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Early Prediction of Sepsis Onset in ICU Patients Using Temporal Feature Engineering and Gradient Boosted Trees

By Shreyan Limaye, Grade 9, Dhirubhai Ambani Int School, Mumbai

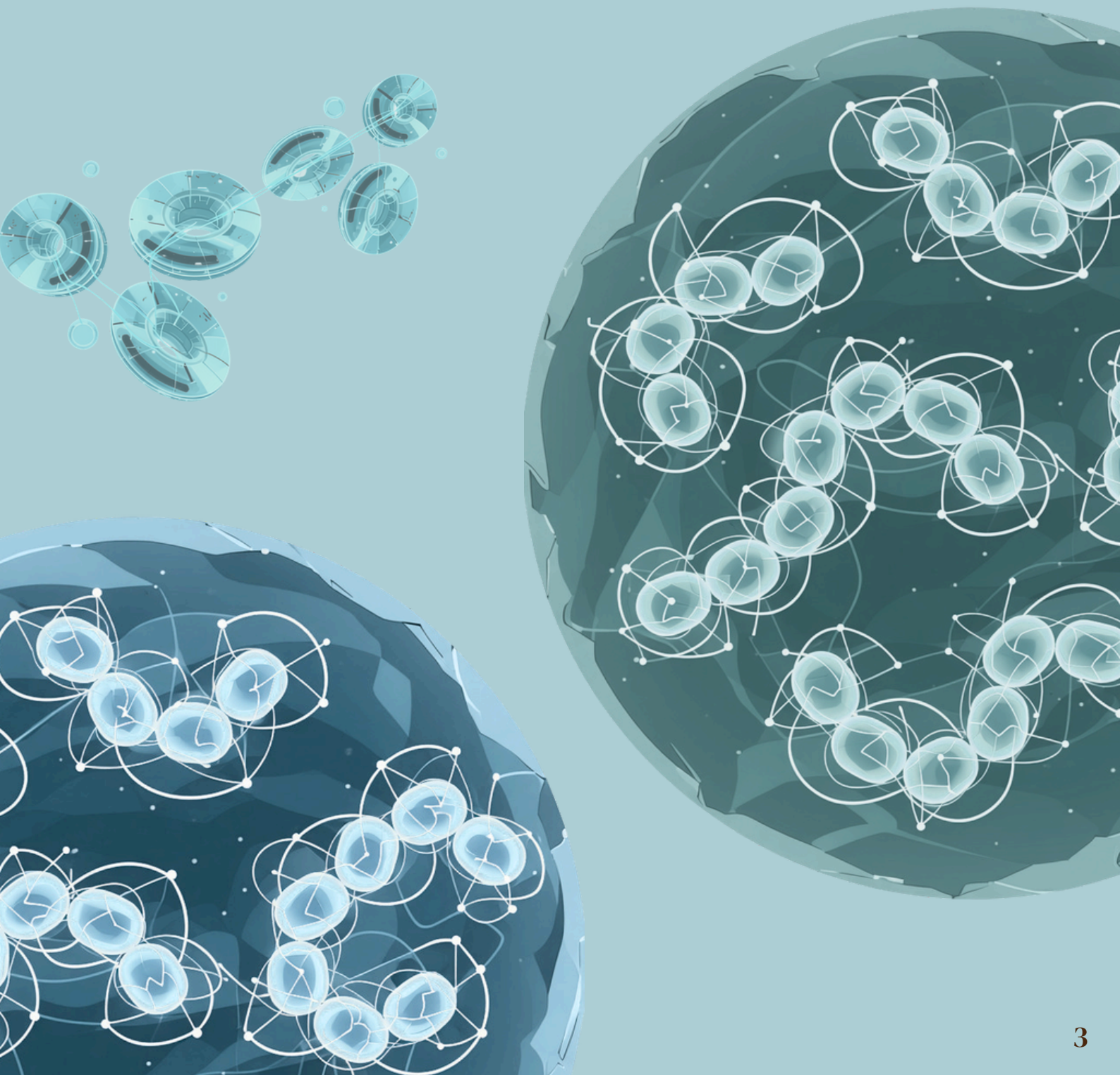
Sepsis, a life-threatening organ dysfunction caused by a dysregulated host response to infection, represents one of the leading causes of in-hospital mortality globally, with an estimated 48.9 million cases and 11 million deaths annually. Every hour of delayed treatment raises the risk of death by 4 to 8 %, and standard clinical scoring tools like qSOFA and SIRS have not been accurate enough to catch this early, which has driven interest in machine learning approaches that can learn from routine ICU monitoring data.

