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Integrating Circadian Rhythm Science and Traditional Herbal Medicine for Stroke and Sudden Cardiac Death Prevention in Young Adults

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Abstract
Background:
The incidence of stroke and sudden cardiac death (SCD) among young adults has been rising alarmingly in recent years, particularly in rapidly modernizing societies such as Vietnam. Irregular sleep patterns, late-night screen exposure, and lifestyle stressors have disrupted circadian rhythms, contributing to cardiovascular vulnerability. While conventional prevention focuses on risk factors like hypertension and cholesterol, the role of biological time alignment and traditional herbal medicine (THM) in cardiovascular prevention remains underexplored.
Purpose:
This study aims to develop and test an integrative model combining circadian rhythm science and herbal chronotherapy to enhance cardiovascular resilience and reduce the risk of stroke and SCD among young adults.
Methods:
Data were collected from 211 valid respondents, primarily under the age of 35, through a structured questionnaire based on five constructs: Circadian Rhythm Alignment (CRA), Herbal Chronotherapy (HCT), Physiological Mechanisms (PM), Cardiovascular Resilience (CVR), and Preventive Outcomes (PO). The model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4.1.
Results:
Findings reveal that both CRA ($\beta = 0.243$, $p < 0.001$) and HCT ($\beta = 0.315$, $p < 0.001$) significantly enhance CVR, while PM serves as a strong mediator ($\beta = 0.334$, $p < 0.001$). CVR strongly predicts preventive outcomes ($\beta = 0.502$, $p < 0.001$), explaining 54% of the variance. The model demonstrates high reliability and explanatory power (R^2 for CVR = 0.67).

Conclusion:
Integrating circadian rhythm alignment with time-specific herbal therapy offers a promising, low-cost preventive approach to improving cardiovascular health in young adults. The study introduces a novel chronobiology–herbal medicine framework, bridging modern science with traditional wisdom and contributing to sustainable strategies for stroke and SCD prevention in Vietnam and similar contexts.
Keywords: *Circadian rhythm, herbal chronotherapy, cardiovascular resilience, stroke prevention, young adults, Vietnam*

1. Introduction

In recent decades, the incidence of stroke and sudden cardiac death (SCD) among young adults aged 18–45 has shown an alarming increase worldwide, challenging the conventional view that these conditions primarily affect older populations. According to the *World Health Organization (WHO, 2023)*, approximately 15% of all stroke cases and 10–12% of cardiac arrests now occur in individuals under 45 years old, often without prior diagnosis

of hypertension or atherosclerosis. These "early-onset" cardiovascular events not only result in catastrophic health and social consequences but also impose a significant economic burden due to loss of productivity and long-term disability. Therefore, there is an urgent need to develop preventive strategies that are both scientifically grounded and culturally adaptive.

A growing body of evidence indicates that disruption of circadian rhythms—including irregular sleep–wake cycles, shift work, excessive nighttime light exposure, and social jet lag—plays a critical role in triggering acute cardiovascular events. Studies have shown that stroke and cardiac arrest are not randomly distributed throughout the day but rather peak in the early morning hours when the sympathetic nervous system, cortisol secretion, and blood pressure rise sharply (*Scheer et al., 2010; Thosar et al., 2018*). Despite these insights, circadian-based preventive interventions remain underdeveloped and rarely integrated into routine cardiovascular health management, particularly in young populations exposed to high levels of digital and lifestyle-related stressors.

In parallel, traditional herbal medicine (THM) offers a rich pharmacological foundation for cardiovascular protection through mechanisms such as antioxidant, anti-inflammatory, and endothelial-modulating effects. Herbs like *Panax notoginseng, Salvia miltiorrhiza, Ginkgo biloba,* and *Crataegus pinnatifida* have demonstrated beneficial effects on vascular tone, platelet aggregation, and lipid metabolism (*Li et al., 2022; Chen et al., 2023*). However, the timing of administration—chronopharmacology—has rarely been explored in THM. Integrating circadian rhythm science with herbal medicine could therefore optimize bioavailability and therapeutic efficacy, aligning biological rhythms with drug action to enhance preventive outcomes.

Moreover, young adults today are experiencing unprecedented circadian disruption due to lifestyle modernization—late-night screen exposure, irregular sleep, stress, and caffeine overuse—all of which compound cardiovascular risk. The absence of culturally relevant, non-invasive, and sustainable interventions for this demographic amplifies the public health urgency. By bridging modern chronobiology and traditional herbal wisdom, this study aims to propose an innovative, low-cost preventive model that is not only biologically sound but also aligned with holistic health traditions prevalent in Asian medicine.

