7.8)	31,635 (4.2)	
Type of Care					<0.0001
Acute Care	500,009 (95.4)	107,152 (92.4)	73,698 (94.4)	698,036 (92.5)	
Other [4]	23,947 (0.9)	8795 (1.6)	4383 (1.4)	56,562 (0.9)	
Expected Source of Payment					<0.0001
Medicare	315,441 (60.2)	101,431 (87.5)	67,753 (86.8)	417,368 (55.3)	
Medi-Cal (Medicaid)	121,779 (23.3)	7901 (6.8)	6463 (8.3)	156,409 (20.7)	
Private Coverage	74,479 (14.2)	5710 (4.9)	3361 (4.3)	155,542 (20.6)	
Other [5]	12,067 (2.3)	881 (0.8)	495 (0.6)	24,981 (3.3)	
Type of Admission					<0.0001
Emergency	297,508 (56.8)	69,839 (60.2)	48,423 (62.0)	379,635 (50.3)	
Urgent	154,218 (29.4)	34,610 (29.9)	22,533 (28.9)	212,778 (28.2)	
Elective	69,049 (13.2)	10,493 (9.1)	6672 (8.5)	153,580 (20.4)	
Trauma	3011 (0.6)	979 (0.8)	447 (0.6)	8431 (1.1)	
Source of Admission					<0.0001
Non-Healthcare Facility	418,371 (80.0)	76,149 (65.8)	50,492 (64.8)	602,401 (79.9)	
Clinic/Physician's Office	17,941 (3.4)	1941 (1.7)	1164 (1.5)	32,408 (4.3)	
Hospital (Different Facility)	49,867 (9.5)	12,550 (10.8)	8704 (11.2)	72,284 (9.6)	
SNF/ICF/ALF	22,401 (4.3)	20,561 (17.8)	14,947 (19.2)	24,626 (3.3)	
Other [6]	14,604 (2.8)	4551 (3.9)	2639 (3.4)	21,850 (2.9)	
COVID-19 Diagnosis					<0.0001
Confirmed Diagnosis	36,230 (6.9)	7112 (6.1)	5541 (7.1)	34,408 (4.6)	
No Confirmed Diagnosis	487,757 (93.1)	108,846 (93.9)	72,547 (92.9)	720,247 (95.4)	

Key: ALF = assisted living facility; ICF = intermediate care facility; SNF = skilled nursing facility; USD = United States Dollar. Percentages may not add to 100% due to rounding. Frequency counts for a given variable may not sum to a column total due to missing data or invalid variable codes. [1] *p*-values generated using Kruskal–Wallis and chi-squared tests. [2] Includes: Other, American Indian/Alaskan Native, Native Hawaiian or Other Pacific Islander, and Multiracial. [3] Includes: SNF, ICF, other types of facilities. [4] Includes: skilled nursing care/intermediate care, psychiatric care, chemical dependency recovery care, and physical rehabilitation care. [5] Includes: workers' compensation, county indigent programs, other government, other indigent, self-pay, and other. [6] Includes: court/law enforcement sites, one distinct unit to another distinct unit of the same hospital, ambulatory surgery centers, hospices, and designated disaster alternate care sites.

Table 2. Multivariable Linear Regression Analysis—Log Total Charges Billed for Hospitalizations by Disease Status, Los Angeles County, 2019–2021.

Covariate	Parameter Estimate	95% Confidence Interval	*p*-Value
Disease Status (Referent: No Diabetes or Dementia)			
Diabetes	0.085	(0.082, 0.089)	<0.0001
Dementia	−0.115	(−0.121, −0.109)	<0.0001
Diabetes + Dementia	−0.029	(−0.036, −0.022)	<0.0001

Multinomial logistic regression examining length of stay revealed that relative to those who were hospitalized for 0–1 days, patients with comorbid diabetes and dementia had the highest odds of a 2–3 day length of stay (AOR = 1.20, 95% CI = 1.17–1.24), with other predictor variables in the model held constant; see Table 3. Model estimates for a length of stay of 4–6 days and 7+ days revealed parallel patterns.

Table 3. Multinomial Logistic Regression Analysis—Length of Stay and of Hospital Discharges by Disease Status on Length of Stay, Los Angeles County, 2019–2021.