This paper presents SepsisWatch, a machine learning system built to predict sepsis six hours before clinical onset, using data from the PhysioNet 2019 Challenge, which covers 40,336 ICU patients and 1,552,210 hours of monitoring data from two hospital systems. The system rests on three main components, a temporal feature engineering pipeline, a gradient boosted tree model trained on various features and variables, and a SHAP (SHapley Additive exPlanations, a game-theory method used to explain machine learning model predictions) based interpretability layer that connects predictions to clinical evidence.

The feature engineering pipeline builds up in three stages so that each stage's contribution can be assessed individually. The first stage uses only raw vital signs, such as heart rate and temperature, along with patient age and gender. The second stage adds rolling averages, minimums, maximums, and six hour rates of change for each vital sign, capturing the trajectory of a patient's condition compared to the readings at a particular time, prioritizing the identification of a trend in the data. The third stage adds lab test information for five markers, including lactate and creatinine, recording both the most recent value and the number of hours since that test was last taken, since testing frequency itself carries importance. For the prediction model, patients were split into training and test groups at the patient level, not the row level, so that no single patient's data appeared in both groups. Four models were trained on this split, including logistic regression, random forest, and XGBoost, a gradient boosting algorithm well suited to tabular clinical data. Enhancement of features improved the AUC-ROC score (ranking/discrimination ability of a model) from 0.7153, using raw vital signs to 0.8178, using laboratory data.

The interpretability layer applies SHAP analysis to the trained XGBoost model, showing how much each feature pushed a given prediction toward or away from sepsis, or in other words, defining the importance of each feature. The five most influential features were length of ICU stay, hours since the last lactate test, most recent creatinine level, body temperature, and white blood cell count, all of which align with established clinical markers of organ dysfunction and infection. One notable pattern emerged around lactate testing, patients who had gone longer without a lactate test were more likely to be flagged as high risk, which may reflect that clinicians test lactate less often when they are not yet worried about a patient, making a long testing gap a sign of risk.

In the future, external validation on independent datasets from geographically and demographically distinct patient populations should be prioritized, and the addition of SOFA (Sequential Organ Failure Assessment) score as a comparative baseline would further highlight the added value of the machine learning approach over existing clinical tools.



From Theory to Reality: The History of Quantum Computing and Networking

By Shreya Upadhyay, Undergrad Student, Columbia University

Quantum mechanics, once relegated to chalkboards and science-fiction plots, is now revolutionizing the world of computing and networking.

To understand why this matters, let's start with the basics. Classical computers store information as bits, which are 0s and 1s. In 1982, physicist Richard Feynman proposed using the strange rules of quantum mechanics to build a new kind of computer conceived the strange idea of using "qubits" instead of "bits". Unlike ordinary bits, qubits can exist in a combination of 0 and 1 at the same time using the property of superposition. They can also become entangled, meaning a change in one qubit instantly affects its partner regardless of the distance between them. These properties give quantum computers the potential to tackle certain problems that would take classical machines longer than the age of the universe to solve.

The theoretical groundwork deepened in 1994 when mathematician Peter Shor published an algorithm showing a quantum computer could crack the encryption protecting most of the internet. It was the moment that transformed quantum computing from an academic curiosity into a subject of urgent international interest.

Of course, moving from theory to actual hardware was extremely hard. Early machines in the 2000s could only handle a handful of qubits, and those qubits were fragile, collapsing under the slightest interference from the surrounding environment. Quantum networking was similarly very new in that researchers were experimenting with quantum key distribution, a method of sending encryption keys

using quantum particles that is theoretically impossible to intercept without detection. The concept was compelling, but making it work reliably at scale remained elusive.