In summary, this research is both scientifically urgent and socially relevant. It addresses the rising epidemic of cardiovascular events among young adults through a novel, integrative framework that synchronizes modern circadian science with traditional herbal medicine. The outcomes are expected to contribute to global strategies in personalized preventive medicine, reduce the burden of premature cardiovascular death, and provide an evidence-based foundation for time-specific herbal therapy protocols.

2. Literature review

2.1. Epidemiological Trends of Stroke and Sudden Cardiac Death in Young Adults

Traditionally, stroke and sudden cardiac death (SCD) have been regarded as disorders of older populations. However, epidemiological studies over the past two decades reveal a significant shift toward younger demographics. The *Global Burden of Disease Study (GBD, 2023)* reported that stroke incidence among individuals aged 18–45 years has risen by nearly 40% since 1990, particularly in low- and middle-income countries. Similarly, *Chugh et al. (2020)* noted that 10–12% of SCD cases now occur in adults under 45 years, often linked to undiagnosed hypertension, arrhythmia, or lifestyle-induced cardiac stress.

Young adults are increasingly exposed to risk factors such as sleep deprivation, night-shift work, stress, and digital overstimulation, which disturb cardiovascular homeostasis and autonomic balance (*Thosar et al., 2018; Wu et al., 2022*). These findings underline the urgent need for preventive models that target biological rhythms and behavioral determinants in younger populations—beyond the traditional focus on cholesterol or hypertension management.

2.2. Circadian Rhythms and Cardiovascular Health

Circadian rhythms, orchestrated by the suprachiasmatic nucleus (SCN) in the hypothalamus, regulate fundamental physiological functions such as blood pressure, heart rate, endothelial tone, and hormonal secretion. Disruptions in circadian rhythms—caused by irregular sleep–wake cycles, exposure to artificial light at night, or social jet lag—are strongly correlated with elevated cardiovascular risk (*Scheer et al., 2010; Morris et al., 2016*).

Morning peaks in sympathetic nervous activity and cortisol levels are linked to the highest incidence of myocardial infarction and ischemic stroke between 6 a.m. and noon (*Elliott et al., 2014*). Circadian misalignment has been shown to alter vascular endothelial function, platelet aggregation, and metabolic responses, leading to increased oxidative stress and inflammatory cytokine expression (*Haus & Smolensky, 2013*).

Experimental studies demonstrate that clock genes such as *BMAL1, PER2,* and *CLOCK* directly regulate cardiac metabolism and electrophysiological stability. Mice lacking *BMAL1* exhibit premature aging, hypertension, and endothelial dysfunction (*Paschos et al., 2012*). Therefore, integrating circadian science into cardiovascular prevention represents a novel approach to anticipate and modulate biological vulnerability windows for cardiovascular events.

2.3. Chronotherapy and Chronopharmacology in Disease Prevention

Chronotherapy—the administration of therapeutic agents in alignment with biological rhythms—has emerged as a promising strategy in cardiovascular medicine. For instance, nighttime dosing of antihypertensive agents has been shown to improve 24-hour blood pressure control and reduce cardiovascular events (*Hermida et al., 2020*). Similarly, the timing of statin administration (evening vs. morning) significantly affects lipid-lowering efficacy due to circadian fluctuations in hepatic cholesterol synthesis (*Suvorov et al., 2021*).

Despite these advances, most existing chronotherapy models rely on synthetic pharmaceuticals, with limited exploration in natural or traditional medicine contexts. This represents a critical gap, particularly in cultures where traditional herbal medicine is widely practiced and socially accepted.

2.4. Cardioprotective Mechanisms of Traditional Herbal Medicine (THM)

Traditional herbal medicine (THM), rooted in systems such as Traditional Chinese Medicine (TCM), Ayurveda, and Vietnamese traditional pharmacology, offers bioactive compounds that exhibit multi-target cardioprotective actions. Herbs like *Panax notoginseng* (Sanqi), *Salvia miltiorrhiza* (Danshen), *Ginkgo biloba*, and *Crataegus pinnatifida* (Hawthorn) have been extensively studied for their anti-oxidative, anti-inflammatory, antithrombotic, and vasodilatory effects (*Li et al., 2022; Chen et al., 2023*).

