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Review Article

Recent Advances in China's Wearable Healthcare Sensors for Chronic, Neurodegenerative, and Cardiovascular Care: A Narrative Review

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Abstract

China's rapid transition into a super-aged society is accelerating demand for advanced wearable healthcare sensors tailored for long-term, low-burden monitoring. While numerous reviews discuss demographic and policy contexts, fewer highlight the latest wearable sensor research emerging from Chinese laboratories and companies. This Mini Review summarizes representative advances published in the last five years across three major application areas—chronic metabolic disease management, neurodegenerative disease monitoring, and cardiovascular risk mitigation—focusing on sensor design, sampling media, data integration, and clinical relevance. Rather than examining demographic trends or general market growth, we emphasize technological breakthroughs such as non-invasive glucose-sensing microneedle patches, CKD-oriented urine/breath analyzers, multimodal gait–EEG neurodegenerative platforms, and bioresorbable cardiovascular implants that reflect China's emphasis on long-term, low-burden, and telemedicine-ready care. By concentrating on these China-originated devices and research prototypes, this review aims to provide a concise update on emerging concepts and highlight how these technologies reflect localized priorities—such as non-invasive sampling and family-assisted tele-care—while shaping future global trends.

Keywords: Wearable healthcare sensors; Non-invasive monitoring; Chronic metabolic diseases; Neurodegenerative diseases

Introduction

Aging has emerged as one of the most defining demographic phenomena of the 21st century, reshaping healthcare systems and societal structures across the globe. According to projections by the China CDC, the country entered an aged society in 2022 and is expected to become a super-aged society by 2033. By 2050, more than 20% of the population will be aged 65 years or older, and over 70% of all individuals with disabilities will be elderly (1). While life expectancy is projected to rise to 81.9 years for men and 88.1 years for women, the number of years lived with disability will also increase to more than 11 years. Unlike South Korea, Japan, or Italy—where aging is fastest, earliest, or most severe in Europe—China's transition is distinguished not only by its unparalleled scale, with nearly 300 million elderly citizens, but also by pronounced rural–urban disparities in healthcare access, which make telemedicine and digital health monitoring central

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priorities under the Healthy China 2030 strategy (2). Furthermore, the rapid rise of so-called "empty-nest" households—where nearly half of elderly individuals live alone or only with a spouse because of urban migration and the one-child policy—intensifies the need for wearable and remote monitoring solutions to address gaps in daily care and health management (3, 4).

This shift creates an urgent need for long-term management strategies and drives increasing demand for continuous health monitoring. In this context, digital health technologies—particularly wearable sensors—have gained considerable momentum (5). These devices enable real-time monitoring of physiological and behavioral markers, support early intervention, and facilitate more effective chronic disease management, ultimately improving quality of life for older adults. The Chinese government has actively advanced digital health technologies within broader policy frameworks. The 14th Five-Year Plan (2021–2025) highlights wearable devices in the context of BeiDou satellite navigation applications and smart health industries, while more broadly promoting the digital economy, telemedicine, AI-assisted diagnostics, and health monitoring systems. Importantly, it incorporates a national strategy for actively responding to an aging population, calling for the development of "technologies and products suitable for aging" and the cultivation of "smart elder care." This commitment is further aligned with the "Healthy China 2030" strategy, which emphasizes healthcare accessibility and integration of telemedicine and digital health into chronic disease management.

While demographic shifts and national policies establish the demand for innovative elder-care solutions, a clear picture of what Chinese researchers and industries are developing is still needed. Recent years have witnessed a surge of publications and prototypes featuring novel sampling strategies—such as tears, interstitial fluid, urine, exhaled breath—and multimodal platforms that integrate physiological, biochemical, and behavioral signals. These developments reveal how policy incentives, cultural familiarity with certain testing media, and domestic manufacturing capacity translate into distinct technical directions. Accordingly, this Mini Review does not attempt to survey the full demographic or policy landscape; rather, it focuses on key wearable sensor technologies developed in China from approximately 2020 onward. We highlight representative research-driven and early-commercial devices in three healthcare domains—chronic metabolic disorders (e.g., diabetes, CKD, respiratory disease), neurodegenerative conditions (e.g., Alzheimer's, Parkinson's), and cardiovascular risk management—where non-invasive sampling, AI-enabled analytics, and integration with national telemedicine platforms converge.