The field had its big public moment in 2019 when Google claimed their 53-qubit Sycamore processor completed a specific calculation in 200 seconds that would take a classical supercomputer 10,000 years. IBM immediately disputed the figures, but the debate almost didn't matter. "Quantum supremacy" had become a global headline, and a race was on. IBM rolled out increasingly powerful processors year after year- 127 qubits in 2021, 433 in 2022, over 1,000 in 2023.

But somewhere around 2024, the conversation shifted in a more fundamental direction. The real challenge was reliability - building qubits that could perform calculations without constantly introducing errors. Error correction became the obsession. Google's Willow chip demonstrated that errors could be reduced exponentially as qubit counts scaled up, a milestone many researchers had considered a fundamental barrier. By 2025, Quantinuum's Helios system reached 48 verified logical qubits a distinction that matters because logical qubits are far more stable and useful than their physical counterparts. The investment world went into a frenzy with quantum companies raising nearly \$3.8 billion in just the first nine months of 2025 alone, almost triple the entire previous year.

On the networking side, the stakes are enormous. A sufficiently powerful quantum computer could theoretically break the encryption that protects global banking, government communications, and personal data- an event researchers have ominously dubbed "Q-Day." The quantum communication market, worth around \$1.2 billion in 2024, is projected to hit as high as \$14.9 billion by 2035 as governments and corporations scramble to build quantum-secure infrastructure before that day arrives.

The gap between theory and reality has narrowed dramatically. What Feynman imagined on a whiteboard in 1982 is now being engineered in laboratories around the world, with billions of dollars and the security of global communications riding on the outcome.

SLEEP – OUR NIGHTLY REBIRTH RITUAL

By Tarini Gopalakrishnan, Grade 7, Hill Spring International School.

The word rebirth is a term connected to the afterlife, post death. It means living once again, a second chance. But perhaps, many of us don't realize that rebirth happens to us every day. Every day while we sleep.

THE STAGES OF SLEEP

Common perception is that, while sleep is important, it is not important enough to make efforts in protecting it. Sleep actually has several stages. They are N1, N2, N3, and REM sleep. N1 is the lightest stage of sleep. It occurs just as someone falls asleep. N2 is where the body starts to relax deeply. Body temperature drops, and muscles begin to relax. N3 is the deepest and most restorative sleep, allowing the body to recover and sleep. REM sleep, or Rapid Eye Movement sleep, is where most dreams occur, and the body is temporarily paralyzed. This stage of sleep gets its name from the darting around of our eyes under our eyelids during this stage.

SLEEP DISORDERS

Sleep is important, but some people are just unable to fall asleep. These people have insomnia, which is a medical condition that makes getting to sleep extremely difficult for them. They also wake up several times in the night and still feel tired after sleeping. Narcolepsy, however is the exact opposite. A person with Narcolepsy finds it hard to stay awake, even after consuming caffeine, and have to take special medicines to stay awake. Sleep Apnea, another sleep disorder, causes a person to repeatedly stop breathing during sleep, leading to choking or gasping, loud snoring, inability to focus, and daytime tiredness.

WHAT HAPPENS IN SLEEP

But more importantly, what happens while you sleep? Firstly, your body repairs damaged cells, muscle tissue recovers after exercise, proteins are built to support growth and healing, and the growth hormone is released.

Setting aside the physical aspect, sleep also tremendously impacts your brain and learning. In the center of your brain, there is a small set of twin structures called the hippocampus. The hippocampus is particularly good at receiving memories and holding on to them. But without sleep, those memories cannot be stored in the long term.

YOU'D BETTER BE SLEEPING (ENOUGH)

A lack of sleep can also have enormous consequences. Every hour of sleep lost can only be gained back by 80% to 90% of the original amount of sleep. And if a person does not get enough sleep for a portion of their life, they have a greater chance of getting Alzheimer's or Dementia later on in life.

