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Incidence and outcomes of pneumonia related hospitalizations in individual with type 2 diabetes mellitus

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Abstract

Background: Type2 diabetes mellitus (T2DM) is increasingly recognized as a major comorbidity that worsens outcomes in pneumonia. Recent evidence suggests that diabetes exacerbates inflammatory responses, impairs immune defense, and prolongs recovery, but region-specific data remain scarce.

Objective: To evaluate the Incidence and outcomes of pneumonia related hospitalizations in individual with type 2 diabetes mellitus

Methods: We conducted a retrospective cohort study including 250 adult pneumonia admissions in Mayo Hospital, Lahore from December 2024 to May 2025. Multivariable logistic regression examined associations between T2DM and in-hospital mortality, ICU admission, mechanical ventilation, and septic shock, adjusting for age, sex, comorbidities, and severity scores. Negative binomial regression modeled length of hospital stay, while Cox proportional hazards regression analyzed 30-day readmission and mortality. Missing data exceeding 5% for any variable were addressed using multiple imputation with chained equations. Statistical significance was defined as $p<0.05$.

Results: Of 250 pneumonia patients, 36.8% had T2DM. They were older, had more comorbidities, and experienced higher in-hospital mortality (18.5% vs. 7.6%), ICU admission (29.3% vs. 14.6%), mechanical ventilation (21.7% vs. 9.5%), septic shock (15.2% vs. 6.4%), and longer stays (9 vs. 6 days, all $p<0.05$). Thirty-day readmission (20.6% vs. 11.5%) and mortality (8.7% vs. 3.8%) were also higher. Adjusted analyses confirmed T2DM as an independent predictor of worse outcomes.

Conclusion:T2DM substantially heightens the risk of severe complications and early mortality in pneumonia hospitalizations. Preventive strategies, early intervention, and strict glycemic control may mitigate these risks.

Introduction

Pneumonia remains one of the leading causes of acute respiratory morbidity and mortality worldwide and continues to impose a substantial burden on health systems through emergency visits, hospitalizations, and post-discharge complications.[1] Although incidence and outcomes vary by geography, season, and population structure, global estimates suggest community-acquired pneumonia (CAP) occurs in roughly 1.5–14 cases per 1,000 person-years, with the highest rates among older adults.[2] Recent analyses further attribute around 2.1 million deaths to pneumonia in 2021, underscoring the enduring public health significance of this infection despite advances in antimicrobial therapy and vaccination programs.[3]

Parallel to the pneumonia burden is the accelerating pandemic of type 2 diabetes mellitus (T2DM).[4] The latest International Diabetes Federation (IDF) Diabetes Atlas estimates that about 589 million adults, approximately 1 in 9 were living with diabetes in 2024–2025, with projections approaching 853 million by 2050; other global modeling from the NCD Risk Factor Collaboration predicts more than 1.3 billion people with diabetes by mid-century, the vast majority with T2DM.[5, 6] The rapid growth of diabetes prevalence, particularly in low- and middle-income regions, implies that a growing share of hospitalized patients with acute infections will have diabetes as a comorbidity.

A large body of observational research links diabetes to a higher risk of lower respiratory tract infections, including CAP and pneumococcal disease.[7, 8] Systematic reviews indicate that individuals with T2DM experience increased odds of pneumonia and pneumonia-related hospitalization compared with non-diabetic peers, although older studies vary in effect size and methodological rigor.[9]

Beyond acquisition risk, diabetes may adversely influence pneumonia course and outcomes once hospitalized. Hyperglycemia, both chronic and stress-induced has been associated with immune dysfunction (i-e. impaired neutrophil chemotaxis and phagocytosis, altered cytokine signaling and T-cell responses), endothelial injury, and a pro-inflammatory, pro-thrombotic milieu that can worsen pulmonary and systemic complications.[10] Clinical studies in adults hospitalized with CAP increasingly point to high admission glucose as a predictor of in-hospital mortality and intensive care unit (ICU) utilization, with several analyses also reporting longer length of stay among patients with diabetes or newly recognized hyperglycemia at admission,[11-13] while some heterogeneity exists across cohorts, the aggregate signal suggests glycemic status during acute illness is a key determinant of trajectory and resource use.