By focusing on device-level innovation rather than market statistics, this review aims to guide researchers and clinicians toward emerging technologies most likely to impact near-term healthcare delivery.

Chronic Metabolic Management

In diabetes monitoring, representative examples include a smart contact lens developed by Deng et al., in which a fluorescent hydrogel embedded with boronic acid-based glucose probes enables tear glucose monitoring over a range of 23 μM–1.0 mM is shown by Fig. 1a (6). The lens allows quantification via smartphone image analysis, offering a discreet and non-invasive solution for diabetic patients. As illustrated in Fig. 1b, another approach by Liu et al features a flexible, enzyme-free microneedle patch using phenylboronic acid (PBA)-loaded silk fibroin for long-term (21-day) glucose monitoring in interstitial fluid with high stability and sensitivity (7). Additionally, Fig. 1c describes that Yao et al developed an integrated point-of-care testing (POCT) device, a textile-based dual-electrode sensor, that combines interstitial fluid extraction via reverse iontophoresis and amperometric glucose detection into a single flexible wearable platform, simplifying home-based glucose monitoring (8).

Emerging Chronic Kidney Disease Monitoring devices in China emphasize non-invasive, real-time diagnostics suitable for both hospital and community health settings. For instance, Chen et al introduced a graphene extended-gate field-effect transistor (EG-FET) sensor for ultrasensitive, label-free detection of urinary Cystatin C, achieving a limit of detection of 0.05 ag/μL, enabling early CKD diagnosis before clinical symptoms emerge (Fig.1 d) (9). Zhao et al (Fig. 1e) reported a flexible NH_3 exhalation sensor operating at room temperature, integrated with SVM-based pattern recognition to facilitate early-stage CKD diagnosis and real-time hemodialysis monitoring (10). In another application, Chang et al developed a creatinine/UA POCT biosensor (Fig.1f) integrated with an ANN-based predictive model using uric acid, creatinine, and age data to assess CKD likelihood, providing an AI-assisted decision tool for point-of-care diagnostics (11). These devices are engineered for high analytical sensitivity, minimal patient burden, and compatibility with AI-enabled clinical workflows. The emphasis on urine and breath sampling reflects both cultural familiarity with urine testing in health checks and the potential of painless, non-invasive alternatives for elderly patients.

Recent advances in chronic respiratory disease monitoring focus on wearable systems capable of continuously tracking respiratory parameters without obstructing daily activities. Yang et al reported an ultra-sensitive, self-powered WSe_2@Si van der Waals photodiode (Fig.1g) for high-precision, non-invasive pulse oximetry, offering rapid SpO_2 detection and reliable performance even under low perfusion conditions (12). Such accuracy is critical for early hypoxemia detection in patients with chronic obstructive pulmonary disease (COPD) and other respiratory disorders. Lin et al introduced an agarose-coated fiber Bragg grating (AG-FBG) sensor (Fig. 1h) that measures respiratory rate through humidity-induced strain shifts, achieving high sensitivity (23.6 pm/%RH) and rapid response/recovery times (778/762 ms), enabling accurate monitoring of diverse breathing patterns under different postures with a compact and low-cost design (13). Zhang et al developed a finger-inspired flexible pressure sensor system (Fig. 1i) that extracts respiratory information directly from pulse wave signals, enabling simultaneous cardiovascular and pulmonary health assessment without the need for additional respiratory sensing hardware. This integrated approach enhances user comfort and supports long-term adherence (14). Together, these systems enhance user comfort, support long-term adherence, and integrate wireless data transmission with telemedicine platforms to facilitate timely clinical intervention and remote disease management.

