Factor Associated with 28-Day Mortality in Elderly Patients with Sepsis

Surawit Ruanchan[1,*] and Nootchanath Kongchouy[2]

[1]Master Degree of Applied Statistics, Computational Science Division, Faculty of Science, Prince of Songkla University, Hat Yai Campus, Songkhla 90110, Thailand
[2]Professor of Applied Statistics, Computational Science Division, Faculty of Science, Prince of Songkla University, Hat Yai Campus, Songkhla 90110, Thailand

([*]Corresponding author's e-mail: Surawit.ps@gmail.com)

Abstract

Sepsis remains a leading cause of mortality among older adults worldwide, largely attributable to immunosenescence and multiple chronic comorbidities. This study aimed to determine the 28-day mortality rate and identify factors associated with 28-day mortality among elderly patients hospitalized with sepsis. A retrospective study was conducted among 209 elderly patients diagnosed with sepsis using purposive sampling. Data collected included demographic characteristics, medical diagnoses, and primary sources of infection. Descriptive statistics were used to summarize the data. Differences between survivors and non-survivors were analyzed using chi-square tests. Multivariable logistic regression was performed to identify independent factors of 28-day mortality. The 28-day mortality rate was 40.2%. Although females comprised 53.6% of patients, males accounted for a greater proportion of deaths (52.4%). Septic shock occurred in 65.6% of cases and was associated with a mortality rate of 78.6%. The most common infection source was the respiratory system (50.7%), and 47.8% of patients required intensive care unit (ICU) admission. Respiratory failure (68.4%) and renal failure (52.2%) were the most frequent complications. Non-survivors had a significantly shorter hospital stay compared with survivors (8.88 vs. 17.98 days), indicating early clinical deterioration. Multivariable analysis identified malignancy as the strongest independent factor of mortality (AOR = 15.96, 95%CI = 2.68 - 94.97). Other significant factors included urinary infection (AOR = 3.29, 95%CI = 1.26 - 8.59), ICU admission (AOR = 1.35, 95%CI = 1.07 - 1.71), age (AOR = 1.05, 95%CI = 1.01 - 1.09), length of stay (AOR = 0.90, 95%CI = 0.86 - 0.95), respiratory failure (AOR = 0.38, 95%CI = 0.15 - 0.92), GI infection (AOR = 0.13, 95%CI= 0.03 - 0.58) and GI failure (AOR = 0.11, 95%CI = 0.03 - 0.40). Elderly patients with malignancy or septic shock are at markedly increased risk of early mortality. Prompt recognition and aggressive management, particularly during the first hour of admission, are critical. Implementation of elderly-focused sepsis protocols emphasizing early organ function monitoring may improve survival outcomes.

Keywords: Sepsis, Elderly, 28-day mortality

Presented at the 5th International Conference on Strengthening Community Capacity and Social Support for Older Adults with Chronic Illnesses (March 28, 2026 at Walailak University, Thailand)

Introduction

Sepsis is a critical medical emergency characterized by a dysregulated immune response to infection, primarily entering through the site of infection, most commonly the respiratory, urinary, or gastrointestinal tracts (Rowe & McKoy, 2017). The global burden of sepsis cases is growing in certain areas especially in low- and middle-income countries, the prevalence is significantly higher than in the west, with rates exceeding 1,500 cases per 100,000 people (La Via et al., 2024), leading to an estimated 21.4 million deaths globally (Gray et al., 2025). In Thailand, the mortality rate of sepsis was 29% in 2021 and increased to 35% in 2023 (Health Data Center, Ministry of Public Health, 2025). The risk of adverse outcomes is heavily dictated by demographic factors, specifically advanced *age* and *sex*. Elderly individuals are physiologically vulnerable due to immunosenescence and increased barrier permeability, while Thai clinical data indicates that septic shock and severe infection pathways often vary by gender-based physiological profiles (Rowe & McKoy, 2017; Moustafa et al., 2025). This vulnerability is significantly compounded by comorbidities, such as heart disease, diabetes, and malignancy, with dementia alone increasing the risk of severe infection by 1.5 times (Ibarz et al., 2024; Sitaruno et al., 2025). In Thai tertiary care settings, chronic kidney disease and malignancy are identified as independent predictors of death (Tancharoen et al., 2022).

