Editorial

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The Kailuan Study

A life-course epidemiological platform for the prevention and health management of non-communicable diseases

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Non-communicable diseases (NCDs) continue to impose an escalating global burden amid population aging, urbanization, metabolic dysregulation, and multimorbidity.[1] Among them, cardiovascular disease (CVD) remains a leading cause of premature mortality and disability worldwide. Despite major advances in pharmacotherapy and clinical care, they have not translated into a commensurate reduction in population-level disease burden. This discordance underscores the limitations of a predominantly downstream, disease-centered paradigm and highlights the urgent need to shift preventive efforts further upstream, toward the early identification and modification of risk factors before irreversible organ damage and clinical events occur. Yet conventional risk assessment, largely based on static measurements of established risk factors, is often insufficient to capture the temporality, cumulative exposure, biological variability, and inter-organ crosstalk that drive contemporary NCDs. In particular, CVD rarely arises from a single exposure at a single time point; rather, it represents the downstream clinical expression of long-term metabolic, vascular, renal, hepatic, inflammatory, and neurocognitive perturbations. Addressing this complexity requires longitudinal epidemiological platforms capable of integrating repeated phenotyping, rigorously validated outcomes, and real-world healthcare data.

Initiated in 2006 in Tangshan, China, the Kailuan Study is a prospective dynamic cohort embedded within a large industrial functional community with an integrated healthcare system.[2] It enrolled 101,510 adults at baseline and has expanded to more than 170,000 participants through rolling recruitment, linking biennial standardized health examinations with annual medical insurance databases and death registries. This infrastructure enables repeated risk profiling and rigorous outcome ascertainment across major NCD domains and outcomes, including cardiovascular events, cancer, metabolic dysfunction, multimorbidity, and mortality. By supporting both risk-factor identification and the real-world evaluation of health management strategies, the Kailuan Study provides prevention-oriented evidence for life-course NCD prevention in China.

1. Transition from static risk assessment to dynamic life-course trajectories

A major strategic contribution of the Kailuan Study is its ability to move NCD epidemiology beyond baseline risk stratification. Repeated measurements across successive examination waves allow investigators to examine when risk factors emerge, how rapidly they progress, how long they persist, and whether their variability or cumulative exposure confers additional risk. This longitudinal architecture is particularly important for NCDs, for which timing and duration often shape clinical consequences.

Evidence from the Kailuan Study has emphasized the importance of early-onset metabolic dysfunction, cumulative exposure, and dynamic risk trajectories. Studies of blood pressure trajectories, visit-to-visit variability in metabolic markers, adiposity changes, and transitions between metabolically healthy and unhealthy phenotypes have shown that risk accumulates and is amplified through dynamic biological processes.[3,4]

The life-course architecture of the Kailuan Study further extends this temporal perspective to developmental

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and intergenerational processes. Historical and early-life exposures, including the Great Chinese Famine and the 1976 Tangshan Earthquake, have provided rare opportunities to examine how developmental adversity may become biologically embedded and later manifest as vascular, metabolic, or oncological risk.[5] The parent–offspring subcohort further enables the investigation of familial aggregation, intergenerational transmission, and shared biological or environmental determinants of disease.[6] These features make the Kailuan Study not merely a platform for adult risk prediction, but a longitudinal infrastructure for understanding how NCD susceptibility is formed, transmitted, and expressed across the life course.