For instance, *Panax notoginseng saponins* enhance nitric oxide (NO) synthesis and attenuate platelet aggregation, while *Salvia miltiorrhiza* modulates calcium influx and reduces ischemia-reperfusion injury (*Zhou et al., 2021*). *Ginkgo biloba* extracts improve cerebral perfusion and neurovascular coupling, contributing to post-stroke recovery (*Wu et al., 2020*). However, the temporal dynamics of herbal compound absorption and metabolism remain poorly understood, and few studies have examined how circadian timing affects herbal efficacy—an emerging field known as herbal chronopharmacology.

2.5. The Emerging Concept of Herbal Chronotherapy

Integrating circadian science with herbal medicine—termed “herbal chronotherapy”—represents an innovative frontier in preventive and personalized healthcare. Preliminary research indicates that the pharmacokinetics of herbal active compounds (such as ginsenosides, tanshinones, and flavonoids) vary across the day, influenced by rhythmic fluctuations in liver enzyme activity, gut microbiota composition, and hormonal milieu (*Zhang et al., 2021; Hu et al., 2023*).

Furthermore, synchronizing herbal intake with the body's biological clock may optimize absorption, minimize side effects, and enhance therapeutic outcomes, especially in diseases with circadian patterns like hypertension, stroke, and arrhythmia. Despite its potential, this field remains underexplored, with limited integration into preventive strategies for young adults exposed to lifestyle-related circadian disruptions.

2.6. Integration of Circadian and Traditional Medicine Paradigms

The philosophical foundation of THM—"harmonizing Yin and Yang" and maintaining balance between activity (Yang) and rest (Yin)—aligns conceptually with circadian science, which emphasizes rhythmic balance between biological activation and restoration. This theoretical convergence provides a scientific rationale for integrative approaches, where time-based herbal administration can reinforce natural physiological cycles.

Modern digital tools, such as wearable devices and circadian monitoring apps, can further enhance this integration by tracking individual rhythm patterns and tailoring herbal prescriptions accordingly. This data-driven and culturally embedded approach may offer a scalable, low-cost, and holistic solution for preventing early-onset cardiovascular events.

Gaps in the Literature: Despite abundant research on circadian biology and herbal pharmacology separately, interdisciplinary integration remains limited. Key research gaps include: Lack of studies focusing on young adults as a target group for circadian-cardiovascular prevention.Insufficient evidence on chronopharmacological mechanisms of herbal compounds. Limited clinical trials testing time-specific herbal interventions for cardiovascular prevention. Inadequate frameworks combining chronobiological biomarkers (e.g., melatonin, cortisol, HRV rhythms) with herbal therapeutic outcomes. Addressing these gaps could yield a new paradigm for preventive cardiology—one that aligns traditional health systems with precision circadian science.

The literature consistently demonstrates the biological, behavioral, and cultural relevance of aligning preventive interventions with circadian rhythms. At the same time, traditional herbal medicine provides a rich, evidence-supported pharmacopeia for cardiovascular protection. The convergence of these fields offers a timely opportunity to innovate preventive health strategies for young adults—those most vulnerable to circadian disruption yet often neglected in cardiovascular research.

This integrative framework thus holds potential to transform the landscape of stroke and sudden cardiac death prevention, advancing a new generation of chronotherapeutic herbal interventions grounded in both modern science and traditional wisdom.

3. Research Framework and Hypotheses Development

3.1 Conceptual Rationale

The proposed study builds on the interdisciplinary intersection of chronobiology, cardiovascular science, and traditional herbal medicine (THM). The conceptual premise is that synchronizing lifestyle and herbal interventions with the body's circadian rhythms can enhance cardiovascular resilience, mitigate biological stressors, and thereby reduce the risk of stroke and sudden cardiac death (SCD) among young adults.

Modern lifestyle patterns—characterized by sleep deprivation, late-night digital exposure, and irregular work–rest cycles—cause circadian misalignment, disrupting hormonal regulation, endothelial tone, and heart rate variability (HRV) (*Haus & Smolensky, 2013; Thosar et al., 2018*). This misalignment amplifies inflammatory and oxidative stress pathways that underlie early vascular aging and cardiac vulnerability.

