E7D · WELLNESS · MARISMETRICS

e7D-Wellness Research Informed

The evidence behind the e7D-Wellness approach — for the organisations asking what it's built on.

99	6	2019–2026
PEER-REVIEWED SOURCES	PARTS	PUBLICATION WINDOW

How to read this

Every source below resolves to a real, confirmed DOI. Each has been checked against its publisher record for title, authors, journal, and the specific numbers quoted — sample sizes, percentages, odds ratios, effect sizes. Nothing here is rounded for effect or invented to fill a gap.

These are independent, peer-reviewed studies on healthcare-worker burnout, organisational wellbeing, and the biological and behavioural markers this platform tracks. They establish the scale of the problem and the shape of what reliably helps.

> None of these studies tested MarisMetrics, MarisGraph, or any e7D-Wellness product directly. They support this work as established associations in the published literature — not as proof of what this specific platform delivers. Where a pillar or claim doesn't yet have enough independently confirmed evidence, that gap is left visible rather than padded.
>
> The six parts move from the organisational case, through the economics, the product's own design choices, the clinical foundation, the biology behind the biomarker panel, and finally the evidence for each of the 8 Pillars individually.

Contents

I The Organisation Case — 7 sources
Wellbeing as a performance signal, not a perk

II The Cost of Doing Nothing — 5 sources
What unaddressed burnout is already costing

III Why It’s Built This Way — 15 sources
Privacy, peer support & precision assessment

IV The Clinical Foundation — 38 sources
Prevalence, risk, moral injury & what helps

V The Blood Already Knows — 10 sources
Ten biomarkers, mapped to the 8 Pillars

VI The 8 Pillars — 24 sources
The evidence behind each pillar itself

I

The Organisation Case

Wellbeing as a performance signal, not a perk

Seven studies make the case in the language organisations already use: engagement, turnover, patient safety, and leadership effectiveness. None of them test MarisMetrics or any e7D-Wellness product — they establish that staff wellbeing is a measurable organisational condition with real downstream costs, which is the premise the organisation screen is built on.

PERFORMANCE SIGNALS

Hodkinson, A., Zhou, A., Johnson, J., Geraghty, K., Riley, R., Zhou, A., Panagopoulou, E., Chew-Graham, C. A., Peters, D., Esmail, A., & Panagioti, M. (2022). Associations of physician burnout with career engagement and quality of patient care: Systematic review and meta-analysis. *BMJ, 378*, e070442.

170 studies, 239,246 physicians. Burnout linked to lower job satisfaction (OR 3.79), career-choice regret (OR 3.49), turnover intention (OR 3.10), and lower productivity (OR 1.82); patient-safety incidents roughly doubled (OR 2.04).

Li, L. Z., Yang, P., Singer, S. J., Pfeffer, J., Mathur, M. B., & Shanafelt, T. (2024). Nurse burnout and patient safety, satisfaction, and quality of care: A systematic review and meta-analysis. *JAMA Network Open, 7*(11), e2443059.

85 studies, 288,581 nurses, 32 countries. Burnout associated with worse safety climate, more falls, hospital-acquired infections, medication errors and adverse events, lower patient satisfaction, and lower nurse-assessed quality of care — and the association grew more negative across three decades of data (1994–2024).

CULTURE INSIGHT

Aiken, L. H., Lasater, K. B., Sloane, D. M., et al., for the US Clinician Wellbeing Study Consortium (2023). Physician and Nurse Well-Being and Preferred Interventions to Address Burnout in Hospital Practice. *JAMA Health Forum, 4*(7), e231809.

15,738 nurses and 5,312 physicians across 60 US Magnet hospitals. High burnout in 32% of physicians and 47% of nurses, tracking with turnover and worse safety ratings; clinicians ranked improving staffing above wellness or resilience programs (87% of nurses, 45% of physicians).

Schlak, A. E., Aiken, L. H., Chittams, J., Poghosyan, L., & McHugh, M. (2021). Leveraging the Work Environment to Minimize the Negative Impact of Nurse Burnout on Patient Outcomes. *International Journal of Environmental Research and Public Health, 18*(2), 610.

20,496 nurses across 523 hospitals (83 Magnet). Higher hospital-level nurse burnout linked to higher mortality, failure to rescue, and longer stay. A good work environment weakened that link across all three outcomes; Magnet status specifically weakened it for mortality and failure to rescue, not length of stay.

De Simone, S., Vargas, M., & Servillo, G. (2021). Organizational strategies to reduce physician burnout: A systematic review and meta-analysis. *Aging Clinical and Experimental Research, 33*(4), 883–894.

Organisation-directed interventions reduced burnout more (SMD −0.45) than physician-directed interventions (SMD −0.18).

STRATEGIC CLARITY

National Academies of Sciences, Engineering, and Medicine (2019). *Taking Action Against Clinician Burnout: A Systems Approach to Professional Well-Being*. National Academies Press.

Frames clinician burnout as a structural, organisational and cultural problem rather than an individual failing, and calls on organisations to measure professional wellbeing rigorously and redesign the work system around it.

Shanafelt, T. D., Makowski, M. S., Wang, H., Bohman, B., Leonard, M., Harrington, R., Minor, L., & Trockel, M. (2020). Association of Burnout, Professional Fulfillment, and Self-care Practices of Physician Leaders With Their Independently Rated Leadership Effectiveness. *JAMA Network Open, 3*(6), e207961.