These platforms reflect a broader trend in China's wearable healthcare sector: prioritizing non-invasive sampling media (tears, interstitial fluid, urine, exhaled breath) to reduce patient discomfort, while integrating long-term monitoring capabilities for chronic condition management. Optical-based devices, such as smart contact lenses, excel in comfort and user familiarity, making them suitable for frequent short-term checks, whereas microneedle patches address stability and adherence challenges in extended monitoring. Integrated textile sensors offer a promising route for multi-analyte detection embedded into daily apparel, while CKD-oriented breath and urine analyzers exemplify how culturally familiar testing formats can boost adoption among elderly and rural populations. In respiratory health, the shift toward multi-modal cardiopulmonary sensing (e.g., simultaneous pulse wave and respiration analysis) underscores a convergence of diagnostic domains, enabling early intervention for comorbid conditions such as COPD and cardiovascular disease. Across all three disease categories, compatibility with mobile health ecosystems and AI-driven analytics emerges as a unifying priority, reflecting China's emphasis on remote monitoring, family-assisted care, and integration with national health data infrastructure.

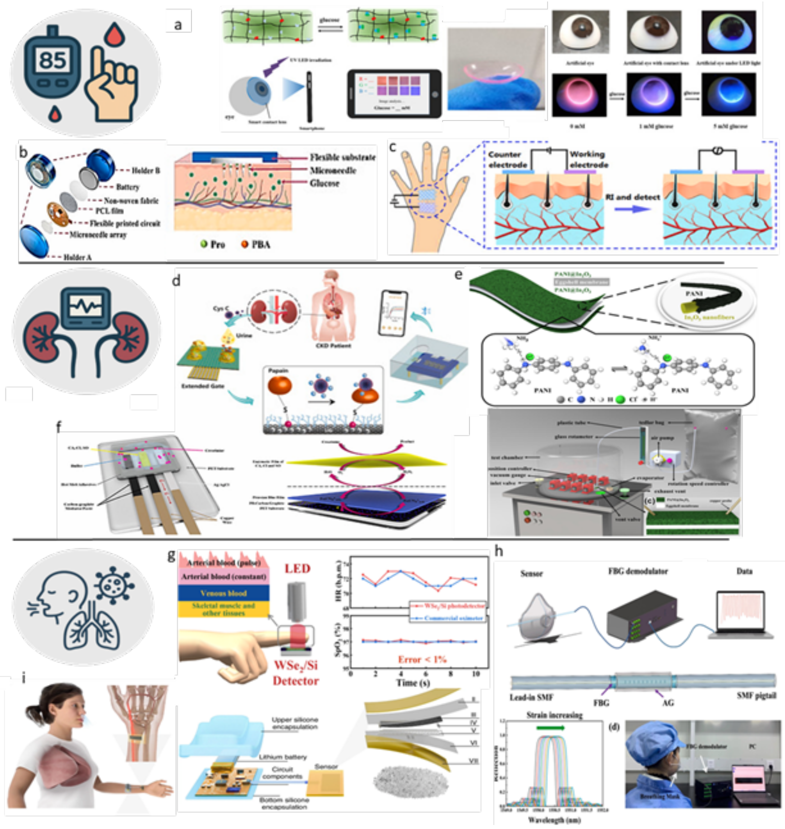

Fig. 1: Chronic Metabolic sensors from China research

This figure presents representative sensor technologies for chronic diseases, including diabetes, chronic kidney disease, and chronic respiratory disease. (a) A fluorescent hydrogel contact lens with boronic acid-based glucose probes enables tear glucose monitoring (23 µM–1.0 mM) via smartphone image analysis (6) 2022 Elsevier. (b) A flexible, enzyme-free microneedle patch using PBA-loaded silk fibroin allows long-term (21-day) glucose monitoring in interstitial fluid with high stability and sensitivity (7). 2025 Elsevier. (c) A textile-based dual-electrode sensor combines ISF extraction via reverse iontophoresis and amperometric glucose detection in a single flexible wearable platform (8). 2021 Elsevier. (d) A graphene extended-gate FET (EG-FET) sensor enables ultrasensitive, label-free detection of urinary Cystatin C (LOD: 0.05 ag/µL) for early CKD diagnosis from (9). 2024 Elsevier. (e) A flexible, room-temperature NH_3 gas sensor integrated with SVM-based pattern recognition enables early-stage CKD diagnosis and real-time dialysis monitoring via exhaled breath analysis (10). 2025 ACS Publications. (f) A screen-printed biosensor for uric acid in kidney stones, coupled with an ANN-based risk model using creatinine and age, predicts CKD likelihood as a point-of-care diagnostic tool (11). 2025 Elsevier. (g) A WSe_2/Si photodiode enables accurate heart rate and SpO_2 monitoring (<1% error) using triple-wavelength detection (12). 2025 Springer. (h) An agarose-coated fiber Bragg grating (AG-FBG) sensor for respiratory monitoring with high sensitivity and sub-second response (13). 2025 Elsevier. (i) A retractable thin-film sensor integrated into a wearable format for multifunctional real-time respiratory monitoring (14). 2025 Nature. Schematic illustration summarizing representative wearable glucose sensing strategies, based on previous studies (Refs. 6-14). Icons and graphical elements were created by the authors. Adapted with permission where required.