2. Transition from cardiovascular focus to multisystem health

Although initially rooted in cardiovascular research, the Kailuan Study has evolved into a comprehensive platform for NCD and multimorbidity research. This evolution reflects a fundamental shift in biomedical understanding: CVD is not an isolated arterial disorder, but a systemic manifestation of metabolic, renal, hepatic, inflammatory, oncological, and neurovascular dysfunction. The Kailuan Study is well-positioned to interrogate these connections because it combines repeated clinical assessments, laboratory measurements, imaging assessments, and validated outcome ascertainment across multiple organ systems, enabling investigators to examine inter-organ and cross-system linkages over time. For example, its findings have linked adiposity, insulin resistance, and vascular stiffness to cardiometabolic deterioration, and metabolic dysregulation to brain structure alterations, cerebral small vessel disease, and cognitive decline.[7]

Importantly, its life-course design allows these multisystem interactions to be interpreted temporally, clarifying how early disturbances in one biological domain may propagate into broader systemic disease burden. This perspective is increasingly necessary in clinical practice. The Kailuan Study provides an epidemiological foundation for understanding how organ systems interact over time and how the risk of specific NCDs becomes embedded within multisystem disease trajectories.

3. Transition from risk identification to population-based intervention

Many observational cohorts excel at identifying associations but remain distant from implementation. By contrast, the Kailuan Study is embedded within a stable functional community and an integrated healthcare system, creating a distinctive environment for evaluating pragmatic, workplace-based, and population-level interventions. This feature is particularly evident in research on hypertension management, statin therapy, and structured health management programs. The workplace-based hypertension management program implemented within the Kailuan Group demonstrates how cohort infrastructure can be leveraged to evaluate prevention strategies in routine practice. By integrating regular blood pressure monitoring, medication access, and individualized health consultations, these programs provide evidence that cardiovascular risk reduction can be operationalized outside highly controlled trial environments. Cost-effectiveness analyses further enhance the policy relevance of these findings.[8]

This transition from association to implementation is essential. The next generation of cohort research should not merely ask whether a risk factor predicts disease; it should ask what would happen if that risk factor were modified, at what point in the life course, in which population subgroup, and through which delivery model. The Kailuan Study is well-suited to answer these questions because it combines repeated exposure assessments, longitudinal outcome surveillance, healthcare utilization data, and a relatively stable population base. These features strengthen the translation of observational evidence into actionable prevention strategies. Its evidence has informed clinical guidelines and expert consensus statements, underscoring its relevance not only for academic research but also for clinical decision-making, health management, and public health practice.

4. Prospects: Toward an intelligent life-course health platform

The future of the Kailuan Study lies in deeper phenotyping, multimodal integration, and intelligent health modeling. Ongoing expansion and further integration of biobank resources, multiomics, advanced imaging, wearable devices, and digital phenotyping will enable investigators to move beyond conventional risk factors toward molecular, structural, behavioral, and environmental signatures of disease susceptibility.[9] Artificial intelligence and machine learning may further enhance disease subtyping, image interpretation, risk prediction, and individualized prevention planning.

However, technological expansion must be anchored in rigorous epidemiological principles. High-dimensional data alone do not guarantee valid inference. Their value depends on temporality, measurement quality, control of confounding, assessment of selection bias, external validation, and clinical interpretability. The strength of the Kailuan platform lies in the combination of advanced data modalities with mature longitudinal follow-up, standardized measurements, validated outcomes, and real-world healthcare linkage.

Several future directions are particularly promising. Multimodal predictive models can identify individuals at high risk for adverse NCD trajectories before overt disease onset. Causal inference approaches, including target trial emulation, can estimate the potential impact of modifying lifestyle, metabolic, vascular, and pharmacological

exposures. Multiorgan disease trajectories can clarify how cardiovascular, renal, hepatic, oncological, neurological, and sensory disorders cluster and progress over the life course. Ultimately, integrating epidemiological evidence with clinical management pathways may support a life-course health management model tailored to the Chinese population.

The Kailuan Study should therefore be viewed not simply as a cohort, but as an evolving learning health system. It connects population-based epidemiological discovery with clinical practice, health management, and public health intervention. In an era when medicine is moving from late-stage treatment to early prevention, from single-disease care to multimorbidity management, and from static prediction to dynamic precision health, the Kailuan Study provides a valuable model for how long-term cohort research can guide the next phase of NCD prevention and life-course health management.

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AI statement

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