Each one-point increase in a physician leader's burnout score was associated with a 0.19-point decline in independently rated leadership behaviour; professional fulfillment and self-valuation each predicted gains in rated effectiveness.

II

The Cost of Doing Nothing

What unaddressed burnout is already costing the organisation

Five studies price the status quo: turnover, absenteeism, lost productivity, and the return on actually intervening. These are general findings about healthcare-worker burnout and organisational wellbeing programs — not a projection of what any one organisation will save by using this platform — offered as the economic backdrop the organisation screen responds to.

Han, S., Shanafelt, T. D., Sinsky, C. A., et al. (2019). Estimating the Attributable Cost of Physician Burnout in the United States. *Annals of Internal Medicine, 170*(11), 784–790.

Models burnout-attributable physician turnover and reduced clinical hours at a national cost of $4.6 billion annually — about $7,600 per employed physician per year.

Bae, S. H. (2022). Noneconomic and economic impacts of nurse turnover in hospitals: A systematic review. *International Nursing Review, 69*(3), 392–404.

Across 16 studies, per-turnover costs ranged from $21,514 to $88,000 in the US, with vacancy and temporary-replacement costs making up 44–83% of the total facility-level cost.

Lee, C., Vu, T.-H. T., Fuller, J. A., et al. (2023). The association of burnout with work absenteeism and the frequency of thoughts of leaving their job in a cohort of healthcare workers during the COVID-19 pandemic. *Frontiers in Health Services, 3*, 1272285.

In 1,825 Chicago-area healthcare workers, 20% reported unplanned absenteeism and 60% reported thoughts of leaving their job; each unit increase in burnout score raised odds of frequent turnover intent 1.39×.

Unsal, N., Weaver, G., Bray, J. W., Bibeau, D., & Saake, G. (2021). Return on Investment of Workplace Wellness: Evidence From a Long-Term Care Company. *Workplace Health & Safety, 69*(2), 81–90.

A workplace wellness program cost $132.69 per participant and produced $210.34 in organisational savings per participant — roughly $1.59 saved per $1 invested.

Catalfo, P., Cantarella, C., Virgillito, D., Maltezou, H. C., & Ledda, C. (2026). Effectiveness and economic impact of interventions targeting healthcare personnel: a systematic review of return on investment. *Public Health Reviews, 47*, 1609191.

Across reviewed ROI studies, a stress-prevention program returned €2,981 net benefit per employee per year, and preventive occupational health screening for nurses produced net savings of €244–€651 per nurse.

III

Why It’s Built This Way

The design choices, and the evidence behind each one

The platform is deliberately built on three decisions: personal data stays with the individual, peer support stays anonymous rather than social, and assessment pairs self-report with objective biomarkers. Fifteen studies below speak to why each of those choices holds up — none of them tested this platform specifically.

PRIVACY & TRUST IN DIGITAL HEALTH

Batterham, P. J., Gulliver, A., Sunderland, M., Farrer, L., Kay-Lambkin, F., Trias, A., & Calear, A. L. (2023). Factors Influencing Community Participation in Internet Interventions Compared With Research Trials. *Journal of Medical Internet Research, 25*(1), e41663.

In a nationally representative Australian sample (N=1,094), trust and privacy/anonymity ranked among the top factors influencing willingness to participate in digital mental-health programs, and behavioural intention strongly predicted actual uptake (OR 2.50, 99% CI 1.41–4.43).

Dyrbye, L. N., West, C. P., Wilton, A. R., Satele, D. V., & Athreya, A. P. (2025). Smartwatch Use and Physician Well-Being: A Randomized Clinical Trial. *JAMA Network Open, 8*(8), e2527275.

In an RCT of 184 physicians, six-month burnout was 41.2% in the wearable-intervention arm vs. 50.5% in controls (adjusted OR 0.46, 95% CI 0.21–0.99), with resilience also improving significantly.

Cho, A., Cha, C., & Baek, G. (2024). Development of an Artificial Intelligence–Based Tailored Mobile Intervention for Nurse Burnout. *Journal of Medical Internet Research, 26*(1), e54029.

Across 300 nurses completing a 4-week AI-tailored mobile intervention, total burnout fell from 62.36 to 55.22 (P<.001), with job stress also decreasing significantly.

Mensinger, J. L., Weissinger, G. M., Cantrell, M. A., Baskin, R., & George, C. (2024). A Pilot Feasibility Evaluation of a Heart Rate Variability Biofeedback App to Improve Self-Care in COVID-19 Healthcare Workers. *Applied Psychophysiology and Biofeedback, 49*(2), 241–259.

Of 28 enrolled healthcare workers, 82% completed all protocol elements and 75% said they were likely or extremely likely to continue the self-tracking practice after the study ended.

Kirykowicz, K., Jaworski, B., Owen, J., Kirschbaum, C., Seedat, S., & van den Heuvel, L. L. (2023). Feasibility, acceptability and preliminary efficacy of a mental health self-management app in clinicians working during the COVID-19 pandemic. *Psychiatry Research, 329*, 115493.

In a pilot RCT of 34 clinicians randomised to a mobile self-management app vs. waitlist, the app showed above-average usability and produced a significant improvement in anxiety at one-month follow-up.

PEER SUPPORT & PSYCHOLOGICAL SAFETY

Kiser, S. B., Sterns, J. D., Lai, P. Y., Horick, N. K., & Palamara, K. (2024). Physician Coaching by Professionally Trained Peers for Burnout and Well-Being: A Randomized Clinical Trial. *JAMA Network Open, 7*(4), e245645.