Neurodegenerative Monitoring

The growing prevalence of dementia in China—estimated at over 15 million cases—has spurred the development of multimodal wearable systems aimed at early diagnosis and home-based disease tracking.

For motion-based diagnostics, Huang et al developed a multisource quantitative gait analysis platform combining inertial measurement units (IMUs) and high-resolution plantar pressure sensor arrays (Fig. 2a) to capture spatiotemporal gait patterns in Parkinson's disease patients. This system measures parameters such as stride length, step time variability, and pressure distribution, enabling identification of subtle motor abnormalities before clinical diagnosis and providing objective markers for disease progression (15). In the domain of neural activity monitoring, Zhang et al introduced a wireless EEG monitoring system (Fig. 2b) integrated with self-powered flexible nanogenerators that harvest biomechanical energy from patient movement. This design removes the need for frequent battery replacement, supports prolonged EEG acquisition in home settings, and uses dry electrodes to improve comfort, thus increasing adherence in elderly patients (16).

Biochemical biomarker detection has also seen advances, with Zou et al fabricating a Zn-based tower-like photoelectrochemical (PEC) sensor array (Fig. 2c) capable of sandwich-type immunosensing for tau protein, a critical Alzheimer's biomarker, achieving detection limits in the sub-picogram per milliliter range (17). Similarly, Dou et al developed an Au-functionalized wrinkle-graphene biosensor for ultrasensitive detection (Fig. 2d) of interleukin-6 (IL-6), enabling real-time monitoring of neuroinflammation, which plays a pivotal role in multiple neurodegenerative pathologies (18). Moving beyond diagnostics into therapeutic intervention, Xie et al reported a wearable, spatiotemporally controllable ultrasonic device (Fig. 2e) designed to disaggregate amyloid-β plaques in Alzheimer's disease models. This system uses patterned phased-array transducers to focus ultrasound energy on targeted brain regions, reducing plaque burden while minimizing off-target effects, and supports repeated, non-invasive treatment sessions (19).

Collectively, these innovations illustrate a growing trend toward multimodal neurodegenerative monitoring platforms that combine motion analysis, electrophysiological recording, biochemical sensing, and even therapeutic capabilities, all linked to cloud-based health platforms for real-time analysis, clinician oversight, and integration into China's community-centered elderly care infrastructure. These neurodegenerative monitoring platforms converge on multi-modal, low-burden designs suited to elderly care in China. Gait analysis and wireless EEG systems passively capture functional and cognitive changes, while biochemical biosensors enable early biomarker detection. Emerging wearable ultrasonic devices integrate monitoring with therapy, creating closed-loop management. Across these technologies, comfort, minimal invasiveness, and telemedicine compatibility remain central to enabling long-term, family-assisted disease management.

Cardiovascular Risk Mitigation

Recent advances in cardiovascular disease (CVD) monitoring in China reflect a strategic convergence of wearable electronics, bioresorbable materials, and rapid biochemical assays, collectively designed to improve early detection, continuous disease surveillance, and optimized recovery after treatment. Cardiovascular diseases remain the leading cause of mortality among the elderly in China, yet diagnosis and follow-up care have been challenged by rural–urban healthcare disparities and limited access to specialized facilities. To address these gaps, research efforts have shifted toward portable, user-friendly sensing platforms capable of delivering hospital-grade data directly to patients' homes and linking seamlessly with AI-assisted telemedicine networks. This direction is reinforced by national initiatives under the Healthy China 2030 framework, which emphasize preventive screening, point-of-care diagnostics, and data interoperability across regional hospitals and community health centers. As a result, the current wave of CVD-focused wearable technologies in China is distinguished by its dual emphasis on continuous physiological data capture and integration with cloud-based clinical decision-support systems, ensuring that both urban tertiary centers and resource-limited rural clinics can benefit from timely, data-driven cardiovascular care.

