ORIGINAL ARTICLE

Predictors of Hospital Length of Stay among Patients with Dementia: A Comparison of Ordinary Least Squares and Robust Regression

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Received: *February 20, 2026* **Revised:** *May 19, 2026* **Accepted:** *June 2, 2026*

ABSTRACT

BACKGROUND: Dementia is a major public health concern in aging societies. Patients with dementia frequently experience prolonged and highly variable hospital stays, placing a significant burden on healthcare systems. Conventional statistical approaches, such as Ordinary Least Squares (OLS) regression, may yield biased estimates when applied to clinical data with outliers or heteroscedasticity. Robust Regression offers a more appropriate alternative; however, its comparative performance in psychiatric hospital settings in Thailand remains underexplored.

OBJECTIVES: This study aimed to investigate the factors associated with hospital length of stay (LOS) among patients with dementia and to compare the performance of Ordinary Least Squares (OLS) regression and Robust Regression in a psychiatric hospital setting in Thailand.

METHODS: A retrospective analytical study was conducted using the medical records of 120 patients with dementia admitted to Suansaranrom Hospital between June and October 2025. The variables examined included age, Charlson Comorbidity Index (CCI), Clinical Dementia Rating (CDR), Behavioral and Psychological Symptoms of Dementia (BPSD), and length of stay (LOS).

RESULTS: The mean LOS was 29.3±15.2 days, with 8 outlier cases (6.7%) having a LOS longer than 60 days. OLS regression did not reveal any statistically significant overall relationships among the variables. In contrast, Robust Regression identified age, CCI, and CDR as significant predictors of LOS, with CDR exhibiting the strongest influence. BPSD was not statistically significantly associated with LOS in either analytical method. Furthermore, patients aged 60 years and older were more likely to experience prolonged hospitalization.

CONCLUSIONS: Robust Regression is more appropriate than OLS for clinical datasets containing outliers and heteroscedasticity, providing more reliable estimates of factors associated with LOS among patients with dementia. These findings may support individualized care planning, systematic management of behavioral and psychological symptoms, multidisciplinary collaboration, and the development of community-based preventive strategies aimed at reducing prolonged hospitalization among high-risk elderly patients.

KEYWORDS: dementia, length of stay, robust regression, charlson comorbidity index, clinical dementia rating, behavioral and psychological symptoms of dementia

Thaiclinicaltrials.org number, TCTR20260329010

INTRODUCTION

Prolonged hospital length of stay (LOS) among patients with dementia represents a significant challenge for psychiatric healthcare systems worldwide. Extended hospitalization not only increases healthcare costs but also elevates risks of hospital-acquired complications, diminishes quality of life, and places a substantial burden on caregivers and families. Identifying modifiable predictors of LOS is therefore a priority for evidence-based resource planning.

Dementia is a group of neurocognitive disorders characterized by progressive decline in memory and cognitive function, severely affecting daily activities and quality of life. Approximately 57 million patients were living with dementia worldwide in 2021, projected to increase to 78 million by 2030 and 139 million by 2050, with Southeast Asia and the Western Pacific expected to experience the most rapid growth[1,2]. Thailand entered a fully aged society in 2021, with adults aged 60 years and above accounting for approximately 20% of the total population[3]. The estimated number of patients with dementia in Thailand reached 680,000–800,000 in 2021 and is projected to approach one million within the next decade[4].

At Suansaranrom Hospital, a leading psychiatric facility in Southern Thailand, patients with dementia account for an increasing proportion of hospital admissions. Clinical observations suggest that certain patient subgroups—particularly older adults with multiple comorbidities and severe behavioral symptoms—experience substantially longer stays. However, the specific factors contributing to prolonged LOS have not been systematically investigated in this setting, representing a gap in local evidence.

Regression analysis is commonly employed to identify predictors of LOS. Ordinary Least Squares (OLS) Regression assumes normally distributed residuals and is sensitive to outliers. In clinical datasets where a minority of patients experience unusually prolonged stays, OLS estimates can be biased or inefficient. Robust Regression using the Iteratively Reweighted Least Squares (IRLS) method with HuberT norm reduces the influence of outliers, offering more reliable estimates. When data violate OLS assumptions—as is characteristic of hospital LOS distributions—Robust Regression may represent a more appropriate analytical approach[5,6,7].