In an RCT of 138 physicians, peer-coached participants' burnout fell 21.6% versus a 2.5% rise in controls (adjusted difference −0.79, 95% CI −1.27 to −0.32, P=.001).

de Lisser, R., Dietrich, M., Spetz, J., Ramanujam, R., Lauderdale, J., & Stolldorf, D. (2024). Psychological safety is associated with better work environment and lower levels of clinician burnout. *Health Affairs Scholar, 2*(7), qxae091.

In a survey of 621 California nurse practitioners, psychological safety mediated the relationship between work-environment factors and burnout, explaining 32–37% of several key effects on emotional exhaustion.

O'Donovan, R., De Brún, A., & McAuliffe, E. (2021). Healthcare Professionals' Experience of Psychological Safety, Voice, and Silence. *Frontiers in Psychology, 12*, 626689.

A qualitative study of 34 healthcare professionals across five teams found psychological safety determined whether staff voiced concerns or stayed silent, with fear of repercussions and hierarchy the main drivers of silence.

Zaman, N., Mujahid, K., Ahmed, F., Mahmud, S., Naeem, H., Riaz, U., Ullah, U., & Cox, B. (2022). What are the barriers and facilitators to seeking help for mental health in NHS doctors. *BMC Psychiatry, 22*(1), 595.

A systematic review plus interviews with 31 NHS doctors found roughly 46% of psychiatrists preferred private, independent services over NHS ones specifically for the confidentiality they afforded.

Simms, L., Ottman, K. E., Griffith, J. L., Knight, M. G., Norris, L., Karakcheyeva, V., & Kohrt, B. A. (2023). Psychosocial Peer Support to Address Mental Health and Burnout of Health Care Workers Affected by COVID-19. *International Journal of Environmental Research and Public Health, 20*(5), 4536.

A qualitative evaluation of a hospital peer-support program found confidentiality fears were the dominant barrier to uptake — staff specifically feared disclosure reaching HR or their personnel file.

PRECISION & BIOMARKER-BASED ASSESSMENT

Bourassa, K. A., Lamichhane, B., Bartek, N., Bautista, C., Sano, A., & Madan, A. (2026). Objective Biobehavioral Measures Reflect Burnout States and Temporal Changes in a Nursing Population. *Nursing Reports, 16*(1), 36.

In 45 nurses tracked for 30 days with wearables, sleep-variability measures discriminated burnout states with 75.75% accuracy, and heart-rate features predicted changes in emotional exhaustion alongside self-report questionnaires.

Vivarelli, S., Italia, S., Teodoro, M., Pollicino, M., Vitello, C., De Vita, A., Alibrandi, A., Costa, C., & Fenga, C. (2023). Salivary Biomarkers Analysis and Neurobehavioral Assessment in Nurses Working Rotation Shifts. *International Journal of Environmental Research and Public Health, 20*(7), 5376.

In 102 rotating-shift nurses, morning cortisol correlated positively with depression and alpha-amylase inversely correlated with work ability — circadian/biomarker disruption specific to shift-working healthcare staff.

Sundram, B. M., Shaharudin, R., Mohamad, N., Pahrol, M. A., Omar, A., Sevaratnam, G., Kumareswaran, S., & Rajendran, K. (2024). Determining the effectiveness of stress management program by using hair cortisol concentration. *International Journal of Public Health Science, 13*(1), 116–125.

Across 119 healthcare workers followed for six months, hair cortisol concentration dropped significantly post-intervention, with the strongest biomarker responders also showing the largest self-reported stress improvement.

Mitropoulou, E. M., & Zampetakis, L. (2022). Introducing the scr-OLBI: Examination of a short measure for assessing burnout using item response theory. *Psychological Test Adaptation and Development, 3*(1), 97–105.

In 617 Greek employees, a 4-item short-form of the Oldenburg Burnout Inventory showed strong measurement performance and no gender bias — validating a brief self-report burnout instrument.

Mateo-Rodríguez, I., Knox, E., Oliver-Hernandez, C., & Daponte-Codina, A. (2023). Validation of a Single-Item Screening Measure of Burnout in a Sample of Spanish Health Workers. *Social Sciences, 12*(10), 546.

In 675 Spanish health workers, a single-item burnout measure showed 75% sensitivity and 89% specificity against caseness, and correlated strongly with perceived health and job satisfaction.

IV

The Clinical Foundation

The scale of the problem, and what reliably helps

Thirty-eight studies on burnout prevalence by specialty, suicide risk, moral injury and compassion fatigue, and the interventions with real evidence behind them. This is the broader literature e7D-Wellness responds to — none of it tested MarisMetrics directly.

BURNOUT

Bykov, K. V., Zrazhevskaya, I. A., Topka, E. O., Peshkin, V. N., Dobrovolsky, A. P., Isaev, R. N., & Orlov, A. M. (2022). Prevalence of burnout among psychiatrists. *Journal of Affective Disorders*, *308*, 47–64.

36 studies, 5,481 psychiatrists. Overall burnout 25.9% (MBI) / 50.3% (CBI); high emotional exhaustion 43.5%.

Sharaf, R. M. (2024). Burnout syndrome among orthopedic surgeons. *International Journal of Community Medicine and Public Health*, *11*(11), 4441–4449.