Zang et al reported a wearable platform (Fig. 2f) that combines electrocardiogram (ECG) and phonocardiogram (PCG) acquisition in a single unit, enabling synchronous electrical and acoustic cardiac signal analysis for improved arrhythmia classification and valvular disorder screening (20). For postoperative care, Ouyang et al developed a bioresorbable dynamic pressure sensor implant (Fig. 2g) designed for cardiovascular surgery patients, which provides continuous hemodynamic pressure data for several weeks before safely degrading in the body, thus eliminating the need for retrieval surgery (21). Biochemical marker detection is also advancing toward rapid, point-of-care formats, exemplified by Wang et al., who introduced a one-step digital immunoassay (Fig. 2h) for cardiac troponin I that achieves high sensitivity within minutes, enabling early myocardial infarction triage in emergency settings (22). Complementing these protein biomarkers, Hong et al presented an on-site colorimetric cholesterol detection method using polypyrrole nanoparticles, delivering a low-cost, portable solution suitable for community health screening and rural clinics (Fig. 2i). These developments align with China's broader digital health strategy by enabling data sharing across AI-enabled clinical networks, ensuring that both urban tertiary hospitals and rural health centers can benefit from continuous cardiovascular monitoring, rapid diagnostics, and personalized rehabilitation programs (23). Cardiovascular monitoring technologies in China demonstrate a dual focus on multi-modal physiological integration and deployment flexibility. Wearable ECG–PCG systems address the diagnostic gap between electrical rhythm analysis and acoustic valve assessment, offering richer datasets for AI-assisted classification. Bioresorbable implants represent a breakthrough for post-surgical monitoring, removing the logistical and infection risks of device retrieval while maintaining high-fidelity pressure tracking during critical recovery phases. Rapid biochemical assays for troponin I and cholesterol extend diagnostic capabilities beyond hospitals, aligning with China's push toward community-based preventive screening and emergency-ready triage tools. Together, these solutions illustrate a coordinated effort to combine continuous sensing, acute event detection, and rehabilitation feedback, creating an end-to-end cardiovascular care model adaptable to both advanced clinical centers and resource-limited environments.