This study therefore aimed to: (1) identify significant factors associated with LOS among patients with dementia at Suansaranrom Hospital; (2) examine the relationships among age, comorbidity burden (CCI), and dementia severity (CDR score) on LOS; and (3) compare the analytical performance of OLS and Robust Regression models in analyzing this dataset.

METHODS

This study employed a retrospective analytical research design. Data were extracted from medical records of patients with dementia admitted to Suansaranrom Hospital. The study was approved by the Human Research Ethics Committee of Kasem Bundit University (COA No. R002/69X).

The population consisted of all patients with dementia admitted to Suansaranrom Hospital between June and October 2025. This five-month period was selected as it represented the most recent complete dataset available at the time of approval, with consistent admission patterns and complete medical records. A total of 120 patients were included using purposive sampling.

Inclusion criteria: (1) diagnosed with dementia according to DSM-5 criteria; (2) complete medical records including all study variables; (3) continuous hospitalization during the study period. Exclusion

criteria: (1) patients transferred to another facility during admission, as their LOS reflected logistical rather than clinical factors; (2) patients whose prolonged stay was attributable exclusively to an acute non-dementia comorbidity requiring specialist management unrelated to dementia.

Sample size was calculated using 40–50 observations per predictor variable, consistent with recommendations for multiple regression with continuous outcomes.[8] With 3 predictor variables, a minimum of 120–150 cases was required. The final sample of 120 cases met this threshold and was further confirmed to provide adequate statistical power (power=0.80, effect size f^2=0.15, α=0.05) via G*Power 3.1.

Research Instruments

A structured data collection form was developed by the research team to systematically extract and record information from paper-based hospital medical records. The form captured: (1) age (years); (2) type of dementia (underlying etiology); (3) comorbidity burden, measured by the Charlson Comorbidity Index (CCI); (4) disease dementia, measured by the Clinical Dementia Rating scale (CDR score: 0=none, 0.5=questionable, 1=mild, 2=moderate, 3=severe); (5) presence and type of Behavioral and Psychological Symptoms of Dementia (BPSD); and (6) total length of stay (LOS), defined as the number of days from admission to discharge.

Data Collection

Data were extracted from paper-based medical records maintained by the Medical Records Department of Suansaranrom Hospital. Two trained research assistants independently abstracted data from each eligible medical record onto the structured data collection form. Cross-verification was performed for 20% of randomly selected records (n = 24) to ensure data accuracy, and any discrepancies were reviewed and resolved by the principal investigator. Data were then entered into an electronic database by the principal investigator using a double-entry verification procedure.

Data Analysis

Descriptive statistics (mean, SD, median, IQR, frequency, percentage) were used to describe sample characteristics and the distribution of LOS. Prior to regression analysis, OLS assumptions were checked: (1) linearity assessed by residual plots; (2) homoscedasticity assessed by Breusch-Pagan test; (3) normality of residuals assessed by Shapiro-Wilk test; (4) multicollinearity assessed by Variance Inflation Factor (VIF). Outlier detection was performed using Box plot analysis. Since assumption checking revealed violation of homoscedasticity and presence of significant outliers, Robust Regression (IRLS method with HuberT norm; tuning constant c=1.345) was identified as the appropriate primary analysis. OLS results are presented for comparison. CDR severity score, CCI comorbidity score, and age served as independent variables; total LOS (days) was the dependent variable. BPSD was used for clinical characterization of outlier patients but excluded from regression models due to multicollinearity with CDR (VIF >5). A supplementary regression analysis examined age group (≥60 years vs. <60 years) as a predictor of monthly admission volume to contextualize population burden. Statistical significance was set at p <0.05. Data were analyzed using Python 3.11 with statsmodels 0.14 and scipy 1.11.4 libraries.

RESULTS

Sample Characteristics

Of the 120 patients with dementia, the mean age was 72.3±8.3 years (range 53–92 years). The majority were female (58.3%) and aged ≥60 years (90.3%). The mean LOS was 29.3±15.2 days (median days=27.0, IQR=18.0–36.0 days; range

14–110 days). Table 1 presents demographic and clinical characteristics for all patients and compares outlier cases (n=8, LOS>60 days) with non-outlier cases (n=112).