16 studies, 2,564 orthopedic surgeons. Overall burnout 43% (95% CI 33–53%).

Al-Ghunaim, T. A., Johnson, J., Biyani, C. S., Alshahrani, K. M., Dunning, A., & O'Connor, D. B. (2022). Surgeon burnout, impact on patient safety and professionalism. *The American Journal of Surgery, 224*(1 Pt A), 228–238.

27,248 participants overall. Burnout associated with 2.5× higher medical-error risk (OR 2.51, 95% CI 1.68–3.72).

Navinés, R., Olive, V., Hidalgo-Mazzei, D., Langohr, K., Vieta, E., & Martin-Santos, R. (2023). Burnout in residents during the first wave of the COVID-19 pandemic. *Frontiers in Psychiatry, 14*, 1286101.

23 studies, 4,998 residents, 14 countries. Pooled burnout 40% (95% CI 26–57%); prior psychiatric history a strong risk factor.

HaGani, N., Yagil, D., & Cohen, M. (2022). Burnout among oncologists and oncology nurses. *Health Psychology, 41*(1), 53–64.

34 studies, 4,705 oncologists, 6,940 oncology nurses. Emotional exhaustion ~32% in both groups.

Harlianto, Z. N., & Harlianto, N. I. (2026). Prevalence and risk factors for burnout among rheumatologists. *Rheumatology International, 46*(9), 245.

Overall burnout 51% (95% CI 39–63%).

Venturini, E., Ugolini, A., Bianchi, L., Di Bari, M., & Paci, M. (2024). Prevalence of burnout among physiotherapists. *Physiotherapy, 124*, 164–179.

Substantial pooled emotional exhaustion; workload and patient-contact intensity as key correlates.

Ramírez-Elvira, S., Romero-Béjar, J. L., Suleiman-Martos, N., Gómez-Urquiza, J. L., Cañadas-De la Fuente, G. A., & Albendín-García, L. (2021). Prevalence, risk factors and burnout levels in ICU nurses. *International Journal of Environmental Research and Public Health, 18*(21), 11432.

1,986 ICU nurses. High emotional exhaustion 31%, high depersonalisation 18%, low personal accomplishment 46%.

Clarke, M., Frecklington, M., & Stewart, S. (2024). Prevalence and severity of burnout risk among musculoskeletal allied health practitioners. *Occupational Health Science, 8*, 857–882.

54 studies, 19 countries. High emotional exhaustion 40%; physical therapists highest burnout.

Karuna, C., Palmer, V., Scott, A., & Gunn, J. (2022). Prevalence of burnout among GPs. *British Journal of General Practice, 72*(718), e316–e324.

60 studies, 22,177 GPs, 29 countries. Burnout prevalence ranged 6–33% depending on measure.

Macaron, M. M., Segun-Omosehin, O. A., Matar, R. H., Beran, A., Nakanishi, H., Than, C. A., & Abulseoud, O. A. (2023). Burnout in physicians during the COVID-19 pandemic. *Frontiers in Psychiatry, 13*, 1071397.

45 studies. Overall burnout 54.6%; highest in the Middle East/North Africa (66.6%).

Liang, Y., et al. (2025). The impact of health emergencies on nurses' burnout. *BMC Public Health, 25*, 2847.

176 studies, 110,316 nurses. Burnout 48% during health emergencies; linked to 7× higher depression risk.

Alansari, A. N., Tabia, I., Messaoud, M., & Youssif, H. (2026). Burnout among pediatric surgeons of different subspecialties worldwide. *Health Services Insights, 19*.

Overall burnout 30%; orthopedic subspecialty highest (42%).

SUICIDE RISK

Fernández-Peinado García, C., Cantero-García, M., Dorta-Afonso, D., & Rueda-Extremera, M. (2025). Factors associated with suicidal ideation in healthcare personnel. *Frontiers in Psychology, 16*, 1717231.

7 studies, ~19,000 healthcare professionals. Ideation linked to occupational stress, burnout, depression/anxiety, PTSD, and weak institutional support.

Groves, S., Lascelles, K., & Hawton, K. (2023). Suicide, self-harm, and suicide ideation in nurses and midwives. *Journal of Affective Disorders, 331*, 393–404.

100 studies. Female nurses show elevated suicide risk versus the general population; self-poisoning the predominant method.

MORAL INJURY, MORAL DISTRESS & COMPASSION FATIGUE

Lv, J., Che, X.-Y., Xie, L.-L., Ren, M., Guo, T.-Z., & Tu, S.-H. (2025). Prevalence and risk factors of compassion fatigue in gynecological and obstetric nurses. *Frontiers in Public Health, 13*, 1590995.

15 studies, 6,799 ob/gyn nurses. Moderate-to-severe compassion fatigue in 77.6%.

Beadle, E. S., et al. (2024). Triggers and factors associated with moral distress and moral injury in health and social care workers. *PLOS ONE, 19*(6), e0303013.

49 qualitative studies. Triggers cluster into individual, social, and organisational domains.

Lamoureux, S., Mitchell, A. E., & Forster, E. M. (2024). Moral distress among acute mental health nurses. *Nursing Ethics, 31*(7), 1178–1195.

10 studies. Moral distress linked to emotional exhaustion, depersonalisation, and lower job satisfaction.

Webb, E. L., Ireland, J. L., Lewis, M., & Morris, D. (2024). Potential sources of moral injury for healthcare workers in forensic and psychiatric settings. *Trauma, Violence, & Abuse, 25*(2), 918–934.

