Original Article

# The optimal oral body temperature cutoff and other factors predictive of sepsis diagnosis in elderly patients

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**Abstract:**

**INTRODUCTION:** The aim of this study was to identify the optimal oral temperature cut-off value and other factors predictive of sepsis in elderly patients presenting to emergency department.

**METHODS:** A hospital-based retrospective study was performed on all elderly patients who presented to the Adult Emergency Department at King Abdulaziz Medical City in Riyadh (January to December 31, 2018).

**RESULTS:** Of total of 13,856 patients, 2170 (15.7%) were diagnosed with sepsis. The associated area under the curve estimate was 0.73, 95% confidence interval (CI) 0.72–0.74. Body temperature ≥37.3 was found as optimal cut-point with sensitivity = 50.97% and specificity = 87.22% and 82.39% of patients with sepsis will be correctly classified using this cut-off. An increase of 1° in body temperature was associated with an odds ratio of 9.95 (95% CI 8.95–11.06, $P < 0.0001$). Those aged ≥100 years having 11.12 (95% CI 2.29–20.88, $P < 0.0001$) times the likelihood for sepsis diagnosis compared with those aged 60–69 years. People admitted in weather such as winter, spring, or autumn were more likely to develop sepsis than people admitted in summer.

**CONCLUSION:** The risk factors of sepsis such as age, temperature, and seasonal variation inform important evidence-based decisions. The hospitals dealing with sepsis patients should assess older patients for other severe illnesses or co-morbid that might lead to sepsis if left untreated. Therefore, older patients need to be prioritized over younger patients. The body temperature of patients admitted to hospitals needs to be monitored critically and it is important to consider seasonal fluctuations while managing cases of sepsis and allocating resources. Our findings suggest that clinicians should explore the possibility of sepsis in elderly patients admitted to emergency units with oral temperature ≥37.3°C. Risk factors for sepsis reported in this study could inform evidence-based decisions.

**Keywords:**

Elderly people, risk factors, Saudi Arabia, Sepsis, temperature cut-off

The elderly people are more susceptible to infection and have a higher morbidity and mortality rate than younger individuals. It is estimated that 60% of all sepsis is diagnosed in patients older than 65 years.[1] In severe sepsis, age is an independent risk factor for increased mortality in the elderly and the very elderly.[2] Therefore, early identification and accurate diagnosis of sepsis are vital. However, infections in the elderly present in nonclassical and can have atypical presentations. Fever, the most cardinal finding may be absent or blunted.[3] Temperature does not rise or rises modestly in septic elderly patients either due to a lower-than-normal baseline temperature or due to their weakened thermoregulatory response. Previous studies showed the baseline temperature of the elderly to be lower than what we regard as normal.[3] Mean morning rectal temperatures of young healthy people were 37.3°C, while mean



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morning rectal temperatures were 36.7°C in frail elderly patients.[4] While many studies have shown that 20–30% of the elderly presenting with serious bacterial infections have no temperature response.[5] Another study on acute surgical abdomens, such as appendicitis, acute cholecystitis, and perforation, has shown that the elderly had temperatures below 37.5°C.[6] An attempt to identify a cut-off for fever in the elderly in nursing homes showed that the most sensitive cut-off for fever in nursing home residents was >37.2°C.[7] However, nursing home residents do not represent the whole spectrum of elderly patients presenting to the emergency department. The objective of this study is to determine incidence, risk factors and the most accurate oral temperature measurement cut-off for sepsis diagnosis in hospitalized patients older than 60 years.

## Methods

A hospital-based retrospective study was performed on all elderly patients who presented to the adult emergency department (ED) at King Abdulaziz Medical City in Riyadh (KAMC-RD), which is the largest university hospital in Saudi Arabia. We included the visits of all adults aged 60 years or older, to the ED of KAMC-RD between January 1, 2018, and December 31, 2018. ED visits that were due to cardiac arrests, or those that did not acquire temperature measurement of the patient were excluded.