The progression of sepsis in the elderly is objectively monitored through *laboratory results*, where critical biomarkers such as serum lactate, creatinine, and bilirubin facilitate early identification of systemic distress (Singer et al., 2016). When these markers indicate physiological deterioration, the subsequent development of organ failure particularly within the respiratory and cardiovascular systems becomes the primary driver of mortality. This is especially evident when the site of infection is the lungs, a condition accounting for 41.5% of Thai cases and independently associated with higher 28-day mortality (Tancharoen et al., 2022; Qin et al., 2025).

The clinical severity is further exacerbated by the presence of chronic comorbidities, such as malignancy, chronic kidney disease, and liver disease, which significantly diminish the patient's physiological reserve (Tancharoen et al., 2022; Qin et al., 2025). Notably, research highlights that patients with dementia face a 1.5 times higher risk of developing severe infections (Ibarz et al., 2024). These baseline risks often culminate in septic shock, which remains the most critical factor for mortality in Thailand, with death rates reaching 52.8% compared to 13.5% in those without shock (Tancharoen et al., 2022).

Beyond physiological markers, the clinical trajectory within the hospital defined by age, sex, and the necessity of *ICU* admission serves as a vital prognostic indicator. High-risk interventions and a prolonged *length of stay* further compound the risk specifically, ICU stays exceeding seven days (OR = 4.4) and the requirement for invasive respiratory support, such as mechanical ventilation (OR = 4.9), significantly elevate the odds of death (Kovitangkoon et al., 2017).

As a low-to-middle-income country, including Thailand faces a disproportionately high mortality rate among elderly patients with sepsis. This challenge is compounded by the unique physiological and socioeconomic conditions of Thailand’s aging population. While existing research has largely focused on urban centers in Central Thailand, there is a critical need for regional studies to identify specific prognostic factors for 28-day mortality in diverse clinical settings. Also, this study aims to identify clinical predictors of 28-day survival among elderly sepsis patients at Hatyai hospital in Songkhla province. By identifying these site-specific risk factors, medical teams can better perform early risk stratification and implement targeted, timely interventions to significantly improve survival outcomes for this vulnerable demographic.

Methodology

Study design and setting

This study is a retrospective cohort design to examine the 28-day mortality rate and identify associated factors among elderly patients with sepsis, enrolled from January to December 2022. Data were extracted from the electronic medical records (EMR) system at Hatyai Hospital, a tertiary referral center in Songkhla Province, Thailand.

Population and sample

Population

The study population comprised elderly patients (age ≥ 60 years) diagnosed with sepsis at Hatyai Hospital, Songkhla province This study excluded patients who presented with alternative forms of shock such as hypovolemic or obstructive shock as well as those who experienced sudden cardiac arrest upon admission or presented with extreme hyperlactatemia (lactate levels > 4.0 mmol/L). These exclusions were implemented to minimize confounding variables and ensure that the outcomes analyzed remained specifically attributable to sepsis. This approach ensured that the selected participants with study's inclusion criteria (age ≥ 60 years and SIRS score ≥ 2), thereby enhancing the reliability of the prognostic factor analysis.

Sample size and sample technique

The sample size was calculated using G*Power for logistic regression analysis, with a significance level (α) of 0.05 and a power ($1-\beta$) of 0.80. Based on a baseline mortality rate (P_0) of 38.4% and an anticipated odds ratio of 2.32 (Martin et al., 2006), the calculated requirement was 152 participants; however, to ensure robust data and account for a 20% margin for incomplete records, a final cohort of 209 patients was enrolled using a purposive sampling technique.

Instruments

The patient and medical data collection form was developed through a comprehensive literature review, supplemented by expert clinical input from physicians specializing in sepsis management. The first part included demographic data, gender and age. Medical information included diagnoses of sepsis or septic shock, and underlying comorbidities, included hypertension, diabetes, dyslipidemia, heart disease, chronic kidney disease, chronic lung disease, chronic liver disease, HIV, and cancer. The primary site of infection was also recoded, including respiratory, digestive, urinary, skin, or others. Additionally, data on ICU admissions, length of hospital stay, laboratory results, and 28-day mortality outcomes were collected by the researchers.