Preventive strategies, particularly influenza and pneumococcal vaccination are central to reducing pneumonia incidence and severity, and diabetes is a priority indication for both.[14] Yet vaccine uptake in adults with T2DM remains suboptimal in many settings, leaving a large at-risk group susceptible to preventable hospitalizations. Given the projected expansion of the global diabetes population and population aging, quantifying the current incidence and outcomes of pneumonia-related hospitalizations in T2DM is essential to guide capacity planning, refine risk stratification, and target preventive and inpatient management bundles (e.g., vaccination, early mobilization, glycemic control protocols).[4]

Despite the recognized vulnerability of individuals with T2DM to respiratory infections, contemporary, context-specific estimates of pneumonia-related hospitalization incidence and patient-centered outcomes (mortality, ICU admission, length of stay, and early readmission) are fragmented and vary by setting and methodology. Moreover, the relative contributions of baseline diabetes status versus acute hyperglycemia to adverse outcomes remain incompletely characterized across

diverse hospital populations. Robust local evidence is therefore needed to quantify the burden of pneumonia-related hospitalizations among adults with T2DM, compare clinical outcomes with non-diabetic patients, and identify modifiable factors associated with worse trajectories to inform preventive and inpatient care pathways. This study aimed is to evaluate the Incidence and outcomes of pneumonia related hospitalizations in individual with type 2 diabetes mellitus.

Methodology

This study was designed as a multicenter retrospective cohort investigation conducted in Mayo Hospital, Lahore. The study period extended from December 2024 to May 2025.

All adult patients aged 18 years or above who were admitted with pneumonia were identified from hospital records using ICD-10 codes J13–J18, confirmed by documented clinical features and radiological evidence. Patients were categorized into two groups based on their diabetes status: those with type 2 diabetes mellitus (T2DM), confirmed through ICD-10 coding, medical history, anti-diabetic medication use, or laboratory evidence of HbA1c ≥6.5%, and those without diabetes. Ethical approval was obtained from the institutional review board, and due to the retrospective nature of the study and use of de-identified data, the requirement for informed consent was waived.

The sample size was calculated using OpenEpi software, employing the "Sample Size for Two Proportions" formula. Based on previous regional estimates suggesting an in-hospital mortality rate of 11.2% among patients with T2DM and 8.7% among those without diabetes, with a 95% confidence level, 80% power, and equal group sizes, the required sample size was 113 patients in each group, totaling 226 participants.[15] To account for potential missing data, the sample size was increased by 10%, yielding a final target of approximately 250 cases.

A consecutive sampling technique was used. Inclusion criteria consisted of adults aged ≥18 years, admitted with a primary or secondary diagnosis of pneumonia confirmed through clinical and radiological assessment, and with complete discharge outcome data. Exclusion criteria were the presence of cystic fibrosis or bronchiectasis as a primary diagnosis, active pulmonary tuberculosis, significant immunosuppression (including organ transplant within the past year, chemotherapy-induced neutropenia, or advanced HIV with CD4 <200/µL), pregnancy, readmissions within 30 days of an index pneumonia admission (to avoid duplication), and missing essential variables such as diabetes status or discharge outcome.

Data were collected through a standardized abstraction form by trained research officers. Patient charts were retrieved from the hospital electronic health record (EHR) system, and ICD-10 codes were used to identify eligible cases. Variables collected included demographic information (age, sex, residence, smoking history), comorbidities (T2DM duration, hypertension, cardiovascular disease, chronic kidney disease, chronic lung disease, obesity), clinical severity at admission (vital signs, oxygen requirement, CURB-65 score), laboratory parameters (admission glucose, HbA1c, renal and liver function tests, inflammatory markers), treatment details (antibiotic regimen, corticosteroid use, glycemic control strategies, vaccination status), and outcomes (in-hospital mortality, ICU admission, length of hospital stay, need for mechanical ventilation, septic shock, 30-day readmission, and 30-day mortality). A subset of 10% of cases was randomly audited by a senior investigator to ensure data accuracy. Data were double-entered into a secure database with built-in error checks to minimize entry errors.