In 2015, KAMC-RD implemented an electronic medical record-integrated database: BESTCare. The following data were retrieved from the BESTCare database: Age, gender, causes of ED initial visit, the date/time of ED arrival, the emergency department diagnosis, the inpatient diagnosis, and the vital signs (heart rate, temperature, blood pressure, and respiratory rate). The temperature measurements in the emergency department that were recorded on BESTCare were oral temperatures. All the temperatures measured during the ED visit were recorded. We have observed the values of the highest temperature recording during each visit for the purpose of the analyses.

The unit of analysis in our study was the ED visit of a patient older than or equal to 60 years. All patients presenting during the study period were followed from initial clinic visit till the last clinic visit. All visits made by each patient were included in the analysis. The primary outcome of the study was diagnosing sepsis during that ED visit. The outcome was determined by reviewing the final diagnosis of the ED visit and the final diagnosis of the inpatient admission that followed. The International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian modification (version 2010) code, chapters I–XXII, was used to map and classify the diagnosis of each ED visit. They were reviewed by three independent emergency physicians who also screened all the relevant diagnoses and determined if the patient had sepsis, as shown by signs of severe sepsis, culture results, or the final judgment of the admitting service. Patients with a clear diagnosis of pneumonia and pyelonephritis were regarded as having sepsis even if they were treated in the outpatient, due to the severity of these infections. The diagnoses of pharyngitis, viral illness, and urinary cystitis may or may not be associated with fever in an average person, so they were not regarded as infections leading to sepsis unless they required admission to the hospital to treat the clinical condition.

### Ethical approval

Ethical approval has been granted by the IRB, King Abdullah International Medical Research Center on April 25, 2019, with reference number IRBC/0565/19. The research article was carried out followed by the principles mention in the Declaration of Helsinki and the written informed consent was taken from all patient before recruitment.

### Statistical methodology

Patients were stratified by sepsis status and descriptive statistics were reported for each group as means (standard deviation [SD]) and proportions (%). Contiguous data were compared using the $t$-test and categorical data using the $\chi^2$ test. Sensitivity, specificity, positive and negative likelihood ratio tests were calculated for sepsis diagnosis at different body temperature cut-offs. A receiver-operator characteristic curve (ROC) was constructed to calculate area under the curve (ROC) (AUC). Univariate and multivariate repeated-measures mixed-effects logistic regression analysis was conducted to determine factors associated with sepsis accounting for all the repeated measures taken from each patients. Further, a mix-effects model was fitted to estimate the marginal means of temperature by age category and season. All tests were two-sided and a $P < 0.05$ was considered statistically significant. Analysis was conducted using the STATA (version 12, StatCorp LLC, Texas, USA) statistical software.

## Results

The study included a total of 13,856 patients. Of these, 2170 (15.7%) were diagnosed with sepsis and the rest (11,656 [84.3%]) had diagnoses other than sepsis. During study follow-up period, a total of 26,376 visits were recorded: 2921 visits in the sepsis group and 23,455 in the sepsis-free group. Baselines mean (SD) body temperature was significantly higher in the sepsis group (37.6 [0.82]) compared with the sepsis-free group (36.9 [0.32]), $P < 0.0001$. Sex distribution in the two groups was similar; approximately 52% of patients in both groups were males ($P = 0.760$). Sepsis-free group patients were relatively younger with a larger proportion (82.2%) of patients aged between 60 and 79 years compared with 66.1% in the sepsis group, $P < 0.0001$. In the sepsis group, a larger proportion (60.1%) of patients were diagnosed during the spring and winter. However, the two groups differed significantly by the time of clinic visit, $P < 0.0001$ [Table 1].