Statistical analysis

Descriptive statistics were employed to summarize the data, using means and standard deviations (SD) for continuous variables and frequencies (n) and percentages (%) for categorical variables. To assess differences in risk factors and 28-day mortality between survivors and non-survivors, Chi-square or Fisher's exact tests were utilized for categorical data, while independent t-tests were used for continuous variables

Multivariable logistic regression analysis was used to identify factors associated with 28-day mortality. First, univariate logistic regression was tested for each variable. Variables with *p*-value < 0.05 were then included in the multiple logistic regression analysis using the stepwise method. All statistics were a significant level of $p < 0.05$.

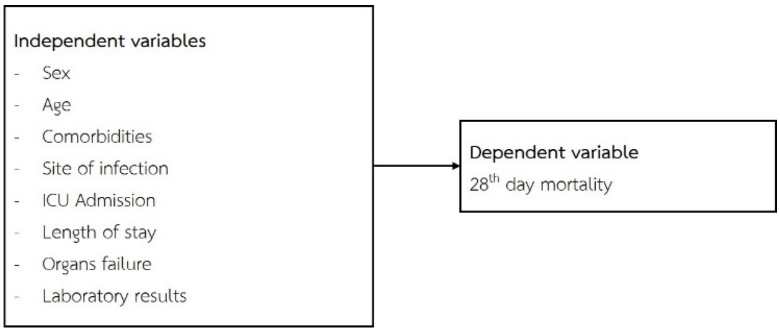

Figure 1 Conceptual framework

Ethical consideration

This study protocol was reviewed and approved by the Institutional Review Board (IRB) of Hat Yai Hospital (Approval No. HYH EC 047-65-01). The researcher submitted a formal request and coordinated with the hospital's Information Technology department through the Director of Hat Yai Hospital to obtain access to the database. After permission was granted, data were collected using the Patient Data Record Form. To ensure participant confidentiality, personal identifiers were replaced with unique study codes for each individual. All research data was stored in a password-protected computer system accessible only by the research team. Furthermore, the findings of this study are presented in an aggregate format only, ensuring that no individual patient can be identified.

Results

The prevalence of 28-day mortality was 40.2%, with mean age 75.17 years old (SD 9.28). Male elderly was a higher prevalence of non-survive than female (44% vs. 40%). Most participants (78.6%) were septic shock and associated with 28-day mortality ($p < 0.001$). Furthermore, malignant was a significant comorbidity that associated with 28-day mortality ($p = 0.01$). Significant of mortality in participants with the primary site of infection included urinary, respiratory, and gastrointestinal system, which related to organ failure (respiratory, renal, hematologic, and gastrointestinal). And ICU admission with length of stay in hospital also associated with 28-day mortality (**Table 1**).

Table 1 Compare survive and non-survive group of 28-day mortality.

Factors	Total (n = 209)	28-day mortality		x^2/f	p-value
		Survive (n = 125)	Non-survive (n = 84)		
Age; years (mean ± SD)	75.17 ± 9.28	74.41 ± 8.88	76.31 ± 9.8	1.10	0.34
Sex - n (%)				2.01	0.10
Female	112 (53.6)	72 (34.5)	40 (65.5)		
Male	97 (46.4)	53 (25.4)	44 (74.6)		
Diagnosis - n (%)				10.55	< 0.001**
Sepsis	72 (34.4)	54 (43.2)	18 (21.4)		
Septic shock	137 (65.6)	71 (56.8)	66 (78.6)		
Comorbidities - n (%)					
Hypertension	151 (72.2)	94 (45.0)	57 (55.0)	1.35	0.16
Diabetes mellitus	92 (44)	58 (27.8)	34 (72.2)	0.72	0.24
Dyslipidemia	76 (36.4)	49 (23.4)	27 (76.6)	1.08	0.19
Heart disease	50 (23.9)	31 (14.8)	19 (22.6)	0.13	0.42
Chronic kidney disease	37 (17.7)	22 (10.5)	15 (89.5)	0.00	0.55
Lung disease	30 (14.4)	17 (8.1)	13 (91.9)	0.14	0.43
Malignancy	19 (9.1)	6 (2.9)	13 (97.1)	6.93	0.01*
Chronic liver kidney	5 (2.4)	3 (1.4)	2 (98.6)	0.00	0.68
Site of infection - n (%)					
Urinary	63 (30.1)	50 (23.9)	13 (76.1)	14.35	< 0.001**
Respiratory	106 (50.7)	47 (22.5)	59 (77.5)	21.41	< 0.001**
Gastrointestinal	23 (11)	19 (9.1)	4 (90.1)	5.59	0.01*
Skin	10 (4.8)	7 (3.3)	3 (96.7)	0.45	0.37
ICU admission - n (%)	100 (47.8)	40 (19.1)	60 (80.9)	31.30	< 0.001**
Organ failure - n (%)					
Respiratory	143 (68.4)	64 (30.6)	79 (69.4)	42.69	< 0.001**
Renal	109 (52.2)	52 (24.9)	57 (75.1)	13.88	< 0.001**
Hematologic	34 (16.3)	8 (3.8)	26 (96.2)	22.23	< 0.001**
Gastrointestinal	33 (15.8)	7 (3.3)	26 (96.7)	24.29	< 0.001**
Length of stay; days (mean ± SD)	14.32 ± 15.81	17.98 ± 18.67	8.88 ± 7.47	1.96	< 0.001**
White blood cell count; $\times 10^3$ / mm^3 (mean ± SD)	12.73 ± 7.54	13.55 ± 7.07	11.53 ± 8.08	0.59	0.86
Platelet count; $\times 10^3/mm^3$ (mean ± SD)	202.10 ± 123.27	207.38 ± 110.37	194.24 ± 140.63	0.68	0.95