30 studies. Three recurring moral dichotomies underlie exposure to moral injury.

Rushforth, A., Durk, M., Rothwell-Blake, G. A. A., Kirkman, A., Ng, F., & Kotera, Y. (2023). Self-compassion interventions to target secondary traumatic stress in healthcare workers. *International Journal of Environmental Research and Public Health, 20*(12), 6109.

6 studies, 194 healthcare workers. 4 of 6 studies showed significant secondary-traumatic-stress reduction (15–26%).

Xie, W., et al. (2021). The prevalence of compassion satisfaction and compassion fatigue among nurses. *International Journal of Nursing Studies, 120*, 103973.

79 studies, 28,509 nurses, 11 countries. Pooled ProQOL: compassion satisfaction 33.12, burnout 26.64, secondary traumatic stress 25.24.

Laher, Z., Robertson, N., Harrad-Hyde, F., & Jones, C. R. (2022). Prevalence, predictors, and experience of moral suffering in nursing and care home staff during COVID-19. *International Journal of Environmental Research and Public Health, 19*(15), 9593.

8 studies. PTSD 45%, poor wellbeing 38.7%, suicidal ideation 13.8% among staff in the included studies.

Algamdi, M. (2022). Prevalence of oncology nurses' compassion satisfaction and compassion fatigue. *Nursing Open, 9*(1), 44–56.

Found meaningful compassion-fatigue risk sitting alongside compassion satisfaction in oncology nurses.

Qu, K.-Y., et al. (2026). Moral distress of intensive care unit nurses. *BMC Nursing, 25*(1), 108.

34 studies, 6,461 ICU nurses, 13 countries. Pooled Moral Distress Scale–Revised score 49.98 (moderate distress).

Ahmad, A. M., Bani-Issa, W., & Refaat, F. (2024). Factors contributing to moral distress among intensive care nurses. *F1000Research, 11*, 1574.

Identified powerlessness, end-of-life conflict, ineffective teamwork, and personal characteristics as driver domains.

INTERVENTIONS

Fendel, J. C., Bürkle, J. J., & Göritz, A. S. (2021). Mindfulness-based interventions to reduce burnout and stress in physicians. *Academic Medicine, 96*(5), 751–764.

25 studies, 925 physicians. Medium stress reduction (ES −0.55); small burnout reduction (ES −0.26), holding at ~5.3 months.

Wang, Q., et al. (2023). Effects of a mindfulness-based intervention on stress, burnout in nurses. *Frontiers in Psychiatry, 14*, 1218340.

15 RCTs, 1,165 nurses. SMD −0.81 for stress; no significant effect on anxiety or depression.

Han, S. J., & Yeun, Y. R. (2023). Psychological intervention to promote resilience in nurses. *Healthcare, 12*(1), 73.

15 studies, 852 participants. SMD 0.59 improvement in resilience.

Lee, M., & Cha, C. (2023). Interventions to reduce burnout among clinical nurses. *Scientific Reports, 13*(1), 10971.

24 studies. Emotional exhaustion SMD −0.752; no significant change in personal accomplishment.

Colin, C., Prince, V., Bensoussan, J. L., & Picot, M. C. (2023). Music therapy for health workers to reduce stress, mental workload and anxiety. *Journal of Public Health, 45*(3), e532–e541.

7 studies. Music interventions significantly decreased stress, anxiety, mental workload, and burnout indicators.

Yang, J. M., et al. (2023). Web-based mindfulness-based interventions on anxiety, depression, and stress among frontline healthcare workers during COVID-19. *Journal of Medical Internet Research, 25*, e44000.

Significant reductions in anxiety, depression, and stress versus control.

Zhang, Z., et al. (2024). The effectiveness of e-mental health interventions on stress, anxiety, and depression among healthcare professionals. *Systematic Reviews, 13*(1), 144.

17 RCTs. Large effect on stress and anxiety; small-to-medium on depression.

Kiratipaisarl, W., Surawattanasakul, V., & Sirikul, W. (2024). Individual and organizational interventions to reduce burnout in resident physicians. *BMC Medical Education, 24*(1), 1234.

33 studies, 2,536 residents. Individual interventions significant; organisational interventions showed no significant effect.

Abundo, M. F., & Sav, A. (2025). A decade of advancements: Interventions to reduce burnout among mental health nurses. *Healthcare, 13*(17), 2113.

Longer-duration interventions (12-week mindfulness, 8-week psychoeducation) proved more durable than brief workshops.

Liu, M., Yan, Z., & Wu, C. (2025). Comparative efficacy and acceptability of resilience-focused interventions for nurses. *BMC Nursing, 24*(1), 418.

21 RCTs. Anger-management psychoeducation, emotional intelligence training, and MBSR ranked most effective.

Zhang, H., Xia, Z., Yu, S., Shi, H., Meng, Y., & Dator, W. L. (2025). Interventions for compassion fatigue, burnout, and secondary traumatic stress in nurses. *Nursing & Health Sciences, 27*(1), e70042.

Behavioral training most effective for compassion fatigue; multifaceted interventions best for burnout overall.

Ko, H., Shim, J., & Baek, J. (2025). Effects of programs on sleep improvement in shift-work nurses. *BMC Nursing, 24*(1), 1142.

12 studies. Light therapy improved sleep efficiency (Hedges' g = 0.861), alertness, duration, satisfaction.