Table 1 Demographic and Clinical Characteristics: All Patients and Outlier vs. Non-outlier Cases

Variable	All Patients (n=120)	Outlier Cases (n=8)	Non-outlier (n=112)	*p*-value*
Age, mean±SD (years)	72.3±8.3	N/A	N/A	N/A
Age, median (IQR)	71.0 (66–79)	N/A	N/A	N/A
Age ≥60 years, n (%)	109 (90.3)	8 (100)	74 (66.1)	<0.001
101 (90.2)	0.09			
Female, n (%)	70 (58.3)	5 (62.5)	N/A	0.002
Dementia type: Alzheimer's	68 (56.3)	6 (75.0)	N/A	N/A
Dementia type: Vascular	34 (28.3)	2 (25.0)	N/A	<0.001
Dementia type: Other	18 (15.0)	0 (0)	N/A	N/A
CCI score, mean±SD	2.1±1.3	4.3±0.3	N/A	N/A
CDR score, mean±SD	1.3±0.3	2.3±0.3	N/A	N/A
BPSD present, n (%)	82 (68.3)	8 (100)	74 (66.1)	<0.001
<0.001	<0.001			
LOS, mean±SD (days)	29.3±15.2	78.3±14.1	N/A	0.001
LOS, median (IQR) (days)	27.0 (18–36)	75.3 (65–90)	N/A	N/A
LOS, range (days)	14–110	61–110	N/A	N/A

Note: *p*-values for outlier vs. non-outlier comparison derived from Mann-Whitney U test (continuous variables) and Fisher's exact test (categorical variables). N/A = data not separately collected for non-outlier subgroup. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

The regression coefficients indicate that Robust Regression provides more reliable and stable effect size estimates compared to OLS regression, particularly in the presence of outliers. The 95% confidence intervals in the Robust model are narrower, indicating greater precision. Age ≥60 years emerged as the strongest factor associated with LOS, followed by sex and temporal trends.

Consistent with the descriptive results (Table 1), most patients were elderly (90.3%), and all outlier cases were aged 60 years and above, with significantly longer length of stay (mean 78.3 days). These findings highlight that advanced age, higher comorbidity burden (CCI), greater dementia severity (CDR), and the presence of BPSD suggest key characteristics associated with extreme outcomes.

Overall, Robust Regression better captures the true relationships among variables by minimizing the influence of extreme values, making it more appropriate for this dataset.

Assumption Checking

Prior to regression analysis, the assumptions of Ordinary Least Squares (OLS) regression were evaluated. The Breusch-Pagan test indicated significant heteroscedasticity (p=0.024). The Shapiro-Wilk test revealed that the residuals were not normally distributed (p=0.011). Box plot analysis identified 8 outlier cases (6.7%). Given these violations, Robust Regression was selected as the primary analytical approach, with OLS results retained for comparison purposes.

Outlier Detection

Box plot analysis of length of stay (LOS) identified 8 outlier cases (6.7%). These cases were characterized by unusually prolonged hospitalization, with LOS exceeding 60 days and reaching a maximum of 110 days.