Factors	**Total (n = 209)**	**28-day mortality**		x^2/f	***p*-value**
		Survive (n = 125)	**Non-survive (n = 84)**		
Blood urea nitrogen; mg/dL (mean ± SD)	32.14 ± 21.46	29.08 ± 19.42	36.71 ± 23.56	1.19	0.19
Creatinine; mg/dL (mean ± SD)	2.01 ± 1.68	1.75 ± 1.37	2.40 ± 1.99	1.32	0.11
Initial lactate level; mmol/L (mean ± SD)	2.89 ± 2.23	2.39 ± 1.61	3.63 ± 2.76	1.02	0.45
Albumin; g/dL (mean ± SD)	2.91 ± 0.77	3.02 ± 0.76	2.75 ± 0.77	1.20	0.21

* *p*-value < 0.05, ** *p*-value < 0.001.

This study examined the adjusted odd ratios of factor associated with 28-day mortality among elderly with sepsis patients. The analysis reveals that patients with malignant had the highest risk factor associated with mortality rate (AOR = 15.96, 95%CI = 2.68 - 94.97). Additionally, length of stay (AOR = 0.90, 95%CI = 0.86 - 0.95) and ICU admission (AOR = 1.35, 95%CI = 1.07 - 1.71) were a high-risk factor of 28-day mortality. The significant site of infection including urinary (AOR = 3.29, 95%CI = 1.26 - 8.59) and GI (AOR = 0.13, 95%CI = 0.03 - 0.58) associated with mortality rate. Furthermore, respiratory (AOR = 0.38, 95%CI = 0.15 - 0.92) and GI (AOR = 0.11, 95%CI = 0.03 - 0.40) organ failure also associated with 28-day mortality (**Table 2**).

Table 2 Factors associated with 28-day mortality in elderly sepsis with sepsis.

Factors	**B**	**S.E.**	**Wald**	**AOR (95%CI)**	***p*-value**
Constant	−2.71	2.13	1.61	0.07	0.204
Age (years)	0.05	0.02	4.43	1.05 (1.01 - 1.09)	0.035*
Length of stay (days)	−0.10	0.03	17.50	0.90 (0.86 - 0.95)	< 0 .001**
Comorbidities; Malignancy (Yes)	2.77	0.91	9.19	15.96 (2.68 - 94.97)	0.007*
Site of infection					
Urinary (Yes)	1.19	0.49	5.89	3.29 (1.26 - 8.59)	0.015*
Gastrointestinal (Yes)	−2.02	0.75	7.19	0.13 (0.03 - 0.58)	0.002*
ICU admission (Yes)	0.30	0.12	6.43	1.35 (1.07 - 1.71)	0.033*
Organ failure;					
Respiratory (Yes)	−0.98	0.46	4.54	0.38 (0.15 - 0.92)	0.001*
Gastrointestinal (Yes)	−2.18	0.64	11.54	0.11 (0.03 - 0.40)	0.018*

* *p*-value < 0.05, ** *p*-value < 0.001 Independence variables: Age, sex, diagnosis, comorbidities, site of infection, icu admission, organ failure, length of stay, white blood cell count, platelet count, blood urea nitrogen, creatinine, initial lactate level and albumin.