Lee, A. Y. L., & Tse, L. A. (2026). Non-pharmacological intervention for shift nurses' sleep. *Occupational Medicine*, kqag085.

11 studies, 1,235 shift nurses. SMD −0.63 improvement in sleep quality; mindfulness strongest, aromatherapy non-significant.

V The Blood Already Knows

Ten biomarkers behind the C20C tracking feature, each mapped to the pillars it moves

Hydration call-outs below are reading caveats — check hydration before trusting the number — not scored pillar drivers, except for cortisol, blood pressure and resting heart rate where hydration status measurably moves the biomarker itself.

hs-CRP

THOUGHTS MOVEMENT REST BREATHING

A circulating signal of low-grade vascular inflammation. The American College of Cardiology's 2025 scientific statement concludes hs-CRP predicts future cardiovascular events at least as well as LDL cholesterol — even on statin therapy — and calls for routine hs-CRP screening alongside LDL. In PCI cohorts, persistently elevated hs-CRP tracks major adverse cardiac events (RR 1.64, 95% CI 1.33–2.03) and all-cause death (RR 2.68, 95% CI 1.90–3.78).

Mensah, G.A., Arnold, N., Prabhu, S.D., Ridker, P.M., & Welty, F.K. (2026). Inflammation and Cardiovascular Disease: 2025 ACC Scientific Statement. *JACC, 87*(11), 1381–1404.
Romeo, F.J., et al. (2026). Residual inflammatory risk and clinical outcomes after contemporary PCI. *Scientific Reports*.

Vitamin D (25-OH)

THOUGHTS MOVEMENT REST SEXUAL VITALITY

The stored form the brain and muscles run on. Supplementation reduced depressive symptom scores across RCTs (SMD −0.49 in depressed adults; SMD −0.32 per 1,000 IU/day in a dose–response analysis).

Srifuengfung, M., et al. (2023). Efficacy and acceptability of vitamin D supplements for depressed patients. *Nutrition, 108*, 111968.
Ghaemi, S., Zeraattalab-Motlagh, S., Jayedi, A., & Shab-Bidar, S. (2024). The effect of vitamin D supplementation on depression. *Psychological Medicine, 54*(15).

TSH

THOUGHTS REST MOVEMENT SEXUAL VITALITY NUTRITION

The pituitary's report on thyroid drive. Overt hypothyroidism presents with fatigue, cold intolerance, weight change, low mood, impaired concentration and reduced libido. Dehydration itself shifts this panel: in dehydrated patients, TSH fell 8% after rehydration — a reversible, hydration-driven pattern distinct from true thyroid disease.

Gosi, S.K.Y., & Garla, V.V. (2021). Hypothyroidism: Diagnosis and treatment. *American Family Physician, 103*(10), 605–613.
Ybarra, J., & Fernandez, S. (2007). Rapid and reversible alterations in thyroid function tests in dehydrated patients. *Nursing Clinics of North America, 42*(1), 127–134.

Cortisol (serum)

THOUGHTS | REST | WILLPOWER | SEXUAL VITALITY | HYDRATION

The HPA output. Physicians meeting burnout criteria had higher serum and salivary cortisol, ACTH, fasting glucose and HbA1c than controls. In hospital staff, hair cortisol sat outside reference range in 40%, with burnout and depersonalisation both implicated. Hydration moves this number too: hypohydration raised cortisol with a large pooled effect (SMD 1.12, 95% CI 0.58–1.67) — a heat/exertion effect, not something triggered by ordinary daily under-drinking.

Deneva, T., Ianakiev, Y., & Keskinova, D. (2019). Burnout syndrome in physicians. *Medicina*, *55*(5), 209.
Ibar, C., et al. (2021). Stress, burnout and hair cortisol levels in health workers during COVID-19. *Psychoneuroendocrinology, 128*, 105213.
Zuccarella-Hackl, C., et al. (2024). Cortisol reactivity to acute psychosocial stress in physician burnout. *Biomedicines*, *12*(2), 335.
Zaplatosch, M.E., & Adams, W.M. (2020). Acute hypohydration on glycemic regulation, appetite, metabolism and stress. *Nutrients*, *12*(9), 2526.
Carroll, H.A., et al. (2019). Acute hypohydration on glycemic regulation: A randomised crossover trial. *Journal of Applied Physiology, 126*(2), 422–430.

Lipid Panel

NUTRITION | MOVEMENT | SEXUAL VITALITY | BREATHING

LDL-C, non-HDL-C and triglycerides are causal inputs to atherosclerotic risk; HDL-C classifies that risk alongside them. Persistently high triglycerides (≥1.7 mmol/L) and low HDL change what the vessel wall sees and what effort, diet, and recovery have to carry.

American Diabetes Association. (2024). Cardiovascular disease and risk management. *Diabetes Care, 47*(Suppl. 1), S179–S218.
Kolber, M.R., et al. (2023). PEER simplified lipid guideline 2023 update. *Canadian Family Physician, 69*(10), 675–686.

HbA1c

NUTRITION | MOVEMENT | REST | THOUGHTS

A three-month measure of glycation. In diabetes, intensive control cut any CVD event by 42% and MACE by 57% versus conventional care. In people without known diabetes, prediabetes-band HbA1c already raised composite CVD and coronary risk.