Length of Stay in Days Categorized by Quartiles (Referent Group: 0–1 Days)			
Length of Stay Groups	**2–3 Days**	**4–6 Days**	**7+ Days**
	Adjusted OR (95% CI)	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Disease Status (Referent: No Diabetes or Dementia)			
Diabetes	1.12 (1.11–1.13) *	1.22 (1.21–1.24) *	1.33 (1.31–1.34) *
Dementia	1.15 (1.13–1.18) *	1.25 (1.22–1.28) *	1.22 (1.20–1.26) *
Diabetes + Dementia	1.20 (1.17–1.24) *	1.42 (1.38–1.46) *	1.49 (1.44–1.53) *

* $p < 0.05$.

After matching, patients with comorbid diabetes and dementia exhibited significant differences across all variables of interest, with the exception of total charges (Table 4).

Table 4. Hospital Discharge Characteristics of Matched Cases (diabetes and dementia) and Controls (diabetes alone), Los Angeles County, 2019–2021.

Characteristics	**Median [Range] or *N* (%)**		
	Cases (*n* = 1492)	**Controls (*n* = 5968)**	***p*-Value [1]**
Length of Stay (days)	5 [0–366]	4 [0–122]	<0.0001
Total Charges (USD)	$77,772 [$4665–$2,657,694]	$74,818 [$0–$2,011,253]	0.38
Age (years)	75.5 [50–103]	75.5 [50–103]	1.0
Sex			1.0
Male	737 (45.0)	2948 (52.7)	
Female	755 (55.0)	3020 (47.3)	
Race/Ethnicity			1.0
White	315 (31.1)	1260 (25.5)	
Black	300 (14.1)	1200 (13.2)	
Hispanic	309 (31.0)	1236 (43.2)	
Asian	289 (15.2)	1156 (10.6)	
Other [2]	279 (0.1)	1116 (0.2)	

Table 4. *Cont.*

Characteristics	**Median [Range] or *N* (%)**		
	Cases (*n* = 1492)	**Controls (*n* = 5968)**	***p*-Value [1]**
Year of Hospital Admission			1.0
2019	499 (35.9)	1996 (35.0)	
2020	494 (33.8)	1976 (32.2)	
2021	499 (30.3)	1996 (32.7)	
Disposition			<0.0001
Routine	284 (19.0)	2642 (44.3)	
Transfer to Short-Term Hospital	40 (2.7)	221 (3.7)	
Transfer Other [3]	782 (52.4)	1307 (21.9)	
Home Healthcare	246 (16.5)	1268 (21.2)	
Against Medical Advice	12 (0.8)	132 (2.2)	
Died	128 (8.6)	398 (6.7)	
Type of Care			<0.0001
Acute Care	1409 (94.4)	5706 (95.6)	
Other [4]	83 (5.6)	262 (4.4)	
Expected Source of Payment			<0.0001
Medicare	1128 (75.6)	3884 (65.1)	
Medi-Cal	220 (14.7)	1083 (18.2)	
Other [5]	143 (9.6)	997 (16.7)	
Type of Admission			<0.0001
Emergency	908 (60.9)	3223 (54.0)	
Urgent	467 (31.3)	2114 (35.4)	
Other [6]	117 (7.8)	630 (10.6)	
Source of Admission			<0.0001
Non-Healthcare Facility	895 (60.0)	4823 (80.8)	
Clinic/Physician's Office	22 (1.5)	170 (2.8)	
Hospital (Different Facility)	187 (12.5)	528 (8.8)	
SNF/ICF/ALF	357 (23.9)	296 (4.9)	
Other [7]	31 (2.1)	151 (3.0)	
COVID-19 Diagnosis			0.15
Confirmed Diagnosis	105 (7.0)	360 (6.0)	
No Confirmed Diagnosis	1387 (93.0)	5608 (94.0)	

Key: ALF = assisted living facility; ICF = intermediate care facility; SNF = skilled nursing facility; USD = United States Dollar. Percentages may add to less or more than 100% due to rounding. [1] *p*-values generated using Kruskal–Wallis and chi-squared tests. [2] Includes: Other, American Indian/Alaskan Native, Native Hawaiian or Other Pacific Islander, and Multiracial. [3] Includes: SNF, ICF, and other types of facilities. [4] Includes: skilled nursing care/intermediate care, psychiatric care, chemical dependency recovery care, and physical rehabilitation care. [5] Includes: workers' compensation, county indigent programs, other government, other indigent, self-pay, and other. [6] Includes: elective and trauma. [7] Includes: court/law enforcement sites, one distinct unit to another distinct unit of the same hospital, ambulatory surgery centers, hospices, and designated disaster alternate care sites.