Further than that, men who sleep 5 hours in a night have significantly smaller testicles than those who sleep a good 7-8 hours per night. Additionally, men who sleep just 4-5 hours per night will have a level of testosterone similar to that of a man ten years their senior. And there is an equivalent impact seen in female reproductive health by lack of sleep.

A lack of sleep can also mimic learning disorders such as ADHD. Without sleep, it becomes almost impossible to focus, and hyperactivity is the body's way of keeping itself awake.

Furthermore, sleep is impacting the daily lives of us and of the younger generation. In studies conducted that were covered in a presentation by Matthew Walker, when a school increased its start time by 1 hour, allowing the students to sleep more, they saw a 70% decline in car accidents involving children between the ages of 16 and 18.

In a second study, when a school increased its start times by one hour, they saw their student's SAT scores go up from around 1340 to above 1500.

In additional studies conducted with teens from the LA Unified School District, teens with sleep deprivation were 55% more likely to have used alcohol in the past, and for each lost hour of sleep, a teen was 38% more likely to feel sad or hopeless, and 58% more likely to commit suicide.

YOU SNOOZE, YOU WIN

Setting that aside, what happens when you do get enough sleep. When you get the recommended 8-10 hours of sleep, your emotions become easier to regulate. Good sleep makes it easier to handle stress and frustration and can improve mood. You will start feeling happier and more alert. Any and all symptoms of sleep-deprivation-induced ADHD will disappear, your face will lose its dark circles and bags, and your overall health and wellbeing will improve.

Additionally, good sleep is important for healthy ageing because during deep sleep, the body releases growth hormone (somatotropin), which helps repair muscles, skin, bones and other tissues. At the same time, cortisol, the body's main stress hormone, normally decreases at night. So, good deep sleep means more growth hormone and lower cortisol, giving the body more time to repair and recover. Poor sleep can have the opposite effect, with higher cortisol and less growth hormone, potentially contributing to faster ageing over time.

CONCLUSION

And this is where rebirth comes in. Rebirth is a concept of coming back anew, refreshed, and rid of stress. And that is exactly what sleep gives us. It refreshes our minds, our bodies, how we feel, and a good night's sleep leaves us feeling happy and satisfied with ourselves



Adolescence and Cancer Risk in Polycystic Ovary Syndrome

By Kiara Purandare, Grade 10, Dhirubhai Ambani Int School, Mumbai

The cancer risk that comes with polycystic ovary syndrome (PCOS) is built during the teenage years, which is when it is easiest to change. Doctors usually discuss cancer prevention with women in their forties. For girls with polycystic ovary syndrome, that is too late. PCOS affects 10 to 13 percent of women worldwide. Among Indian girls aged fourteen to nineteen, a review of twelve studies covering 4,473 participants found a rate of 17.74 percent. This was close to one in five.

The risk lies in the endometrium, the lining of the uterus that thickens each month and sheds as a period. A 2024 review of thirteen studies found a relative risk of 2.91, meaning nearly three times the risk of women without PCOS. On the other hand breast cancer is not increased. Leaving out women over fifty-four pushed the odds ratio from 2.79 to 4.05. This made ovarian cancer significant at 2.52. The risk is highest in younger women. The first cause is skipped ovulation. In a normal cycle an ovary releases an egg, and the structure left behind starts producing progesterone. Progesterone is a hormone which acts as the stop signal. It tells the endometrium to stop thickening and shed. Girls with PCOS often do not ovulate, so that progesterone never arrives. Oestrogen keeps telling the lining to grow every month, and no hormone arrives to switch it off. Doctors call this unopposed oestrogen. Cells that keep dividing without a stop signal are more likely to pick up errors. This overgrown lining can eventually turn cancerous.

The second cause is insulin. Insulin is the hormone that moves sugar out of the blood and into cells. In insulin resistance the cells stop responding properly, so the pancreas makes more of it. Insulin levels in the blood therefore stay high. This happens in many girls with PCOS. High insulin raises IGF-1, which is a growth factor, and switches on signalling pathways that tell cells to divide and to avoid dying. It also lowers SHBG, the protein that normally binds testosterone and keeps it inactive. As a result, more free testosterone circulates and the chances of ovulation decrease even more. Insulin worsens the ovulation problem, and the ovulation problem raises the cancer risk.