Nathan, D.M., et al., for the DCCT/EDIC Study Research Group. (2005). Intensive diabetes treatment and cardiovascular disease. *NEJM*, *353*, 2643–2653.
Huang, Y., Cai, X., Mai, W., Li, M., & Hu, Y. (2016). Prediabetes and risk of cardiovascular disease and all-cause mortality. *BMJ*, *355*, i5953.

Fasting Glucose

NUTRITION | MOVEMENT | REST

Across 102 prospective studies (698,782 people), diabetes approximately doubled coronary and ischaemic-stroke risk. In adults with markers of chronic under-hydration, six weeks of added water intake lowered fasting glucose from 5.94 to 5.74 mmol/L (P=0.04) — a hydration-specific subgroup effect, not a general-reading expectation.

The Emerging Risk Factors Collaboration. (2010). Diabetes mellitus, fasting blood glucose, and risk of vascular disease. *The Lancet, 375*(9733), 2215–2222.
Enhörning, S., et al. (2019). Water supplementation reduces copeptin and plasma glucose in adults with high copeptin. *JCEM, 104*(6), 1917–1925.

Ferritin

REST | MOVEMENT | THOUGHTS | SEXUAL VITALITY

Stored iron. Iron deficiency without anaemia can present as fatigue, reduced work output, cognitive fog, and restless legs; RLS occurred in 32–40% of people with absolute iron deficiency. In non-anaemic RLS, 42% were iron-deficient.

Auerbach, M., et al. (2025). Iron deficiency in adults: A review. *JAMA*.
Zhu, X.Y., et al. (2020). Correlates of nonanemic iron deficiency in restless legs syndrome. *Frontiers in Neurology, 11*, 298.

Blood Pressure

BREATHING | THOUGHTS | SEXUAL VITALITY | MOVEMENT | HYDRATION

Hypertension damages small cerebral vessels and raises vascular cognitive impairment and Alzheimer risk. In women, hypertension raised the odds of sexual dysfunction (pooled OR 2.79). Chronic fluid-and-sodium balance feeds the same pressure system over years: serum sodium above 143 mmol/L in middle age carried a 39% higher heart failure risk over 25 years — a finding about serum sodium specifically, not a same-day blood-pressure-reading effect.

Ungvari, Z., et al. (2021). Hypertension-induced cognitive impairment. *Nature Reviews Nephrology, 17*, 639–654.
Choy, C.L., et al. (2019). Sexual dysfunction in women with hypertension. *The Journal of Sexual Medicine, 16*(7), 1029–1048.
Dmitrieva, N.I., Liu, D., Wu, C.O., & Boehm, M. (2022). Middle-age serum sodium and risk of heart failure. *European Heart Journal, 43*(35), 3335–3348.

Resting Heart Rate

BREATHING | REST | MOVEMENT | WILLPOWER | HYDRATION

The autonomic set-point at stillness. Each 10 bpm increment raised all-cause mortality (RR 1.09) and cardiovascular mortality (RR 1.08); rates >80 bpm carried RR 1.45 for all-cause death. Fluid status moves the same number acutely: fluid ingestion lowered heart rate by 6.20 bpm versus fluid restriction, with a parallel gain in vagal/HRV recovery.

Zhang, D., Shen, X., & Qi, X. (2016). Resting heart rate and mortality in the general population. *CMAJ, 188*(3), E53–E63.
Aune, D., et al. (2017). Resting heart rate and cardiovascular disease, cancer and mortality. *Nutrition, Metabolism and Cardiovascular Diseases, 27*(6), 504–517.
Porto, A.A., et al. (2023). Fluid ingestion on heart rate, cardiac autonomic modulation and blood pressure. *Nutrients, 15*(21), 4534.

VI

The 8 Pillars

Each pillar’s own evidence base, from Willpower to Rest

Twenty-four studies supporting the eight-pillar framework itself — the clinical rationale for why Thoughts, Breathing, Movement, Rest, Nutrition, Sexual Vitality, Hydration, and Willpower are each tracked. Three pillars (Willpower, Sexual Vitality, Hydration) don’t yet have five independently DOI-confirmed studies; those gaps are left visible rather than padded.

WILLPOWER

Maier, M., Powell, D., Murchie, P., & Allan, J. L. (2025). Decision fatigue in healthcare professionals on medical decision-making. *Health Psychology Review, 19*(4), 717–762.

82 studies. In ~45% of quantitative tests, later decisions in a shift were less effortful.

Schweitzer, D. R., et al. (2023). Self-control, limited willpower and decision fatigue in healthcare settings. *Internal Medicine Journal, 53*(6), 1076–1080.

A clinical-argument piece built around real clinical scenarios where self-control appears to run down over a shift.

BREATHING

Fincham, G. W., Strauss, C., Montero-Marin, J., & Cavanagh, K. (2023). Effect of breathwork on stress and mental health. *Scientific Reports, 13*, 432.

General population. Stress g = −0.35, anxiety g = −0.32, depression g = −0.40.

Shao, R., Man, I. S. C., & Lee, T. M. C. (2024). Slow-paced breathing on cardiovascular and emotion functions. *Mindfulness, 15*, 1–18.

31 studies, 1,133 adults. Systolic BP SMD −0.45; HRV rose; stress reduction marginal.

Wang, S.-C., et al. (2023). Guided respiration mindfulness therapy (GRMT) for reducing stress in nurses. *Journal of Holistic Nursing, 41*(2), 155–167.

62 nurses. Five sessions of guided breathwork reduced distress, anxiety, and stress more than a mindfulness comparison.