Figure 1 shows the ROC curve. The associated AUC estimate was 0.73, 95% confidence interval (CI) 0.72–0.74. Table 2 shows the diagnostic utility for different body temperatures cut points between 36.2°C and 38.2°C for sepsis diagnosis. The table shows that the body temperature ≥37.3°C is the optimal cut-point at which the sensitivity is 50.97%, the specificity is 87.22% and that 82.39% of patients with sepsis will be correctly classified, taking into account the fact that the optimal cut-point is the value at which sensitivity and specificity are closet to the value of the AUC and the absolute value of the difference between the sensitivity and specificity is minimum together with a higher proportion of patients will be correctly classified as having the disease.

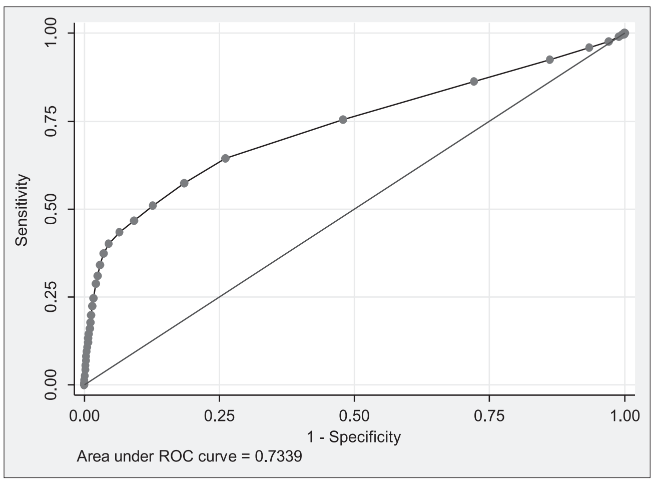


**Figure 1:** Receiver-operator characteristic curve. Area under the curve (AUC = 0.73; 95% confidence interval 0.72–0.74)

In a stratified analysis, the AUC estimates, although not markedly different, was larger in younger patients; ranging between 0.751 (95% CI 0.733–0.769) and 0.699 (95% CI 0.602–0.795) in those aged 60–69 years and ≥100 years, respectively. Further, the AUC estimates for patients visiting the clinic at the different four seasons of the year were similar to the overall AUC estimate of 0.73 [Table 3].

In the repeated measure mixed-effects analysis conducted to estimate the marginal means of body temperature, a significantly higher marginal mean temperature was consistently observed between patients in the sepsis group and those in the sepsis-free group across the four seasons of the year ($P < 0.0001$). Those with sepsis had estimates consistently ranging between 37.5° and 37.6° degrees and those who remained sepsis-free had estimates consistently ranging between 36.9° and 37.0° [Figure 2]. This difference was also observed when patients in the two comparison groups were stratified by age category [Figure 3]. Patients with sepsis had higher body temperature ranging between 37.6° and 37.7° whereas those without sepsis had a body temperature ranging between 37.0 and 37.1. However, in both groups, body temperature was higher in older patients. A repeated-measures mixed effects logistic regression analysis was conducted to determine factors associated with sepsis diagnosis. Factors found significant in univariable analysis were body temperature, age category, and season of the year. These factors remained significantly independently associated with the likelihood of sepsis diagnosis in multivariable analysis.

**Table 1: Baseline characteristics of patients**

| Characteristics | No sepsis group (*n*=11,686) | Sepsis group (*n*=2170) | *P** |
|---|---|---|---|
| Normal body temperature, mean (SD) | 36.98 (0.32) | 37.61 (0.82) | <0.0001 |
| Age category | | | |
| 60-69 | 5738 (49.1) | 669 (30.8) | <0.0001 |
| 70-79 | 3995 (34.2) | 766 (35.3) | |
| 80-89 | 1599 (13.7) | 556 (25.6) | |
| 90-99 | 315 (2.7) | 149 (6.9) | |
| ≥100 | 39 (0.3) | 30 (1.4) | |
| Sex | | | |
| Male | 6049 (51.8) | 11,131 (52.1) | 0.760 |
| Female | 5637 (48.2) | 11,039 (47.9) | |
| Season | | | |
| Summer | 3054 (26.1) | 463 (21.3) | <0.0001 |
| Autumn | 2175 (18.6) | 390 (18.0) | |
| Spring | 3733 (31.9) | 733 (33.8) | |
| Winter | 2724 (23.3) | 584 (26.9) | |