Simultaneously, traditional herbal medicines offer cardioprotective properties through their antioxidant, vasodilatory, and anti-thrombotic effects (*Li & Zhao, 2022; Chen et al., 2023*). When administered in harmony with the circadian rhythm—an approach known as herbal chronotherapy—the pharmacodynamics of active herbal compounds may align more effectively with the body's metabolic and hormonal rhythms, maximizing therapeutic outcomes (*Zhang et al., 2021; Hu et al., 2023*).

3.2 Theoretical Foundation

This study integrates two theoretical paradigms:

The Circadian Regulation Model (CRM) – which posits that biological rhythms govern physiological homeostasis, and disruptions to these rhythms elevate cardiovascular risk.

The Yin–Yang Balance Framework from Traditional Medicine (YBTM) – emphasizing equilibrium between activation (Yang) and restoration (Yin), analogous to biological oscillations in activity and rest.

By combining CRM and YBTM, the study conceptualizes cardiovascular health as a rhythm-dependent equilibrium, influenced by both endogenous biological clocks and exogenous interventions (e.g., herbal timing, light exposure, sleep schedule).

Constructs and Operational Definitions

Construct	Conceptual Definition	Key Indicators (Examples)	Source
Circadian Rhythm Alignment (CRA)	Degree to which an individual's behavioral and physiological cycles align with the natural 24-hour rhythm.	Sleep regularity, melatonin onset, cortisol rhythm, HRV rhythmicity	Scheer et al. (2010); Morris et al. (2016)
Herbal Chronotherapy (HCT)	Timing of herbal medicine administration aligned with the body's circadian cycles to maximize bioavailability and efficacy.	Herbal intake timing (morning/evening), dosage synchronization, compliance	Zhang et al. (2021); Hu et al. (2023)
Physiological Mechanisms (PM)	Biological mediators linking CRA and HCT to cardiovascular health.	Biomarkers: CRP, IL-6, oxidative stress index, NO levels, HRV variability	Haus & Smolensky (2013); Li & Zhao (2022)
Cardiovascular Resilience (CVR)	The body's adaptive capacity to maintain stable cardiovascular function under stress.	Resting HRV, endothelial reactivity, blood pressure variability	Elliott et al. (2014); Thosar et al. (2018)
Preventive Outcome (PO)	Long-term reduction in risk factors associated with stroke and SCD among young adults.	Composite cardiovascular risk index (Framingham score, carotid IMT)	Chugh et al. (2020); WHO (2023)

Source: Author

4. Results

4.1. Hypothesis testing

Sample Characteristics

Demographic	Frequency (n=211)	Percentage (%)	Remarks
Gender	Male: 96 – Female: 115	45.5 / 54.5	Female respondents slightly outnumbered males, showing greater engagement in preventive health.
Age group	<25: 61 25–30: 98	**92.4% under 35**	The sample primarily represents young adults—those most

Demographic	Frequency (n=211)	Percentage (%)	Remarks
	31–35: 36 >35: 16	**years old**	exposed to circadian disruption due to modern lifestyles.
Occupation	Students: 72 Office workers: 92 Shift workers: 35 Others: 12	34 / 44 / 17 / 5	Around 61% have regular work hours, 17% are shift workers—both directly affecting circadian rhythm stability.
Average sleep duration	<5h: 28 5–6h: 81 7–8h: 86 >8h: 16	13 / 38 / 41 / 8	**51% sleep less than 7 hours/day**, showing widespread sleep deprivation and rhythm irregularity.
Use of herbal supplements	Yes: 132 No: 79	62.6 / 37.4	The majority reported using herbal or functional supplements for cardiovascular health.

Source: Author

Reliability and Convergent Validity

Construct	Cronbach's α	Composite Reliability (CR)	AVE	Assessment
CRA	0.83	0.88	0.60	Acceptable
HCT	0.85	0.89	0.62	Acceptable
PM	0.82	0.87	0.58	Acceptable
CVR	0.86	0.90	0.63	Acceptable
PO	0.88	0.92	0.66	Acceptable

Source: Author

All constructs exhibit high reliability (CR > 0.7) and strong convergent validity (AVE > 0.5).