Body mass index at ages seven and thirteen predicted endometrial cancer decades later. A sample of 800,024 people found that the path from teenage weight to adult weight predicted obesity-related cancers. In the Women's Health Initiative, 36,794 women who deliberately lost 5 percent or more of their weight had a hazard ratio of 0.60, which is a 40 percent lower risk. At the same time, gaining ten pounds raised risk by 26 percent. This concludes that losing weight and then regaining it was worse than doing nothing. Diet and movement reduces insulin resistance. A 24-week low glycaemic index diet, which contains slower-digesting carbohydrates gave 80 percent of women more regular periods, lowered testosterone and raised SHBG. Active women have about 30 percent lower risk. Research indicates that cycles should be tracked regularly. In the Nurses' Health Study II, 79,505 women with long or irregular cycles at ages fourteen to seventeen had a 34 to 40 percent higher chance of dying before seventy.

Bibliography and References

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- [1] Rudd, K. E., S. C. Johnson, K. M. Agesa, et al. "Global, Regional, and National Sepsis Incidence and Mortality, 1990–2017: Analysis for the Global Burden of Disease Study." *Lancet* 395, no. 10219 (2020): 200–211.
- [2] Kumar, A., D. Roberts, K. E. Wood, et al. "Duration of Hypotension before Initiation of Effective Antimicrobial Therapy Is the Critical Determinant of Survival in Human Septic Shock." *Crit Care Med* 34, no. 6 (2006): 1589–96.
- [3] Reyna, M. A., C. S. Josef, R. Jeter, et al. "Early Prediction of Sepsis from Clinical Data: The PhysioNet/Computing in Cardiology Challenge 2019." *Crit Care Med* 48, no. 2 (2020): 210–17.
- [4] Singer, M., C. S. Deutschman, C. W. Seymour, et al. "The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)." *JAMA* 315, no. 8 (2016): 801–10.
- [5] Angus, D. C., W. T. Linde-Zwirble, J. Lidicker, et al. "Epidemiology of Severe Sepsis in the United States: Analysis of Incidence, Outcome, and Associated Costs of Care." *Crit Care Med* 29, no. 7 (2001): 1303–10.
- [6] Paoli, C. J., M. A. Reynolds, M. Sinha, M. Gitlin, and E. Crouser. "Epidemiology and Costs of Sepsis in the United States—An Analysis Based on Timing of Diagnosis and Severity Level." *Crit Care Med* 46, no. 12 (2018): 1889–97.
- [7] Seymour, C. W., V. X. Liu, T. J. Iwashyna, et al. "Assessment of Clinical Criteria for Sepsis: For the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)." *JAMA* 315, no. 8 (2016): 762–74.
- [8] Kijpaisalratana, N., D. Sanglertsinlapachai, S. Techaratsami, et al. "Machine Learning Algorithms for Early Sepsis Detection in the Emergency Department: A Retrospective Study." *Int J Med Inform* 160 (2022): 104689.
- [9] Islam, K. R., J. Prithula, J. Kumar, et al. "Machine Learning–Based Early Prediction of Sepsis Using Electronic Health Records: A Systematic Review." *J Clin Med* 12, no. 17 (2023): 5658.
- [10] Fleuren, L. M., T. L. T. Klausch, C. L. Zwager, et al. "Machine Learning for the Prediction of Sepsis: A Systematic Review and Meta-analysis of Diagnostic Test Accuracy." *Intensive Care Med* 46, no. 3 (2020): 383–400.
- [11] Mao, Q., M. Jay, J. L. Hoffman, et al. "Multicentre Validation of a Sepsis Prediction Algorithm Using Only Vital Sign Data in the Emergency Department, General Ward, and ICU." *BMJ Open* 8, no. 1 (2018): e017833.
- [12] Wang, D., J. Li, Y. Sun, et al. "A Machine Learning Model for Accurate Prediction of Sepsis in ICU Patients." *Front Public Health* 9 (2021): 754348.
- [13] Islam, M. M., T. Nasrin, B. A. Walther, et al. "Prediction of Sepsis Patients Using Machine Learning Approach: A Meta-analysis." *Comput Methods Programs Biomed* 170 (2019): 1–9.
- [14] Nemati, S., A. Holder, F. Razmi, et al. "An Interpretable Machine Learning Model for Accurate Prediction of Sepsis in the ICU." *Crit Care Med* 46, no. 4 (2018): 547–53.
- [15] Park, S. B., J. Choi, J. S. Oh, et al. "Development and Validation of Deep-Learning-Based Sepsis and Septic Shock Early Prediction System (DeepSEPS) Using Real-World ICU Data." *J Clin Med* 12, no. 22 (2023): 7156.
- [16] Chen, T., and C. Guestrin. "XGBoost: A Scalable Tree Boosting System." In *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 785–94. New York: ACM, 2016.
- [17] Lundberg, S. M., and S. I. Lee. "A Unified Approach to Interpreting Model Predictions." *Advances in Neural Information Processing Systems* 30 (2017).
- [18] Vincent, J. L., J. Rello, J. Marshall, et al. "International Study of the Prevalence and Outcomes of Infection in Intensive Care Units." *JAMA* 302, no. 21 (2009): 2323–29.
- [19] Moor, M., B. Rieck, M. Horn, et al. "Early Prediction of Sepsis in the ICU Using Machine Learning: A Systematic Review." *Front Med* 8 (2021): 607952.