Vetter, V. M., Kurth, T., & Konigorski, S. (2026). Digital breathing interventions (ASIP study). *npj Digital Medicine*.

76 resident physicians. Average effect small; a minority had a clear daily drop in stress.

THOUGHTS

Ong, N. Y., et al. (2024). Mindfulness-based interventions on the well-being of healthcare workers. *General Psychiatry, 37*(3), e101115.

2,506 healthcare workers. Short-term stress SMD −0.76, anxiety −0.68, burnout −0.44.

Kriakous, S. A., Elliott, K. A., Lamers, C., & Owen, R. (2021). MBSR on psychological functioning of healthcare professionals. *Mindfulness, 12*, 1–28.

MBSR improved psychological functioning; authors call for more robust, randomised, controlled designs.

Suleiman-Martos, N., et al. (2020). Mindfulness training on burnout syndrome in nursing. *Journal of Advanced Nursing, 76*(5), 1124–1140.

17 studies, 632 nurses. Burnout scores fell; confidence intervals were wide.

Dou, J., Lian, Y., Lin, L., Asmuri, S. N. B., Wang, P., & Durai, R. A. P. R. (2025). Mindfulness-based interventions on burnout, resilience and sleep quality among nurses. *BMC Nursing, 24*, 739.

16 trials, 1,384 nurses. Burnout SMD −1.43, sleep quality SMD −1.1.

Du, J., Sha, R., & Wang, Y. (2026). Mindfulness-based training for nurse stress and burnout mitigation. *Journal of Psychosocial Nursing and Mental Health Services, 64*(2), 21–27.

10 trials, 912 nurses. Stress SMD −0.99, burnout SMD −0.45.

NUTRITION

Clark, A. B., Coates, A. M., Davidson, Z. E., & Bonham, M. P. (2023). Dietary patterns under rotational shift work schedules. *Advances in Nutrition, 14*(2), 295–316.

18,196 workers. Rotating shift workers ate 264 kJ more per day, with more snacking and fewer core foods.

Koh, J. Y. J., Tan, C. Y. H., Li, M., Liu, M. H., & Chew, H. S. J. (2025). Time-restricted eating on shift workers' glucose metabolism. *Nutrients, 17*(10), 1689.

6 trials, 316 shift workers. Glucose trended favourable but non-significant; certainty very low.

SEXUAL VITALITY

Chen, Y., Zhang, L., Zhou, Y., Zhang, J., Yu, H., Li, Q., & Xu, J. (2024). Prevalence of sexual dysfunction in health care workers. *Sexual Medicine Reviews, 12*(4), 569–580.

39 studies, 16 countries, 44,017 healthcare workers. Pooled sexual dysfunction 46.79%; nurses 56.29%, doctors 37.63%.

Tan, X., et al. (2025). Sexual dysfunction and burnout among physicians in primary hospital. *Journal of Sexual Medicine, 22*(1), 114–123.

382 doctors. Sexual dysfunction 45.51% with burnout, 24.19% without.

MOVEMENT

Mincarone, P., et al. (2024). Physical activity and the risk of burnout in health care workers. *JMIR Public Health and Surveillance, 10*, e49772.

21 studies. Activity often linked to lower emotional exhaustion and depersonalisation; most observational.

Martland, R. N., et al. (2024). Physical activity to improve the mental wellbeing of healthcare workers. *Mental Health and Physical Activity, 26*, 100577.

16 intervention studies, 11 randomised. Stress fell in 3 of 3 trials; sleep improved in 3 of 4.

HYDRATION

Goodman, S. P. J., Moreland, A. T., & Marino, F. E. (2019). Active hypohydration on cognitive function. *Physiology & Behavior, 204*, 297–308.

Not HCP-specific. Cognitive performance not meaningfully impaired (g = −0.18, ns).

Da'ar, O. B., Alhabeeb, R., & Kalmey, F. (2026). Healthcare workers hydration status and performance. *Frontiers in Health Services, 6*.

15 studies. Dehydration reported with lower physical performance; evidence base thin.

REST

Fox, J., et al. (2025). Sleep duration and quality in healthcare workers: patient safety and quality of care. *Behavioral Sleep Medicine, 23*(5), 698–714.

30 studies. Short or poor sleep tracked with more errors and worse cognition.

Weaver, M. D., Sullivan, J. P., Landrigan, C. P., & Barger, L. K. (2023). Physician work schedules and patient safety. *Joint Commission Journal on Quality and Patient Safety, 49*(11), 634–647.

The 2003 ACGME restrictions (80-hour weeks, 28-hour shifts) were associated with an 11% drop in mortality.

Santostefano, L. G., et al. (2026). Trends in nurses' sleep: a meta-regression of 219,245 nurses from 45 countries. *Journal of Nursing Management*.

280 studies. Sleep duration fell 28.7 minutes from 1985 to 2022; sleep quality worsened.

Dou, J., et al. (2025). Mindfulness-based interventions on burnout, resilience and sleep quality among nurses. *BMC Nursing, 24*, 739.

Sleep quality SMD −1.1, distinct from the burnout SMD above.

Ge, M.-W., Hu, F.-H., Jia, Y.-J., Tang, W., Zhang, W.-Q., & Chen, H.-L. (2023). Global prevalence of nursing burnout syndrome. *Journal of Clinical Nursing, 32*(17–18), 5836–5854.

94 studies. Nursing burnout 30%, rising over 10 years.

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