Discussion

The results of this study highlight a significant clinical challenge, revealing a 28-day mortality rate of 40.2% among elderly sepsis patients at Hat Yai Hospital. This figure exceeds the national average of 35% reported by the Thai Ministry of Public Health (2025), suggesting that regional tertiary centers in Southern Thailand may encounter cases with greater physiological complexity and severity. These findings align with prior research (Tancharoen et al., 2022), confirming that sepsis remains a primary driver of mortality within Thailand's aging population.

Interestingly, *sex* was not a statistically significant factor (44% in men vs. 40% in women), supporting the theory that age-related immunosenescence the progressive erosion of the immune system affects the elderly demographic uniformly. This lack of gender disparity contrasts with some Western studies that suggest a protective effect of estrogen in younger females, but aligns with Rowe & McKoy (2017), who argue that post-menopausal physiological changes level the risk between sexes in geriatric populations. Furthermore, the rapid clinical decline seen in non-survivors (mean length of stay of 8.8 days vs. 18 days for survivors) reinforces the critical window concept found in recent Southeast Asian research, where the first 72 to 96 h dictate the ultimate survival outcome (Singkun et al., 2023).

The site of infection proved decisive, with respiratory (50.7%) and urinary (30.1%) infection being the most lethal ($p < 0.001$). These findings are consistent with the Surviving Sepsis Campaign's global observations and local data from Suksai (2025), which consistently identify pneumonia as the primary catalyst for sepsis-related death in Thailand. Pathophysiologically, the reduced pulmonary compliance and weakened cough reflex in the elderly lead to rapid respiratory failure and a subsequent need for mechanical ventilation, a high-risk factor identified in multiple Thai ICU cohorts (Kovitangkoon et al., 2017). Additionally, urinary infections posed a substantial risk (AOR = 3.29, 95%CI = 1.26 - 8.59). This corroborates research by Dülger *et al.* (2025), which highlights that invasive devices like urinary catheters provide a direct gateway for multidrug-resistant pathogens. When these infections disseminate, they trigger a domino effect of organ failure ($p < 0.001$), where the failure of the respiratory system initiates a systemic shutdown due to inadequate oxygenation, a phenomenon described as multi-organ crosstalk in recent critical care literature (Qin et al., 2025).

The most significant independent risk factor identified was comorbidity, specifically malignancy. Patients with malignancy were nearly 16 times more likely to die (AOR = 15.96, 95% CI: 2.68 - 94.97, $p = 0.007$). This risk is substantially more pronounced than the 2.37-fold increase reported in the Bangkok-based SITU study (Tancharoen et al., 2022), highlighting a possible regional disparity in oncology-sepsis management. This double-hit phenomenon where the frailty of advanced age is compounded by malignancy-induced immunosuppression leaves the patient with virtually no physiological defense (Ellaithy et al., 2025). Other critical indicators, such as advancing age (5% increased risk per year) and the necessity of ICU admission (AOR = 1.35, 95%CI = 1.07 - 1.71), serve as definitive markers of clinical severity. These factors, alongside abnormal laboratory results (such as elevated lactate and creatinine), provide a validated framework for early risk stratification.

For a primary strength of this research is its focus on a major regional tertiary center in Southern Thailand. While a significant portion of sepsis research in the country is conducted in Bangkok, this study provides vital, localized evidence for clinicians at Hatyai Hospital. By specifically analyzing patients aged 60 and older, the study addresses the most vulnerable and fastest-growing demographic in Thailand's aging society. Furthermore, the use of multivariate analysis allowed for the precise identification of high-impact prognostic factors, confirming that malignancy and septic shock are the most critical red flags for mortality. This provides a clear, evidence-based roadmap for early intervention in a real-world clinical setting. However, several limitations must be acknowledged. As a single-center study, the findings may not be fully generalizable to smaller rural clinics or other regions with different resource levels. Additionally, the retrospective design limited the researchers to data already documented in past medical records, which may lack certain biological markers or specific clinical details. Furthermore, the 28-day follow-up period focuses only on short-term survival, consequently, the study does not capture long-term recovery outcomes or the prevalence of Post-Sepsis Syndrome after hospital discharge. Future research should consider a multi-center approach and longer observation periods to better understand the long-term functional recovery of elderly Thai survivors.