Conditional logistic regression analyses revealed that there were minimal differences in diabetic complications among those with comorbid diabetes and dementia as compared to those with dementia, with the exception of hypertensive diseases (Table 5). Comorbid diabetes and dementia were associated with a decreased risk of hypertensive diseases (OR = 0.81, 95% CI = 0.67–0.97).

Table 5. Crude Conditional Logistic Regression Analyses—Associations Between Disease Status and Diabetic Complications Among Hospitalizations in Los Angeles County, 2019–2021.

Diabetic Complications	Matched Odds Ratio	95% Confidence Interval	*p*-Value
Kidney Complications	1.04	0.92–1.18	0.49
Ophthalmic Complications	0.69	0.47–1.02	0.06
Neurologic Complications	1.00	0.80–1.27	0.98
Hypertensive Diseases	0.81	0.67–0.97	0.02
Low-Extremity Amputation Procedures	1.36	0.73–2.55	0.33

4. Discussion

Previous studies have explored the economic burden of and factors influencing hospitalizations among patients with diabetes, dementia, and their associated comorbidities [8,9,19,20]. However, these studies have primarily focused on a single disease profile, such as diabetes or dementia, or examined the two as part of a more general description of comorbidities. Our study specifically sought to build upon this research by providing a more comprehensive understanding of the health profiles of hospitalized patients in Los Angeles County who had comorbid diabetes and dementia. Four takeaways can be gleaned from examining these hospitalization data.

First, patients with comorbid diabetes and dementia experienced longer hospital stays compared to the other groups. This is in keeping with previous research which showed that patients with dementia may require more time to assess and manage comorbidities before discharge, have longer recovery periods more generally, or have increased disease severity, and are often moved to skilled nursing facilities and other post-hospitalization venues for further management [19]. Interestingly, despite patients with diabetes generally having a shorter length of stay, they had the highest total charges, after adjusting for covariates and comparing them to other disease groups. This may be attributed, in part, to high-cost care procedures being implemented in the first days of admission. For example, a study by Fine et al. found that the cost of care for hospitalized patients with pneumonia was lowest on the day of discharge and the 2 days preceding discharge [21]. Furthermore, caregivers of patients with comorbid diabetes and dementia may need further support in learning how to manage their condition, which may extend the length of stay with minimal relative added costs [22]. Increasing age may have also played a role in extending the length of stay in the hospital. In the literature, advanced age has been found to be associated with increases in longer duration of hospitalization; it also correlates with disease severity [23].

Second, our study showed that there were differences in racial and ethnic disparities across the different disease profiles in the HCAI data. This may suggest that health inequities are present in how hospitals detect and manage patients with comorbid diabetes and dementia. Prior research indicates that documentation of a dementia diagnosis is likely distorted in hospitalization records, as dementia diagnoses were often missed or delayed among non-White racial and ethnic groups [24]. For example, non-Hispanic Black adults and Hispanics have been shown to be 27% and 84% more likely, respectively, to have a missed or delayed diagnosis of dementia compared to non-Hispanic whites [24].

These racial and ethnic differences may also be explained by payer category. For instance, prior research has highlighted both lower dementia diagnosis prevalence and incidence rates among Medicare Advantage (MA) beneficiaries versus beneficiaries of traditional Medicare (TM) [25]. MA plans are private options that incentivize the use of preventive services. In 2022, large percentages of racial and ethnic minorities were enrolled in these plans. However, despite MA beneficiaries being more likely to receive annual wellness visits and structured cognitive assessments, as compared to TM beneficiaries, the prevalence of diagnosed dementia (MA = 7.10% vs. TM = 8.70%) and incidence rate for this condition (MA = 2.50% vs. TM = 2.99%) were still lower for these MA beneficiaries [25].

Third, patients with dementia and those with comorbid diabetes and dementia were more frequently transferred to specialized long-term care facilities (e.g., SNF), whereas patients with diabetes alone had more routine discharges. This finding aligns with existing literature showing that transitions to a skilled nursing facility are especially common among patients with dementia [26]. Patients with dementia are more likely to have multiple coexisting chronic conditions, often requiring more complex and intensive care [27]. It could also be the case that the community resources that are geared toward diabetes care are generally more organized and reimbursable than dementia care—this is an area of need where better health policies and interventions should be implemented [28–30].