**P*: $\chi^2$ for categorical variables and *t*-test for continuous variables. SD=Standard deviation

An increase of one degree in body temperature was associated with an odds ratio of 9.95 (95% CI 8.95–11.06, $P < 0.0001$). Further, the likelihood of sepsis diagnosis gradually increased by age with those aged ≥100 years having 11.12 (95% CI 2.29–20.88, $P < 0.0001$) times the likelihood for sepsis diagnosis compared with those aged 60–69 years [Table 4].

## Discussion

We undertook this study to determine incidence, risk factors, and the most accurate oral temperature measurement cut-off for sepsis diagnosis in hospitalized patients older than 60 years presenting to the emergency department. We found that around 16% of elderly patients presenting to the ED were eventually diagnosed with sepsis. Our validity analysis revealed a temperature of at least 37.3°C centigrade as a cut-off with reasonable sensitivity and specificity and this cut-of helped to diagnose around 83% of the patients with sepsis correctly. The independent predictors of sepsis included body temperature, age, and type of weather. More specifically, with every 1° centigrade increase in the body temperature, the odds of having sepsis increased by 9.95 with significant results. Likewise, older people beyond 70 years were more likely to develop sepsis than younger patients and we found a dose-response relationship between age and sepsis. We also found that

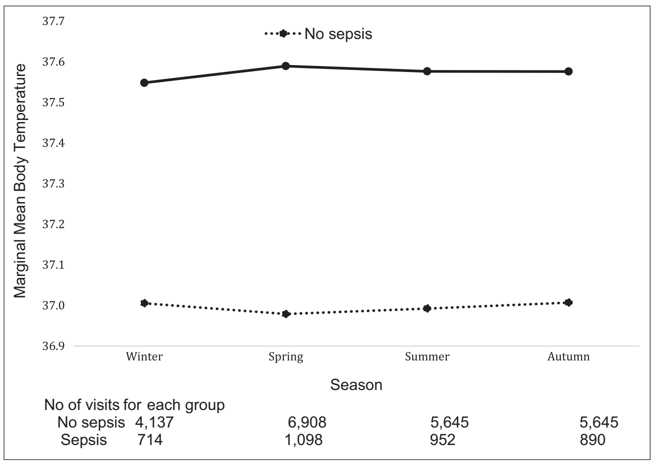


**Figure 2:** Seasonal trend of marginal mean of body temperature among study participants

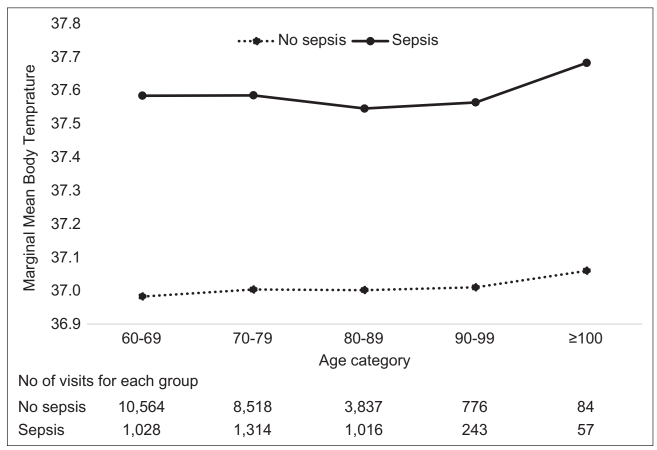


**Figure 3:** Trend of marginal mean body temperature by age groups among study subjects

**Table 2: Sensitivity, specificity, positive and negative likelihood ratio test for sepsis diagnosis at different body temperatures cut-points between 36.2°C and 38.2°C**