Conclusions

In conclusion, this study shows that sepsis is very deadly for older people, with about 40% of patients dying within 28 days. The main driver of these deaths was septic shock, which affected nearly 80% of those who did not survive. The biggest risk factor was cancer, which made a patient almost 16 times more likely to die. This happens because of a double hit, the body is already weak from old age and then made even weaker by cancer and its treatments. Most infections started in the lungs or the urinary tract, and these deaths happened very quickly which usually within 9 days. This rapid decline was caused by a domino effect where the lungs, kidneys, and digestive systems all stopped working at the same time. Older age and needing to go to the ICU were also major signs that a patient was in high danger.

Based on these results, while Thai hospitals already use systems like qSOFA and NEWS, we suggest moving toward a more proactive and personalized approach. Since malignancy and lung infections are such high risks, hospitals should consider using AI-driven screening that automatically flags cancer patients the moment their lab results change, even before their vital signs drop. Following the Surviving Sepsis Campaign (Evans et al., 2021), the Golden Hour should not just be about giving fluids, but also about early lung protection (such as using high-flow oxygen early) to prevent the domino effect of organ failure. As suggested by Sitaruno et al. (2025), the focus should shift from just finding sepsis to pre-sepsis monitoring, using wearable sensors that track heart rate changes all the time. Additionally, because urinary tract infections remain a major risk, hospitals should move beyond basic care and use Antimicrobial Stewardship, a system that ensures the right antibiotics are used immediately to stop resistant bacteria (Rowe & McKoy, 2017). Future research should also look at biomarkers (special blood tests) that can predict which elderly patients will crash fastest, helping doctors at Hatyai hospital provide even more precise and life-saving care.

Acknowledgements

This research was successfully completed with the invaluable support and contributions of many individuals. I would like to express my deepest gratitude to my advisor, Asst. Dr. Noodchanath Kongchouy, for her exceptional guidance, academic mentorship, and unwavering support throughout every stage of this study.

I also wish to extend my sincere thanks to Dr. Chutima Cheranakhorn and Dr. Sorawat Sangkaew, doctors at Hat Yai Hospital, for their precious advice regarding the study design, data collection, data management, and statistical analysis. Furthermore, I am grateful to the Human Research Ethics Committee of Hat Yai Hospital for their review and approval of this work.

Finally, I would like to express my profound gratitude to all participants and volunteers who generously sacrificed their time to participate in this study. Their cooperation provided the essential data that made this research possible. The researcher is truly grateful for all the support received.

References

Dülger, D., Ture, Z., Yolcu, A., Eren, E. E., Sanlier, N., & Alp, E. (2025). Sepsis in elderly patients: Investigation of prognostic factors in a secondary healthcare facility. *BMC Infectious Diseases, 25*, 907.

Ellaithy, I., Elshiekh, H., Elshennawy, S., Elshenawy, S., Al-Shaikh, B., & Ellaithy, A. (2025). Sepsis as a cause of death among elderly cancer patients: An updated SEER database analysis 2000-2021. *Annals of Medicine and Surgery, 87*(4), 1838–1845.

Evans, L., Rhodes, A., Alhazzani, W., Antonelli, M., Coopersmith, C. M., French, C., Machado, F. R., Mcintyre, L., Ostermann, M., Prescott, H. C., Schorr, C., Simpson, S., Wiersinga, W. J., Alshamsi, F., Angus, D. C., Arabi, Y., Azevedo, L., Beale, R., Beilman, G., … Levy, M. (2021). Surviving sepsis campaign: International guidelines for management of sepsis and septic shock 2021. *Intensive Care Medicine, 47*(11), 1181–1247.

Gray, A. P., Chung, E., Hsu, R. L., Araki, D. T., Hayoon, A. G., Weaver, N. D., Swetschinski, L. R., Wool, E. E., Han, C., Mestrovic, T., Ikuta, K. S., Abbas, N., Abbasi, M., ElHafeez, S. A., Abdisa, W. M., Abdoun, M., Abdullahi, A., Abebe, M., Abejew, A. A., … Naghavi, M. (2025). Global, regional, and national sepsis incidence and mortality, 1990–2021: A systematic analysis. *The Lancet Global Health, 13*(12), e2013–e2026.