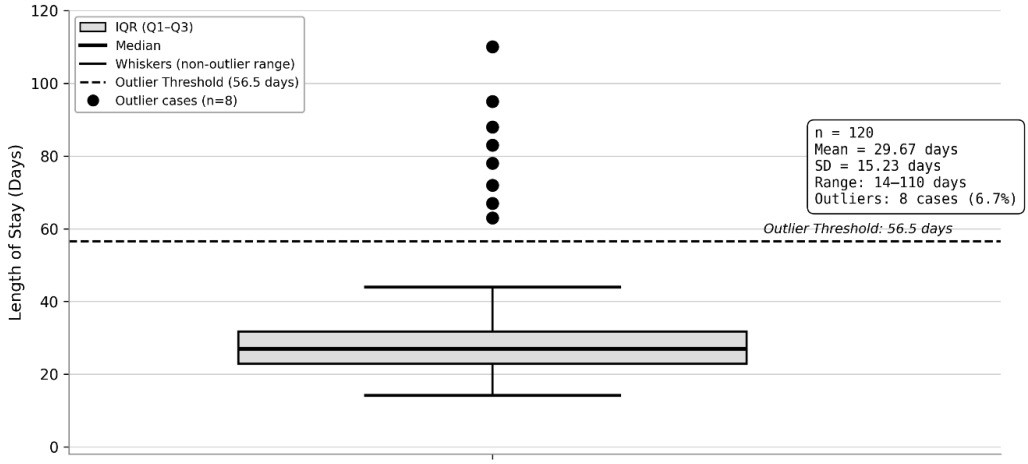
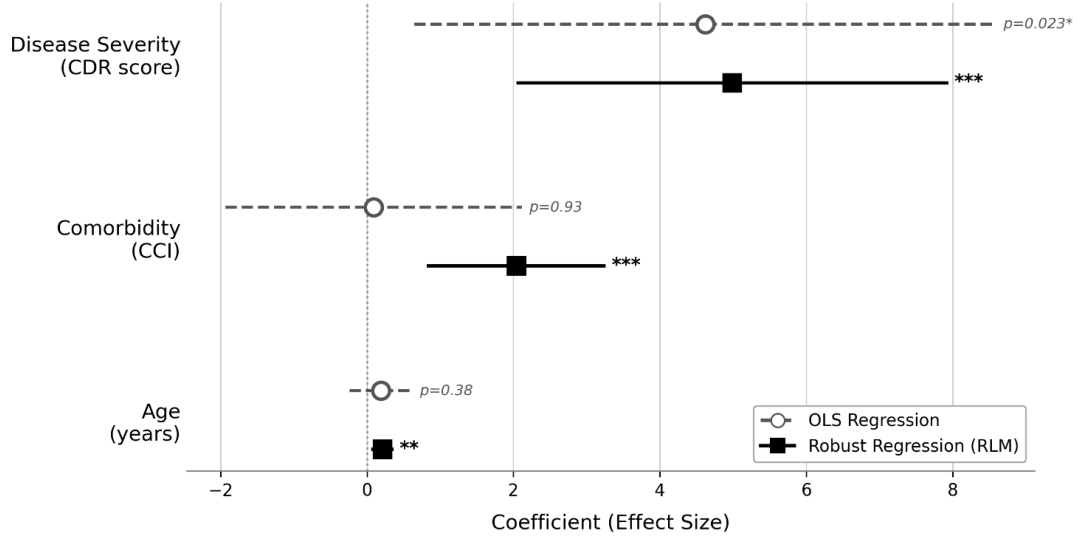


Figure 1 Box plots of the hospital length of stay (LOS) distribution among patients with dementia (n=120), illustrating 8 outlier cases (6.7%) with LOS exceeding 60 days. These outlier patients were characterized by advanced age (>75 years), multiple comorbidities (Charlson Comorbidity Index ≥3), high disease severity (CDR 2–3), and complex behavioral and psychological symptoms (BPSD).



*Note. Error bars represent 95% CI. * p<0.05, ** p<0.01, *** p<0.001.*

Figure 2 Coefficient plots comparing ordinary least squares (OLS) and robust linear model (RLM) estimates with 95% confidence intervals for age, comorbidity burden (CCI), and dementia severity (CDR score) as predictors of hospital length of stay (LOS)

Regression Analysis: OLS vs. Robust Regression

Table 2 Regression Coefficients and Model Fit: OLS vs. Robust Linear Model (RLM)

Variable	OLS Coefficient	OLS *p*-value	RLM Coefficient	RLM *p*-value
Constant	11.25	0.51	1.48	—
Age (years)	0.19	0.38	0.21	0.002**
Comorbidity (CCI)	0.09	0.93	2.04	<0.001***
Severity (CDR score)	4.62	0.023*	4.99	<0.001***
Overall model fit	R^2=0.05 Adj.R^2=0.02 F=1.92 (*p*=0.13)	—	Scale=8.34	—

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$. RLM=Robust Linear Model using IRLS with HuberT norm (tuning constant c=1.345). CDR=Clinical Dementia Rating (0–3); CCI=Charlson Comorbidity Index.

OLS Regression showed no overall statistical significance (R^2=0.05, F=1.92, p=0.13), with only CDR severity significant (β=4.62, p=0.023). In contrast, Robust Regression revealed all three variables were statistically significant: age (β=0.21, p=0.002), CCI comorbidity (β=2.04, $p<0.001$), and CDR severity (β=4.99, $p<0.001$). Disease severity (CDR) exerted the strongest influence on LOS, followed by comorbidity (CCI) and age.

A separate supplementary regression analysis—using age group (≥60 years vs. <60 years) as the independent variable and monthly admission count as the dependent variable—demonstrated that the age group ≥60 years was the strongest predictor of admission volume per month (β=162.37, SE=5.21, $p<0.001$), contextualizing the population burden at this facility.

DISCUSSION

This study identified disease severity (CDR score), comorbidity (CCI), and age as significant predictors of LOS among patients with dementia at Suansaranrom Hospital, using Robust Regression analysis—a method appropriate for this dataset given the confirmed violations of OLS assumptions (heteroscedasticity and non-normality of residuals).