| Body temperature | Sensitivity (%) | Specificity (%) | Correctly classified (%) | $LR^+$ | $LR^-$ |
|---|---|---|---|---|---|
| ≥36.2 | 99.75 | 0.14 | 13.42 | 0.999 | 1.7212 |
| ≥36.3 | 99.70 | 0.27 | 13.52 | 0.9997 | 1.1177 |
| ≥36.4 | 99.48 | 0.55 | 13.74 | 1.0003 | 0.9431 |
| ≥36.5 | 99.04 | 1.09 | 14.15 | 1.0013 | 0.8787 |
| ≥36.6 | 97.65 | 2.88 | 15.52 | 1.0055 | 0.8152 |
| ≥36.7 | 96.01 | 6.51 | 18.43 | 1.0269 | 0.6137 |
| ≥36.8 | 92.53 | 13.74 | 24.24 | 1.0727 | 0.5434 |
| ≥36.9 | 86.38 | 27.80 | 35.61 | 1.1964 | 0.4898 |
| ≥37 | 75.39 | 52.11 | 55.21 | 1.5741 | 0.4723 |
| ≥37.1 | 64.42 | 73.95 | 72.68 | 2.4734 | 0.4811 |
| ≥37.2 | 57.40 | 81.50 | 78.28 | 3.102 | 0.5228 |
| ≥37.3 | 50.97 | 87.22 | 82.39 | 3.9897 | 0.5621 |
| ≥37.4 | 46.73 | 90.81 | 84.93 | 5.0837 | 0.5866 |
| ≥37.5 | 43.51 | 93.46 | 86.80 | 6.6531 | 0.6045 |
| ≥37.6 | 40.09 | 95.45 | 88.07 | 8.8185 | 0.6277 |
| ≥37.7 | 37.33 | 96.49 | 88.61 | 10.6427 | 0.6495 |
| ≥37.8 | 34.18 | 97.13 | 88.74 | 11.9008 | 0.6777 |
| ≥37.9 | 31.09 | 97.56 | 88.70 | 12.7254 | 0.7063 |
| ≥38 | 28.82 | 97.92 | 88.71 | 13.874 | 0.7269 |
| ≥38.1 | 24.64 | 98.32 | 88.50 | 14.6838 | 0.7665 |
| ≥38.2 | 22.42 | 98.51 | 88.37 | 15.0625 | 0.7875 |

people admitted in weather such as winter, spring, or autumn were more likely to develop sepsis than people admitted in summer.

Our findings regarding age being a risk factor for sepsis are analogous to the findings of other studies conducted across the world. For instance, a systematic review conducted by Fathi *et al*. demonstrated age as an important risk factor for sepsis with a higher likelihood of sepsis among older patients.[8] In addition, the longitudinal cohort has reported a direct relationship between age and sepsis, implying that the risk of sepsis increases with increasing age.[9,10] It has been demonstrated that particularly aged people are more prone to develop sepsis and two-third of all admitted patients in the hospitals of the USA are diagnosed with sepsis.[11] These findings regarding the relationship between older age and sepsis can be explained by several reasons that are multifactorial in nature. Some of these reasons could be a due decline in the physiologic reserve among the elderly, compromised immune system, sensitive clinical presentations, repeated use of invasive devices, and frequent admission into the hospital that can increase the chances of nosocomial infection, thereby sepsis.[12] Besides, older patients are also more likely to suffer from comorbid such as cardiovascular disease and chronic obstructive pulmonary disease, which might explain an increased predisposition to sepsis among elderly patients than younger patients.[11,13] Further, most of the epidemiological research studies suggest that around 60% of sepsis occurs among patients older than 65 years of age. These findings indicate that like industrialized countries, a higher proportion of aged people due to change in the demographics and longevity might describe the rising rate of sepsis cases even in countries like Saudi Arabia, which is consistent with findings from other developed countries.[11,14,15]