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- [Sleep Is Your Superpower | Matt Walker | TED Talk](#)
- [Why sleep matters now more than ever | Matt Walker](#)
- [What staying up all night does to your brain – Anna Rothschild](#)
- [What lack of sleep does to the teenage brain – Wendy Troxel](#)
- Book– Why We Sleep: The New Science of Sleep & Dreams–by Matthew Walker
- [National Heart, Lung, and Blood Institute \(NHLBI\)](#)
- First-person interview with sleep doctor Nupur Jhunjunwala

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- Recommendations from the 2023 International Evidence-Based Guideline for the Assessment and Management of Polycystic Ovary Syndrome <https://academic.oup.com/jcem/article/108/10/2447/7242360>
- International Evidence-Based Recommendations for Polycystic Ovary Syndrome in Adolescents <https://link.springer.com/article/10.1186/s12916-025-03901-w>
- Polycystic Ovary Syndrome among Indian Adolescent Girls: A Systematic Review and Metanalysis <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8560138/>
- Polycystic Ovarian Syndrome and the Risk of Ovarian, Endometrial, and Breast Cancer: A Systematic Review and Meta-Analysis <https://pubmed.ncbi.nlm.nih.gov/40740582/>
- Risk of Endometrial, Ovarian and Breast Cancer in Women with Polycystic Ovary Syndrome: A Systematic Review and Meta-Analysis <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4326303/>
- A Systematic Review of the Molecular Mechanisms Involved in the Association between PCOS and Endometrial and Ovarian Cancers <https://pmc.ncbi.nlm.nih.gov/articles/PMC11669186/>
- Childhood Body Mass Index and Height and Risk of Histologic Subtypes of Endometrial Cancer <https://pubmed.ncbi.nlm.nih.gov/27121254/>
- Adolescent to Adulthood Weight Trajectories and the Risk of Obesity-Related Cancers <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12809738/>
- Intentional Weight Loss and Endometrial Cancer Risk <https://pubmed.ncbi.nlm.nih.gov/28165909/>
- Intentional Weight Loss, Weight Cycling, and Endometrial Cancer Risk: A Systematic Review and Meta-Analysis <https://pubmed.ncbi.nlm.nih.gov/31451560/>
- Does a Restricted Energy Low Glycemic Index Diet Have a Different Effect on Overweight Women with or without Polycystic Ovary Syndrome? <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6720418/>
- Physical Activity, Sedentary Behaviours, and the Prevention of Endometrial Cancer <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2965881/>
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