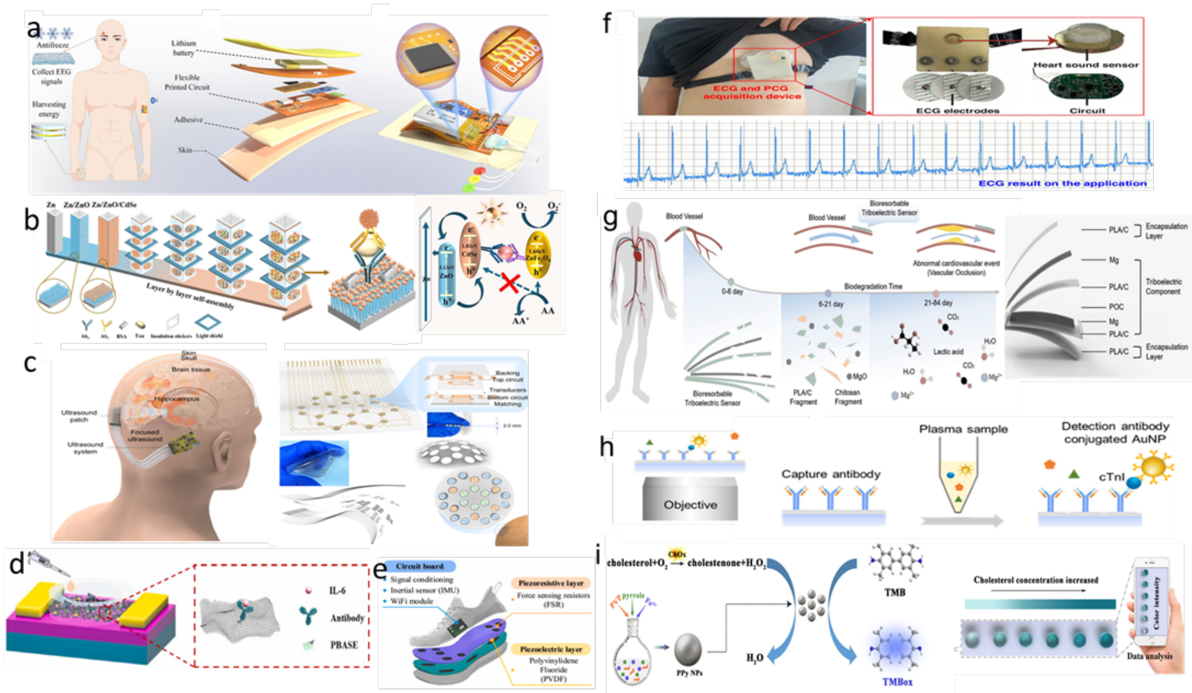

Fig. 2: Neurodegenerative monitoring sensors and cardiovascular monitoring from China research

Sensors are categorized by modality: electrophysiological, biofluid-based, cell-level, and wearable digital systems. (a) A wireless, self-powered EEG system using hydrogel sensors for real-time brain monitoring (15). 2025 Elsevier. (b) A ZnO/CdSe-based PEC sensor with high sensitivity for Tau protein detection (16). 2025 ACS Publications. (c) A wearable ultrasonic patch for noninvasive Aβ disaggregation in Alzheimer's therapy (17). 2025 Science. (d) A graphene-based FET biosensor for ultrasensitive IL-6 detection (18). 2024 Elsevier. (e) A wearable system integrating multiple sensors for quantitative Parkinson's gait analysis (19). t 2024 Elsevier. (f) A wearable system integrating ECG and PCG for real-time, noninvasive monitoring (20). 2025 Nature. (g) A triboelectric implantable sensor for postoperative blood pressure monitoring, fully degradable in vivo (21). 2021 Wiley. (h) A one-step digital immunoassay detecting cTnI in plasma within 10 minutes (22). 2020 ACS Publications. (i) A nanozyme-based visual assay for cholesterol, compatible with portable test kits (23). 2020 ACS Publications. Schematic illustration summarizing representative wearable glucose sensing strategies, based on previous studies (Refs. 15-23). Icons and graphical elements were created by the authors. Adapted with permission where required.

Conclusion

China's recent surge in wearable healthcare sensor development reflects a distinct interplay of engineering ingenuity, national policy priorities, and sociocultural practices. Across chronic metabolic, neurodegenerative, and cardiovascular domains, non-invasive sampling (tears, interstitial fluid, urine, breath), multimodal signal integration, and telemedicine-ready connectivity have emerged as defining hallmarks of Chinese research and early-stage products. These approaches address practical barriers to long-term monitoring among older adults, particularly those in rural or resource-limited regions, and demonstrate how localized needs can shape global technology trends. While the technologies reviewed here have shown encouraging laboratory performance—achieving higher sensitivity, longer wearability, and even combined diagnostic-

therapeutic functions—translation to routine clinical use remains uneven. Challenges ahead include: (i) large-scale clinical validation under diverse demographic and environmental conditions; (ii) cost-effective manufacturing and supply-chain stability; (iii) robust data governance to protect privacy within expanding AI-enabled platforms; and (iv) user-centered design for elderly individuals with limited technical literacy. Sustained collaboration among academia, industry, clinicians, and regulators will be essential to bridge these gaps.
Looking forward, integration of multimodal sensors into textile or implant-resorbable formats, coupled with real-time AI analytics and interoperable cloud platforms, is expected to define the next phase of innovation. Cross-disciplinary efforts that pair material science advances (e.g., bioresorbable polymers, energy-harvesting nanogenerators) with culturally attuned service models—such as family-assisted tele-care—may further accelerate adoption. As China continues to scale national health-data infrastructure and elder-care policy initiatives, the lessons learned from these wearable sensor developments could inform strategies for other rapidly aging societies facing similar disparities in healthcare access. In summary, this Mini Review highlights how context-driven engineering in China has produced a diverse pipeline of wearable healthcare devices with potential for global relevance, highlighting that future success will hinge on harmonizing engineering innovation with clinical usability, cultural acceptance, and robust data governance.

Journalism Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

The authors declare that there is no conflict of interests.

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