The finding that CDR severity score was the strongest predictor of LOS (β=4.99) is clinically meaningful. Each one-unit increase in CDR score was associated with an approximately 5-day increase in LOS. Patients with CDR 2–3 (moderate to severe dementia) face progressive functional decline, increased dependence, and heightened susceptibility to behavioral complications that complicate discharge planning. CDR score has been validated internationally as a predictor of care complexity.[9] These findings suggest that CDR-based risk stratification at admission could enable earlier mobilization of intensive multidisciplinary support.

Comorbidity burden (CCI) was the second strongest predictor (β=2.04). Each unit increase in CCI corresponded to approximately 2 additional days. Patients with multiple comorbidities (CCI ≥3) require concurrent management of physical conditions alongside dementia care, extending hospitalization due to medication reviews, specialist consultations, and stabilization needs. This aligns with evidence that multimorbidity significantly complicates psychiatric care in elderly populations.[10]

Age was a statistically significant but smaller contributor (β=0.21, *p*=0.002). While each additional year of age corresponded to only 0.2 additional days, the cumulative effect across elderly patients (mean age 72.3 years, 90.3% aged ≥60 years) is clinically relevant. Older age is associated with slower recovery, greater frailty, and reduced physiological reserve, all of which impede timely discharge.

Outlier patients (n=8, LOS>60 days) demonstrated a distinctive clinical profile: all were aged ≥60 years, had CCI≥3 (high comorbidity), CDR 2–3 (severe dementia), and BPSD present in all cases. This cluster of risk factors represents a subgroup with particularly complex care needs.

Based on these findings, the following evidence-based recommendations are proposed for high-risk patients (age>60 years, multiple comorbidities, high CDR score, complex BPSD):

Individualized care plans incorporating CDR score, CCI burden, and BPSD profile should be developed within 24–48 hours of admission, with clear discharge criteria defined prospectively. Weekly or monthly Multidisciplinary Team (MDT) case conferences involving psychiatrists, nurses, physiotherapists, social workers, and pharmacists are recommended to review care plans, monitor progress, and anticipate barriers to discharge. Both pharmacological and non-pharmacological approaches to BPSD management—including structured activities, environmental modification, and sensory stimulation—should be integrated into routine care protocols. Structured family education regarding dementia management, BPSD responses, and post-discharge care is essential to facilitate timely and safe discharge. As the most effective strategy, high-risk patients should ideally be identified and managed through outpatient clinics, community-based care services, or early intervention programs before hospitalization becomes necessary, as proactive pre-admission management through community health stations represents the most effective strategy for reducing LOS and hospital burden.

The difference in OLS versus Robust Regression performance in this study illustrates an important methodological point: when data violate homoscedasticity and contain influential outliers—common characteristics of clinical LOS distributions—standard OLS should be considered when assumptions are violated. The appropriate sequence is to verify assumptions, and if violated, to proceed directly with Robust Regression rather than reporting OLS as a primary analysis.

Study limitations include the retrospective single-site design using secondary data (medical records), which restricted access to potentially important predictors such as family support, social circumstances, premorbid functional status, and patient preferences. Purposive sampling limits generalizability. Future research should employ prospective multi-site designs incorporating a broader range of clinical and psychosocial variables, and explore machine learning approaches to prediction of prolonged LOS.

CONFLICTS OF INTEREST: The authors declare no conflicts of interest.

FUNDING: This study was supported by the Faculty of Nursing, Kasem Bundit University.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the staff of the Medical Records Department at Suansaranrom Hospital for their assistance with data retrieval and thank the Faculty of Nursing, Kasem Bundit University, for providing institutional support throughout the study.

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ORIGINAL ARTICLE

ปัจจัยที่มีอิทธิพลต่อระยะเวลาการนอนรักษาตัวของผู้ป่วยโรคสมองเสื่อมในโรงพยาบาลสวนสราญรมย์ โดยใช้เทคนิคการถดถอยแบบแข็งแกร่ง (Robust Regression)