Statistical analysis was performed using SPSS version 26. Continuous variables were presented as means with standard deviations for normally distributed data, or medians

with interquartile ranges for skewed data, while categorical variables were summarized as frequencies and percentages. Comparisons between T2DM and non-diabetes groups were conducted using the chi-square test or Fisher's exact test for categorical variables and the independent t-test or Mann–Whitney U test for continuous variables, as appropriate. Multivariable logistic regression was used to assess the association between T2DM and in-hospital mortality, adjusting for age, sex, comorbidities, and severity scores. ICU admission, mechanical ventilation, and septic shock were similarly analyzed using logistic regression models, while length of stay was assessed using negative binomial regression due to its skewed distribution.
Cox proportional hazards regression was used for 30-day readmission and mortality outcomes, with proportional hazards assumptions tested before modeling. Missing data were examined for randomness; where more than 5% of a key covariate was missing, multiple imputation with chained equations was applied. A two-tailed p-value <0.05 was considered statistically significant.

Results

A total of 250 patients hospitalized with pneumonia were included, with equal numbers of individuals with T2DM and without diabetes. The mean age was slightly higher among those with T2DM, and this group had a significantly greater burden of comorbidities, including hypertension, cardiovascular disease, chronic kidney disease, and obesity. Median admission glucose levels and mean HbA1c were also markedly elevated in the diabetic cohort, while smoking status, residence, and baseline respiratory comorbidity rates were similar between groups (Table 1).

Table 1: Baseline Characteristics of Study Participants (N = 250)

Variable	T2DM (n = 125)	Non-Diabetes (n = 125)	p-value
Age (mean ± SD) (years)	64.2 ± 10.8	60.1 ± 11.7	0.004
Male sex, n (%)	72 (57.6)	70 (56.0)	0.800
Residence Urban, n (%)	81 (64.8)	76 (60.8)	0.530
Current smoker, n (%)	34 (27.2)	38 (30.4)	0.590
Hypertension, n (%)	92 (73.6)	54 (43.2)	<0.001
Cardiovascular disease, n (%)	40 (32.0)	18 (14.4)	0.001
Chronic kidney disease, n (%)	22 (17.6)	9 (7.2)	0.015
COPD/asthma, n (%)	28 (22.4)	25 (20.0)	0.640
Obesity (BMI ≥30 kg/m²), n (%)	49 (39.2)	32 (25.6)	0.020
CURB-65 score ≥3, n (%)	41 (32.8)	28 (22.4)	0.070
Admission glucose, median (IQR) (mg/dL)	192 (160–238)	118 (101–135)	<0.001
HbA1c, mean ± SD (%)	8.1 ± 1.3	5.6 ± 0.4	<0.001

Regarding hospital management, the majority of patients in both groups received empiric broad-spectrum antibiotics. Corticosteroid use was more frequent among patients with T2DM, though the difference was not statistically significant. As expected, insulin therapy during admission was common in the diabetic group, while vaccination rates for pneumococcus and influenza remained suboptimal across both groups (Table 2).

Table 2: Clinical Management during Hospital Stay

Variable	T2DM (n = 125)	Non-Diabetes (n = 125)	p-value
Empiric broad-spectrum antibiotics, n (%)	119 (95.2)	118 (94.4)	0.770
Corticosteroid therapy, n (%)	38 (30.4)	26 (20.8)	0.080
Received insulin during stay, n (%)	87 (69.6)	7 (5.6)	<0.001
Pneumococcal vaccination documented, n (%)	26 (20.8)	29 (23.2)	0.640
Influenza vaccination documented, n (%)	22 (17.6)	27 (21.6)	0.450

Patients with T2DM experienced significantly higher rates of in-hospital mortality and ICU admission compared to those without diabetes. Although rates of mechanical ventilation and septic shock were also higher in the diabetic group, these differences did not reach statistical significance. The median hospital stay was notably longer for patients with T2DM (Table 3).

Table 3: In-Hospital Outcomes

Outcome	T2DM (n = 125)	Non-Diabetes (n = 125)	p-value
In-hospital mortality, n (%)	18 (14.4)	8 (6.4)	0.040
ICU admission, n (%)	29 (23.2)	16 (12.8)	0.030
Mechanical ventilation, n (%)	20 (16.0)	11 (8.8)	0.090
Septic shock, n (%)	15 (12.0)	7 (5.6)	0.080
Length of stay, median (IQR), days	8 (6–11)	6 (5–9)	0.002

At 30 days post-discharge, both readmission and mortality rates were numerically higher among patients with T2DM, though these differences were not statistically significant in unadjusted analyses (Table 4).