**Table 3: Area under the curve by age category and season**

| Variable | Number of visits | AUC (95% CI) |
|---|---|---|
| Overall | 27,437 | 0.73 (0.72-0.74) |
| Age | | |
| 60-69 | 11,592 | 0.751 (0.733-0.769) |
| 70-79 | 9832 | 0.732 (0.715-0.749) |
| 80-89 | 4853 | 0.715 (0.695-0.736) |
| 90-99 | 1019 | 0.722 (0.681-0.764) |
| ≥100 | 141 | 0.699 (0.602-0.795) |
| Season | | |
| Summer | 8041 | 0.737 (0.717-0.757) |
| Winter | 4855 | 0.732 (0.710-0.755) |
| Spring | 8006 | 0.734 (0.715-0.753) |
| Autumn | 6535 | 0.731 (0.711-0.752) |

AUC=Area under the curve, CI=Confidence interval

Likewise, our study sought to establish a relationship between body temperature and the occurrence of sepsis among patients. We found a direct relationship between these two variables, which could be helpful for clinicians. This is because it might be possible that thermoregulation among elderly patients gets affected before overt signs and symptoms of sepsis. Therefore, temperature changes may warn clinicians to take immediate and timely actions to manage patients effectively could help to diagnose of sepsis prior to any prominent signs and symptoms of disease. Further, the temperature has been found a strong predictor of mortality among patients diagnosed with sepsis, therefore, this relationship between temperature and sepsis implies that physicians should become alter among patients with higher body temperature regardless of overt signs and symptoms.[16] Our findings regarding the relationship between temperature and sepsis are consistent with other studies conducted across the world. For instance, one study found that trends of higher maximum temperature in the initial period of 3 days among patients who were later diagnosed with sepsis.[17] The same study also found that patients with sepsis had higher and more sporadic variations in body temperature than patients without sepsis. However,

**Table 4: Repeated-measures mixed-effects logistic regression analysis for factors associated with sepsis**

| Factor | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|
| | OR (95% CI) | *P* | OR (95% CI) | *P* |
| Body temperature | 10.42 (9.36-11.59) | <0.001 | 9.95 (8.95-11.06) | <0.001 |
| Age category | | | | |
| 60-69 | 1 | <0.001 | 1 | <0.001 |
| 70-79 | 1.85 (1.61-2.11) | | 1.71 (1.49-1.96) | |
| 80-89 | 3.76 (3.21-4.41) | | 3.48 (2.96-4.08) | |
| 69-99 | 5.46 (4.14-7.20) | | 4.71 (3.57-6.22) | |
| ≥100 | 15.70 (8.39-29.37) | | 11.12 (2.92-20.88) | |
| Season | | | | |
| Summer | 1 | | 1 | |
| Winter | 1.33 (1.15-1.52) | <0.001 | 1.32 (1.14-1.54) | <0.001 |
| Spring | 1.19 (1.05-1.34) | | 1.24 (1.09-1.42) | |
| Autumn | 1.27 (1.12-1.45) | | 1.24 (1.08-1.42) | |

OR=Odds ratio, CI=Confidence interval

these findings contradict other studies with respect to the fluctuations in the body temperature among patients with sepsis.[18-20] These findings could be explained by the complex process of thermoregulation, which is influenced by numerous exterior and biological factors such as vasoactive medicines, drowsiness, mechanical ventilation, and underlying disease progressions.[21] Further, such thermoregulation reaction to sepsis differs amongst patients, and prior research studies has indicated that body temperature among patients with sepsis might be affected by factors such as age, other ailments, cause of infection or form of organism.[22-26] We did not explore any variations in the patterns of temperature among patients who were positive for specific types of organisms such as Gram-negative versus Gram-positive, patients with or without septic shock, or survivors versus nonsurvivors, which need to be explored in the future to understand the relationship between temperature and sepsis in a specific group of patients.