Structural Path Analysis (Bootstrapping, 5,000 samples)

Relationship	Path Coefficient (β)	T Statistics	P Values	Interpretation
CRA → CVR	0.243	4.62	0.000	Significant positive effect
HCT → CVR	0.315	6.05	0.000	Strong positive effect
CRA × HCT → PM	0.278	5.24	0.000	Significant interaction effect
PM → CVR	0.334	6.48	0.000	Strong mediating effect
CVR → PO	0.502	8.91	0.000	The strongest and most significant pathway

Source: Author

H1: Circadian Rhythm Alignment (CRA) → Cardiovascular Resilience (CVR)

The positive relationship (β = 0.243, p < 0.001) suggests that individuals who maintain regular sleep–wake cycles and align daily behaviors with their biological rhythms exhibit higher cardiovascular adaptability. This aligns with *Scheer et al. (2010)* and *Thosar et al. (2018)*, who demonstrated that circadian synchronization improves autonomic stability and reduces vascular stress.

H2: Herbal Chronotherapy (HCT) → Cardiovascular Resilience (CVR)

The strongest direct effect among independent variables (β = 0.315, p < 0.001) confirms that timing herbal interventions according to circadian cycles significantly enhances resilience. Respondents who consciously adjust herbal intake times (morning vs. evening) reported better cardiovascular health indicators.

H3: Interaction (CRA × HCT) → Physiological Mechanisms (PM)

The interaction term (β = 0.278, p < 0.001) reveals a synergistic effect: circadian alignment amplifies the physiological benefits of timed herbal intake. This finding indicates that behavioral rhythm regulation enhances the body's receptivity to herbal bioactives, improving inflammatory and oxidative stress pathways (*Chen et al., 2023*).

H4: Physiological Mechanisms (PM) → Cardiovascular Resilience (CVR)

The mediating path (β = 0.334, p < 0.001) highlights that the regulation of inflammatory, metabolic, and stress-related physiological processes serves as a key channel through which circadian and herbal practices influence cardiovascular resilience.

H5: Cardiovascular Resilience (CVR) → Preventive Outcomes (PO)

The final pathway shows the strongest overall effect (β = 0.502, p < 0.001), confirming cardiovascular resilience as the core predictor of stroke and SCD prevention outcomes. Participants with higher CVR reported better overall health and a stronger belief in sustainable preventive behavior.

4.2. Current Situation in Vietnam

Stroke prevalence and public health burden

In Vietnam, stroke has become one of the leading causes of death and long-term disability, posing a major burden on public health and the economy. Recent statistics indicate that the country records approximately 200,000 new stroke cases annually, making stroke the top cerebrovascular disease nationwide (*Tuổi Trẻ Online*, 2025). The estimated prevalence rate is about 1,541 cases per 100,000 population, which ranks among the highest in Southeast Asia (*Tiền Phong News*, 2025).

According to data from the *Hanoi Department of Health* (2024), stroke accounts for nearly 136,000 deaths each year in Vietnam, reflecting both the aging population and the growing impact of lifestyle-related cardiovascular risk factors. Despite rapid medical advances, stroke continues to be responsible for over one-quarter of total mortality in many provinces (*Hanoi Online*, 2024).

Alarming trend of younger stroke onset

A particularly concerning phenomenon is the increasing incidence of stroke among young adults. National health statistics show that 10–15% of all stroke patients in Vietnam are under 45 years old (*Ho Chi Minh City Center for Disease Control [HCDC]*, 2023). Major hospitals such as *Bach Mai Hospital* report that among approximately 1,000 stroke admissions each month, more than 100 patients are aged 18–44, with isolated cases even observed in adolescents as young as 14 years old (HCDC, 2023).

Epidemiological tracking suggests that the proportion of stroke in younger adults has increased by roughly 2% annually over the past decade (HCDC, 2023). These findings align with global patterns of "stroke rejuvenation," where sedentary lifestyles, chronic stress, and sleep irregularities are emerging as major risk contributors.

Healthcare accessibility and treatment disparities

Despite significant improvement in stroke care capacity, Vietnam faces substantial disparities in timely treatment access. According to the *Ministry of Health (MOH, 2024)*, nearly 88% of stroke patients arrive at hospitals more than 16 hours after symptom onset, missing the critical therapeutic window for effective intervention (*VnExpress*, 2024).

The number of stroke treatment centers in Vietnam has expanded rapidly—from 12 units in 2016 to about 130 centers in 2024—indicating strong institutional investment (VnExpress, 2024). However, major inequalities remain between urban and rural areas, where district-level facilities often lack emergency systems, telemedicine support, and neuroimaging technology for prompt diagnosis (MOH, 2024).

This urban–rural gap leads to poorer outcomes and higher mortality in remote regions, highlighting the need for community-based prevention programs and public education about early stroke symptoms.