Fourth, results from the matched case–control analysis suggest that the presence of hypertensive complications was lower among patients with comorbid diabetes and dementia than among patients with diabetes alone. While somewhat counterintuitive since hypertension is a risk factor for dementia, this finding, nonetheless, aligns with other studies that have found an inverse association between dementia and late-life hypertension [31,32]. However, these differences should be interpreted cautiously and within the context of the data source that was used to ascertain the diagnoses—i.e., hospitalization records versus full medical history records. Data derived from hospitalization records may not reflect all diagnoses that relate to earlier hospitalizations or pre-existing medical conditions and they typically do not include information about medication or prescribed treatments. These aspects of the data source may have lowered observations of hypertensive disease in those with both conditions, even though hypertension is an established risk factor for dementia and is known to affect cognition [33–37]. As an example, a systematic review of observational studies found that 73% of those with dementia were taking at least one antihypertensive medication [35].

While our study focuses on the hospital setting specifically, it is essential to recognize that there is a broader healthcare context to this work. For example, emerging evidence suggests that cardiovascular and cerebrovascular disease caused by diabetes are closely associated with the onset of cognitive decline for individuals with these types of vascular etiology [38]. Additionally, the cerebral insulin resistance caused by diabetes has been found to be associated with increased beta-amyloid production and tau protein phosphorylation, two hallmark characteristics of Alzheimer's disease [38]. These potential causal connections highlight the importance of implementing comprehensive healthcare strategies that can take care of both the acute and long-term care needs of patients who have comorbid diabetes and dementia. The complex interplay between these two conditions highlights the need for tailored healthcare policies that can meaningfully address the unique challenges presented by both of these conditions, not only during hospitalization but also in post-acute care settings.

As previously noted, this study coincides with the COVID-19 pandemic, which had a significant impact on hospitalizations, especially for older adults [39]. Age was and is still considered to be the most important risk factor for severe COVID-19 symptoms, with the risk of severe outcomes increasing with advancing age [40]. Diabetes has also been identified as a significant risk factor for severe COVID-19 and subsequent hospitalization [41,42]. A national analysis found that the rate of in-hospital mortality due to COVID-19 was greater among diabetic patients than among non-diabetic patients (16.3% versus 8.1%, $p < 0.0001$) [43]. Emerging literature also suggests that those with dementia are at increased risk for more severe COVID-19 complications, including hospitalization [44,45]. A multivariable logistic regression analysis found increased odds of in-hospital mortality among patients with diabetes and all-cause dementia when they were hospitalized for COVID-19 [46]. Cardiovascular disease and related conditions represent another factor that may have impacted those with diabetes and dementia, as these conditions were found to be associated with greater COVID-19 mortality and intensive care unit admission [47–51].

Limitations

While this study has a number of strengths, including its large sample size and low rate of missing data, it has several limitations. First, discharge records represent unique hospitalizations rather than individuals and do not allow for examination of readmissions after discharge or recurrent hospitalizations. Second, recorded diagnoses related to a prior episode that have no bearing on the current hospital stay were excluded. This may have resulted in an underestimation of patients with diabetes and dementia. Third, the use of ICD-10-CM codes alone to determine the presence of dementia likely contributed to an underestimation of dementia. Research has shown that many of those who meet the diagnostic criteria for dementia are not diagnosed by a physician [52]. Fourth, the reliance on ICD-10-CM codes to ascertain dementia diagnoses could have led to misclassification bias; as such, incorrect diagnoses may have affected observed estimates. Finally, detailed information on patient risk factors, medical history, and socioeconomic status, which can increase the severity of disease and, correspondingly, hospitalization outcomes, were not available. Without such information, we were unable to adequately adjust for these confounding factors in our analyses.

5. Conclusions

Study findings highlight the substantial healthcare burden associated with comorbid diabetes and dementia. This burden is expected to grow as the number of Americans with these conditions is projected to increase substantially over the next few decades [52–55]. Our results underscore the need for a multi-faceted approach to address both diabetes and dementia, in many instances, concurrently, especially for high-risk populations that lack adequate access to health services, are vulnerable to socioeconomic challenges, and have historically experienced health inequities and barriers to care, including systemic racism [56,57]. Investments in strategies such as preventative care, care coordination, advance care planning, personalized care plans, and community support for improving self-management and caregiver assistance will be critical for mitigating the financial and social impacts of these prevailing and costly chronic diseases [58–64]. These are all areas of health policy research, strategy intervention, and program implementation that will be required to address the comorbidity of diabetes and dementia in Los Angeles County and elsewhere across the US [65–67].

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/diabetology4040052/s1, Table S1: ICD-10-CM and ICD-10-PCS Codes Used.

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