Finally, we found a relationship between the type of season and occurrence of sepsis with a higher risk of sepsis during winter, autumn, and spring seasons than summer. Such seasonal differences have been found in other studies, which reveal that sepsis is more widespread during the winter season. For example, an epidemiological study found a rising trend in the number of sepsis cases from fall (41.7 sepsis cases per 1000 patients) to a higher incidence during winter (48.6 septic cases per 1000 patients).[27] These findings are coherent with a previous study assessing the seasonal difference in hospital admission rates in the intensive care units due to sepsis.[28] Such seasonal variation might be due to different types of organisms being common during different seasons. For example, organisms causing respiratory infections and thereby sepsis as a complication are prevalent during the winter season.[29] These findings regarding seasonal variation inform clinicians to make timely and evidence-based decisions by preparing themselves and their teams to diagnose the patients in a timely manner as well as to treat them effectively.[30] Thus, planning in health care and suitable allocation of resources could be done based on the season when sepsis is more prevalent. More specifically, such seasonal variation in the burden of sepsis could help to allocate limited resources effectively as sepsis is very expensive to treat. The mean length of stay among septic patients is about 2 weeks resulting in around $18,000–31,000, excluding external expenditures.[31] Our study findings of an increased likelihood of sepsis during specific seasons mainly in the winter season will be helpful for hospital administration to arrange more resources in the units such as intensive care units where patients with sepsis are usually admitted.

### Strengths and limitations

One of the larger strengths of this study is that this is the first study to determine the reasonable cut-off for oral temperature measurement among elderly patients >60 years presenting to the emergency department to diagnose sepsis. Besides, this is the first largest study of its kind, which was undertaken on all patients who visited he emergency department. The sample size of the large cohort, which provided us an opportunity to study the epidemiology of sepsis on appreciably large sample size. Second, besides assessing the risk factors through repeated measured analysis, we also measured the cut-off where a substantial proportion of cases could be diagnosed with reasonable sensitivity and specificity. However, our study findings should be interpreted under the light of some caveats. First, we did not study the geographical variation in sepsis as there might be more cases in one region than another, which will affect the health care planning. Second, we did not study the types of organisms that could cause sepsis during different seasons, which warrants carrying out large and robust epidemiological studies to elucidate the reasons for seasonal differences in sepsis.

## Conclusion

Our study aimed to find the most accurate cut-off for oral temperature measurement in all patients aged above 60 years presenting to the emergency department to sepsis. We found that a temperature of at least 37.3°C as a cut-off with reasonable sensitivity and specificity and this cut-of helped to diagnose around 83% of the patients with sepsis correctly. We also studied the risk factors for sepsis and found that age, temperature, and seasonal variation as important risk factors that may be helpful in making informed important evidence-based decisions. The hospitals dealing with sepsis patients should assess older patients for other severe illnesses or co-morbid that might lead to sepsis if left untreated. Therefore, older patients need to be prioritized over younger patients. Likewise, the body temperature of patients admitted to hospitals needs to be monitored critically to become suspicious of sepsis even there are no obvious signs and symptoms of sepsis among patients. Lastly, it is important to consider seasonal fluctuations while managing cases of sepsis and allocating resources. Seasonal variation in sepsis warns physicians as well as hospital administration to take necessary steps to treat patients effectively and promptly. Given the fact, that this study was first of its kind to find the most accurate cut-off for oral temperature measurement in elderly patients, we recommend conducting more robust epidemiological studies in geographic area to add to the evidence and enhance knowledge about the similar clinical area of interest. This will help clinicians to make informed and evidence-based decisions to treat the patients with sepsis effectively.


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Nil.

### Conflicts of interest

There are no conflicts of interest.


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