Health Data Center, Ministry of Public Health. (2025). *Health data and epidemiological statistics of Thailand.* https://hdc.moph.go.th

Ibarz, M., Haas, L. E. M., Ceccato, A., & Artigas, A. (2024). The critically ill older patient with sepsis: A narrative review. *Annals of Intensive Care, 14*(1), 6.

Kovitangkoon, K., Putthanachote, N., Sangsa, N., Kaewmafai, J., & Sarakran, P. (2017). Factors Associated with Bacterial Septicemia among Patients in Intensive Care Unit, Roi Et Hospital, Roi Et Province. *Srinagarind Medical Journal, 32*(2), 111–118.

La Via, L., Sangiorgio, G., Stefani, S., Marino, A., Nunnari, G., Cocuzza, S., La Mantia, I., Cacopardo, B., Stracquadanio, S., Spampinato, S., Lavalle, S., & Maniaci, A. (2024). The Global Burden of Sepsis and Septic Shock. *Epidemiologia, 5*(3), 456–478. https://doi.org/10.3390/epidemiologia5030032

Martin, G. S., Mannino, D. M., Eaton, S., & Moss, M. (2003). The epidemiology of sepsis in the United States from 1979 through 2000. *The New England Journal of Medicine, 348*(16), 1546–1554.

Martin, G. S., Mannino, D. M., Eaton, S., & Moss, M. (2003). The epidemiology of sepsis in the United States from 1979 through 2000. *The New England Journal of Medicine, 348*(16), 1546–1554. https://doi.org/10.1056/NEJMoa022139

Ministry of Public Health. (2025). *Annual health statistics report 2024: Mortality and key health indicators in Thailand.* Health Data Center. https://hdc.moph.go.th/center/public/main

Moustafa, H. A. M., Montasser, M., Ahmed, I., Mansy, A. E. A., & Habib, T. (2025). Impact of sex on outcomes in septic shock patients treated with hydrocortisone. *Scientific Reports, 15*, 42924.

Qin, C., Ma, D., Pang, L., Hu, M., Lin, S., Zhou, Z., Xu, X., & Ji, C. (2025). Prognostic factors of sepsis: A systematic review and meta-analysis. *BMC Infectious Diseases, 25*, 1670.

Rowe, T. A., & McKoy, J. M. (2017). Sepsis in Older Adults. *Infectious Disease Clinics of North America, 31*(4), 731–742.

Singer, M., Deutschman, C. S., Seymour, C. W., Shankar-Hari, M., Annane, D., Bauer, M., Bellomo, R., Bernard, G. R., Chiche, J.-D., Coopersmith, C. M., Hotchkiss, R. S., Levy, M. M., Marshall, J. C., Martin, G. S., Opal, S. M., Rubenfeld, G. D., van der Poll, T., Vincent, J.-L., & Angus, D. C. (2016). The Third international consensus definitions for sepsis and septic shock (Sepsis-3). *JAMA, 315*(8), 801–810.

Singkun, S., Chaveepojnkamjorn, W., Ekcjariyawat, P., & Mongkolsomlit, S. (2023). Association between length of stay and healthcare-associated infections among inpatients in a secondary health care hospital. *Universal Journal of Public Health, 11*(6), 792–799.

Sitaruno, S., Jaroenmark, T., Wani, A., Dangchuen, T., Binyala, W., Morapan, N., & Vattanavanit, V. (2025). Epidemiology of sepsis and septic shock in the medical intensive care unit after implementing the national early warning score for sepsis detection. *Journal of Health Science and Medical Research, 43*(6), e20251181.

Suksai, M. (2025). Risk factors for septic shock in adult patients: Evidence from a General Hospital. *Journal of the Medical Association of Thailand, 108*(12), 986.

Tancharoen, L., Pairattanakorn, P., Thamlikitkul, V., & Angkasekwinai, N. (2022). Epidemiology and Burden of Sepsis at Thailand's Largest University-Based National Tertiary Referral Center during 2019. *Antibiotics, 11*(7), 899.