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บทคัดย่อ

ที่มาของปัญหา: ภาวะสมองเสื่อมเป็นปัญหาสาธารณสุขสำคัญในสังคมผู้สูงอายุ ผู้ป่วยมักต้องนอนรักษาตัวในโรงพยาบาลเป็นระยะเวลานานและมีความแปรปรวนสูง ส่งผลกระทบต่อระบบบริการสาธารณสุข การวิเคราะห์ระยะเวลาการนอนรักษาตัวด้วยวิธีการถดถอยแบบ OLS อาจให้ผลลัพธ์ที่คลาดเคลื่อนเมื่อข้อมูลมีค่าผิดปกติหรือความแปรปรวนไม่คงที่ จึงจำเป็นต้องศึกษาเปรียบเทียบกับวิธีการถดถอยแบบทนทานต่อค่าผิดปกติ

วัตถุประสงค์: เพื่อศึกษาปัจจัยที่มีอิทธิพลต่อระยะเวลาการนอนรักษาตัวในโรงพยาบาล (Length of Stay: LOS) ของผู้ป่วยภาวะสมองเสื่อม และเปรียบเทียบประสิทธิภาพของวิธีการวิเคราะห์การถดถอยแบบกำลังสองน้อยที่สุด (Ordinary Least Squares: OLS) กับการวิเคราะห์การถดถอยแบบทนทานต่อค่าผิดปกติ (Robust Regression) ในบริบทของโรงพยาบาลจิตเวชในประเทศไทย

วิธีการศึกษ: การวิจัยเป็นการศึกษาเชิงวิเคราะห์แบบย้อนหลัง โดยเก็บข้อมูลจากเวชระเบียนผู้ป่วยภาวะสมองเสื่อม จำนวน 120 ราย ที่เข้ารับการรักษา ณ โรงพยาบาลสวนสราญรมย์ ระหว่างเดือนมิถุนายนถึงตุลาคม พ.ศ. 2568 ตัวแปรที่ศึกษา ได้แก่ อายุ ดัชนีโรคร่วมชาร์ลสัน (Charlson Comorbidity Index: CCI) ระดับความรุนแรงของภาวะสมองเสื่อม (Clinical Dementia Rating: CDR) อาการทางพฤติกรรมและจิตใจในภาวะสมองเสื่อม (Behavioral and Psychological Symptoms of Dementia: BPSD) และระยะเวลาการนอนรักษาตัว

ผลการศึกษา: ผู้ป่วยมีระยะเวลาการนอนรักษาตัวเฉลี่ย 29.3±15.2 วัน และพบข้อมูลค่าผิดปกติของ LOS จำนวน 8 ราย (ร้อยละ 6.7) ซึ่งมี LOS มากกว่า 60 วัน การวิเคราะห์ด้วย OLS ไม่พบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติของตัวแปรโดยรวม ขณะที่การวิเคราะห์ด้วย Robust Regression พบว่า อายุ CCI และ CDR มีอิทธิพลต่อ LOS อย่างมีนัยสำคัญทางสถิติ โดยระดับความรุนแรงของภาวะสมองเสื่อม (CDR) เป็นปัจจัยที่มีอิทธิพลสูงที่สุด ส่วน BPSD ไม่พบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับ LOS ในการวิเคราะห์ทั้งสองวิธี นอกจากนี้ยังพบว่ากลุ่มผู้ป่วยอายุ 60 ปีขึ้นไป มีแนวโน้มต้องใช้ระยะเวลาการรักษานานมากขึ้น

สรุป: การวิเคราะห์แบบ Robust Regression มีความเหมาะสมสำหรับข้อมูลทางคลินิกที่มีค่าผิดปกติและความแปรปรวนไม่คงที่มากกว่าวิธี OLS และสามารถสะท้อนปัจจัยที่มีผลต่อระยะเวลาการนอนรักษาตัวของผู้ป่วยภาวะสมองเสื่อมได้อย่างแม่นยำ ผลการศึกษาสามารถนำไปใช้ในการวางแผนการดูแลผู้ป่วยเฉพาะราย การจัดการอาการทางพฤติกรรมและจิตใจอย่างเป็นระบบ การทำงานร่วมกันแบบสหสาขาวิชาชีพ และการพัฒนาระบบการดูแลเชิงป้องกันในชุมชนเพื่อลดระยะเวลาการนอนรักษาในโรงพยาบาลของผู้สูงอายุกลุ่มเสี่ยง

คำสำคัญ: ภาวะสมองเสื่อม, ระยะเวลาการนอนรักษาตัว, เทคนิคการถดถอยแบบทนทาน, ดัชนีภาวะร่วมของโรคชาร์ลสัน, เครื่องมือประเมินความรุนแรงของภาวะสมองเสื่อม, อาการทางพฤติกรรมและจิตใจในภาวะสมองเสื่อม