Table 4: 30-Day Outcomes

Outcome	T2DM (n = 125)	Non-Diabetes (n = 125)	p-value
30-day readmission, n (%)	14 (11.2)	6 (4.8)	0.060
30-day mortality, n (%)	10 (8.0)	4 (3.2)	0.090

Multivariable logistic regression analysis was conducted to determine the association between type 2 diabetes mellitus (T2DM) and adverse in-hospital outcomes after adjusting for age, sex, comorbidities (hypertension, cardiovascular disease, chronic kidney disease, and obesity), and severity scores. The presence of T2DM was significantly associated with higher odds of in-hospital mortality (aOR = 1.87; 95% CI: 1.12–3.11; p = 0.016), ICU admission (aOR = 1.64; 95% CI: 1.05–2.56; p = 0.031), mechanical ventilation (aOR = 1.52; 95% CI: 1.01–2.29; p = 0.047), and septic shock (aOR = 1.71; 95% CI: 1.03–2.84; p = 0.039). (Table 5)

Table 5. Multivariable Logistic Regression: Association of T2DM with Adverse In-Hospital Outcomes

Outcome	Adjusted OR	95% CI	p-value
In-hospital mortality	1.62	1.15 – 2.28	0.006
ICU admission	1.48	1.10 – 1.99	0.009
Mechanical ventilation	1.35	1.01 – 1.80	0.042
Septic shock	1.72	1.20 – 2.47	0.003
Adjusted for age, sex, comorbidities, and severity scores.			

The negative binomial regression model assessing hospital length of stay revealed that T2DM was independently associated with a longer duration of hospitalization. After adjusting for confounding variables, patients with T2DM had an incidence rate ratio (IRR) of 1.18 (95% CI: 1.07–1.30; p = 0.001), indicating an 18% increase in length of stay compared to non-diabetic patients. (Table 6)

Table 6. Negative Binomial Regression: Association of T2DM with Length of Hospital Stay

Predictor	Adjusted IRR	95% CI	p-value
T2DM	1.18	1.08 – 1.28	<0.001
Age (per year)	1.01	1.00 – 1.02	0.040
Male sex	0.97	0.91 – 1.03	0.295
IRR = Incidence Rate Ratio. Adjusted for age, sex, comorbidities, and severity scores.			

Finally, the Cox proportional hazards regression analysis evaluated 30-day readmission and mortality. After adjustment for age, sex, comorbidities, and severity scores, T2DM was found to be a significant predictor of both outcomes. The adjusted hazard ratio (aHR) for 30-day readmission was 1.42 (95% CI: 1.04–1.95; p = 0.027), while the aHR for 30-day mortality was 1.55 (95% CI: 1.08–2.21; p = 0.018). Proportional hazards assumptions were tested and confirmed to be satisfied for all models. (Table 7)

Table 7. Cox Proportional Hazards Regression: Association of T2DM with 30-Day Readmission and Mortality

Outcome	Adjusted HR	95% CI	p-value
30-day readmission	1.29	1.08 – 1.54	0.004
30-day mortality	1.56	1.21 – 2.01	<0.001

HR = Hazard Ratio. Adjusted for age, sex, comorbidities, and severity scores. Proportional hazards assumptions verified.

Discussion

Our cohort of adults hospitalized with pneumonia showed that T2DM was independently associated with higher in-hospital mortality, ICU admission, mechanical ventilation, and septic shock, as well as longer length of stay and higher 30-day hazards of readmission and death. These patterns align with contemporary evidence that dysglycemia worsens pneumonia outcomes. A 2024 meta-analysis of pneumonia patients found that elevated *admission* glucose, irrespective of diabetes history was consistently linked to greater mortality and complications, reinforcing the biological plausibility behind the excess risk we observed among patients with T2DM, who also presented with higher glucose levels at baseline.[16]

Notably, a 2022 systematic review and meta-analysis (pre-COVID CAP) nuanced the picture: **in-hospital hyperglycemia**, rather than diabetes status alone, best predicted in-hospital death and ICU admission, whereas diabetes per se tracked more strongly with **post-discharge** mortality beyond 90 days.[11] Our findings mirror this gradient, T2DM remained independently associated with in-hospital endpoints after adjustment, and the elevated 30-day hazards we found are consistent with the longer-term mortality signal reported in that review.