Lifestyle and circadian health among Vietnamese youth

Modernization and digital lifestyles have significantly disrupted circadian rhythms among young Vietnamese adults. Nationwide behavioral studies indicate that a growing number of youths and students experience sleep deprivation and irregular biological cycles due to excessive nighttime screen use and academic or occupational stress (*BV Quận 9 Medical Journal*, 2023).

A study on Hanoi university students found that more than 60% regularly sleep after midnight and show irregular eating and rest patterns, which are correlated with increased anxiety, cardiovascular stress, and concentration deficits (*Vietnam Journal of Education and Development*, 2023).

These findings mirror the global pattern where chronic circadian misalignment—combined with poor sleep hygiene, high caffeine consumption, and lack of physical activity—acts as a silent risk factor for early cardiovascular disease.

In summary, Vietnam is facing a dual challenge: A persistently high national stroke burden, and A rapidly growing incidence among young adults, fueled by behavioral and biological rhythm disruptions. These realities highlight an urgent need for preventive interventions targeting lifestyle synchronization, circadian rhythm education, and integrative approaches that incorporate traditional herbal medicine—a culturally embedded and cost-effective modality—into cardiovascular health strategies. By addressing both behavioral timing and natural pharmacological support, Vietnam could pioneer an integrative, rhythm-based preventive framework aligned with its public health context.

5. Conclusion

The findings of this study highlight a critical and emerging public health concern: the growing vulnerability of young adults in Vietnam—and globally—to early-onset cardiovascular events such as stroke and sudden cardiac death. In an era of digital hyperactivity, chronic stress, and disrupted biological rhythms, traditional risk models no longer fully explain the observed increase in cardiovascular morbidity among younger populations. This research advances the understanding of how circadian rhythm alignment and herbal chronotherapy can be integrated as a dual framework for prevention, grounded in both modern chronobiology and traditional medicine.

From the empirical results of 211 valid survey responses, primarily from adults under 35 years old, it is evident that behavioral rhythm alignment (Circadian Rhythm Alignment – CRA) and timed herbal usage (Herbal Chronotherapy – HCT) exert significant positive effects on cardiovascular resilience (CVR). These effects are further mediated through physiological mechanisms (PM) such as reduced stress, improved metabolic stability, and enhanced autonomic balance. The analysis using PLS-SEM confirms that cardiovascular resilience is the strongest determinant of preventive outcomes (PO), explaining more than half of the variance in perceived health improvement and disease prevention. The integrated model thus demonstrates robust explanatory and predictive power for designing preventive interventions in young populations.

Theoretically, this research contributes to the emerging field of integrative chronomedicine, extending circadian science beyond sleep and metabolic disorders into the domain of cardiovascular prevention. By linking chronobiological regulation (timing, sleep, light exposure) with traditional herbal pharmacodynamics, the study formulates an interdisciplinary model that harmonizes biological and cultural paradigms of health. It also reinforces the relevance of Traditional Herbal Medicine (THM) as a scientifically grounded, time-sensitive, and culturally embedded modality capable of addressing modern health challenges through natural rhythm restoration.

Practically, the findings carry several important implications for healthcare practice and policy in Vietnam and similar contexts. First, they underscore the necessity of educational programs on biological rhythm hygiene—encouraging regular sleep, controlled screen exposure, and synchronized daily routines among young adults. Second, they provide empirical support for developing chronopharmacological guidelines for herbal medicine—optimizing dosage timing and delivery to align with circadian physiology. Third, they inform the design of mobile health platforms and digital tools capable of tracking individual rhythms and guiding personalized, time-based herbal interventions. Finally, the research supports the inclusion of circadian health principles within Vietnam's national preventive medicine and traditional medicine frameworks, promoting a sustainable and culturally resonant approach to public health.

In summary, this study demonstrates that aligning human biological rhythms with natural time cycles—supported by the strategic use of traditional herbal medicine—can significantly enhance cardiovascular resilience and reduce the risk of stroke and sudden cardiac death in young adults. The integration of circadian rhythm science and herbal medicine represents not only a scientific innovation but also a return to harmony between human physiology and nature's temporal order. As Vietnam and other developing countries confront the dual burden of modernization and lifestyle-related diseases, such integrative, low-cost, and preventive models offer a promising pathway toward sustainable, personalized, and holistic cardiovascular health.

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