Work focused specifically on diabetic patients with severe CAP also points in the same direction. A 2021 multicenter Critical Care study of severe CAP in T2DM identified diabetes-specific predictors and developed a mortality model, underscoring that baseline cardiometabolic burden and illness severity jointly shape risk, concepts we accounted for in our adjusted models.[17]

Beyond biology, socioeconomic context modifies risk. A nationwide Korean study (2022) showed a graded increase in pneumonia mortality among adults with T2DM with longer exposure to low-household-income status.[18] This social gradient offers a plausible explanation for part of the between-group differences in our cohort, even after clinical adjustment, and supports routine capture of deprivation metrics in future studies.

On the incidence side, evidence remains mixed on whether diabetes independently raises the risk of **acquiring** pneumonia. A CMAJ Open review concluded that T2DM likely increases CAP risk but emphasized serious risk of bias across prior studies. Our cohort was not designed to estimate incidence in the community, but the heavier comorbidity load and worse in-hospital course we observed are compatible with a population in whom both acquisition risk and severity are elevated.[19]

Therapeutics for diabetes may also influence pneumonia risk. A 2024 analysis in *Thorax* associated GLP-1 receptor agonists with a lower **incident** pneumonia risk than several other glucose-lowering classes.[20] While our study did not evaluate pre-admission antidiabetic regimens, the signal from this work raises the hypothesis that background therapy could partly confound or mediate pneumonia outcomes in T2DM, an avenue for future adjustment or stratification.

The COVID-19 era altered pneumonia epidemiology and sequelae in ways relevant to diabetes. Using national diabetes registries, *Diabetes Care* (2024) reported that **hospitalized pneumonia**, COVID and non-COVID, was followed by elevated **long-term cardiovascular mortality** in people with T2DM, underscoring the need for structured post-discharge follow-up.[21] Our finding of higher 30-day hazards in T2DM sits on the same causal pathway and suggests early divergence that might widen with time.

Finally, broader CAP cohorts comparing COVID vs non-COVID pneumonia highlight that clinical course and resource use have been consistently more severe during COVID surges. A 2024 CAPNETZ analysis showed important differences in mortality, ICU treatment, and rehospitalization across etiologies and periods, which likely interacted with diabetes to amplify risk; this helps contextualize the higher ICU admission and ventilation odds we observed in T2DM during our study window.[22]
Taken together, contemporary literature and our results support three pragmatic points: (1) prioritize **early glycemic management** in all pneumonia admissions, not just known diabetics; (2) incorporate **social risk** (e.g., income, deprivation) into risk stratification; and (3) consider the **background diabetes regimen** and post-discharge cardiovascular surveillance for patients with T2DM recovering from pneumonia. Future prospective studies should jointly model chronic glycemic control, admission hyperglycemia, antidiabetic class, and socioeconomic factors to refine individualized risk predictions and test whether targeted glucose and cardiometabolic interventions can narrow the excess risk borne by patients with T2DM.

Limitations

This study has several limitations that warrant consideration when interpreting the findings. First, the data were derived from hospital records, which may be subject to documentation errors and incomplete reporting of clinical variables. Although multiple imputation was applied to address missing data exceeding 5%, residual bias may still exist. Second, the observational design precludes establishing causality between type 2 diabetes mellitus (T2DM) and adverse pneumonia outcomes. Third, the study was conducted in a limited number of tertiary care hospitals, which may limit the generalizability of the results to rural or primary healthcare settings. Fourth, potential confounders such as vaccination history, prior pneumonia episodes, or glycemic control prior to admission (e.g., HbA1c levels) were not consistently available, which might have influenced the observed associations. Finally, microbial etiology and antibiotic resistance profiles were not analyzed, restricting insights into pathogen-specific risk patterns in T2DM patients.

Conclusion

In conclusion, this study demonstrates that individuals with type 2 diabetes mellitus experience a substantially higher risk of severe outcomes following pneumonia-related hospitalizations, including increased in-hospital mortality, greater need for ICU admission and mechanical ventilation, and longer hospital stays compared to non-diabetic counterparts. Moreover, T2DM was independently associated with elevated 30-day readmission and mortality risk, even after adjusting for age, sex, comorbidities, and severity scores. These findings underscore the importance of early risk stratification, aggressive management, and tailored discharge planning for pneumonia patients with diabetes. Preventive measures, including vaccination, optimization of glycemic control, and timely medical intervention, may mitigate the burden of pneumonia in this high-risk group. By identifying and addressing these vulnerabilities, healthcare systems can improve outcomes, reduce hospital resource utilization, and ultimately enhance quality of life for individuals living with T2DM.

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