Review Article

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# Evolutionary Public Health: Advancing Precision Public Health and Universal Health Coverage in Thailand

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## Abstract

**Background:** Thailand is experiencing rapid population ageing, a rising burden of non-communicable diseases (NCDs), and persistent health inequalities. Although Thailand has achieved near-universal health coverage and substantial reductions in catastrophic health expenditure, current policy debates remain focused largely on affordability and service availability, with limited attention to the evolutionary and historical determinants of population vulnerability. **Objective:** This article examines Thailand's contemporary health challenges through an evolutionary public health framework, highlighting how evolutionary and historical factors may contribute to population vulnerability and shape current health inequalities. **Methods:** Using narrative review and concept paper methodology, this article examines how evolutionary mismatch and inequitable human niche construction shape Thai health outcomes, and how intergenerational cultural mismatches in health beliefs affect health literacy and resilience in rapidly urbanising communities. **Results:** The analysis indicates that while universal health coverage (UHC) provides essential financial protection, it does not by itself address the upstream environmental and social conditions that generate disease. We argue that precision public health should be reoriented beyond genomic risk stratification to incorporate site-specific environmental exposure and early-life developmental programming. This reoriented approach supports a community-centred model that leverages Thailand's existing primary care infrastructure, Sub-district Health Promoting Hospitals (SHPH) and village health volunteers (VHV) to modify unhealthy environments and strengthen community resilience. **Conclusion:** Grounding public health policy in evolutionary principles offers Thailand a pathway toward not only universal access to healthcare, but universal conditions for health.

**Keywords:** Evolutionary public health, Universal Health Coverage, Precision Public Health, Social determinants of health, Niche construction

## Introduction

Over recent decades, Thailand has undergone rapid social, economic, and demographic change, converging into a set of pressing health challenges: population ageing, a rising burden of non-communicable diseases (NCDs), persistent social and geographic inequalities, repeated zoonotic threats, and the health impacts of climate change [1]. NCDs are now responsible for roughly 71-74% of all deaths in Thailand, killing more than 1,000 people daily and causing an estimated 354,000 – 400,000 deaths annually, concentrated disproportionately among the poor and ageing urban populations[2, 3].

This apparent shift from infectious to chronic disease is not a clean substitution. Classical epidemiological-transition theory anticipated a sequential shift from an "age of pestilence and famine" to an "age of degenerative and man-made diseases" [4], but Thailand instead faces a triple burden in which infectious disease, NCDs, and their comorbidities cluster within the same households and patients, diabetes worsens tuberculosis outcomes,[5] and COVID-19 exposed a bidirectional feedback loop with pre-existing cardiometabolic disease [6]. These interactions constitute a syndemic diseases that cluster and are jointly driven by shared adverse social conditions[7], reflecting how the same resource-constrained niches that elevate NCD risk also intensify human-animal-environment contact and the emergence of novel pathogens[8].

Thailand introduced the Universal Coverage Scheme (UCS) in 2002 and has made rapid progress towards universal health coverage (UHC), achieving near-universal enrolment and large reductions in catastrophic health expenditure[9], Yet policy debates remain framed mainly around affordability and service delivery [10, 11], with far less attention to the evolutionary and historical determinants of population vulnerability[12, 13].

Evolutionary public health is an emerging field applying principles of human evolutionary biology, including mismatch between ancestral and modern environments, developmental plasticity, life-history trade-offs, and gene-culture coevolution to explain the upstream, ultimate origins of disease and to identify environmental and social interventions addressing those origins directly, rather than only their downstream clinical manifestations[12]. Existing scholarship remains largely theoretical and globally framed [12, 14], and, to our knowledge, none has yet applied an evolutionary lens specifically to a national UHC system or emerging precision-public-health policy in Southeast Asia;

a parallel initiative, Genomics Thailand, advances genomic testing infrastructure but focuses on risk stratification rather than the niche-level and developmental determinants addressed here[15]. This article addresses that gap, pursuing three aims: summarizing key evolutionary concepts relevant to population health; examining how they can inform emerging precision-public-health discussions in Thailand; and considering their implications for UHC's future development.

## Materials and Methods

This article is a narrative review and concept paper that: (1) to summarize key evolutionary perspectives relevant to public health; (2) to explore how these perspectives can inform Thai discussions of emerging precision public health; and (3) to consider implications for the future evolution of UHC in Thailand, aiming to stimulate dialogue among Thai health professionals about integrating evolutionary thinking into policy, planning, and practice.

The paper synthesis published literature in evolutionary medicine, public health, precision public health, and universal health coverage, with particular attention to sources relevant to Thailand and the Asia–Pacific region. Sources were identified through purposive iterative searches of PubMed, Google Scholar and institutional websites (e.g. WHO, Thai health agencies) in English and Thai, selected for conceptual relevance rather than formal systematic review criteria. A methodological choice that carries an inherent risk of confirmation bias, acknowledged here as a limitation. Source screening was performed jointly by the authors (CC, RI), assisted by AI (Perplexity) for literature retrieval and drafting support and Grammarly for language editing; all AI-retrieved sources and interpretive claims were independently verified by the authors against primary sources, with every reference individually re-verified as part of this revision. Reporting was additionally guided by the SANRA framework with respect to justification of the review's importance, explicit aims, transparency of source identification, and consistent referencing[16]. This manuscript forms one chapter of a broader, multi-chapter textbook on evolutionary public health in active development since 2025; the most recent search-and-verification pass was completed in July 2026.

## Evolutionary Public Health in Thailand

### Deep-time determinations and the Neolithic transition

For most of human evolutionary history, small, mobile hunter-gatherer groups lived at low population density, with acute infections, injuries, and nutritional variability as major selective pressures; obesity, type 2 diabetes, and atherosclerotic disease are rare in contemporary hunter-

gatherer populations such as the Tsimane of the Bolivian Amazon, who show the lowest reported coronary atherosclerosis of any population studied [13, 17, 18]. This should not be read as evidence of superior ancestral health overall: the same populations carry a substantial infectious and parasitic disease burden, illustrating that the ancestral environment traded one set of health burdens for another.

The transition to sedentary agriculture and animal domestication around 10,000 years ago created new zoonotic reservoirs and favoured the emergence of epidemic infections, a dynamic supported by transmission modelling of brucellosis in Neolithic goat populations[19] and by ancient-DNA evidence showing zoonotic pathogens including plague and leprosy, becoming detectable only after the widespread domestication of livestock roughly 5,000-6,500 years ago[20]. This "Neolithic package" made infectious disease a structural feature of human populations and laid the groundwork for later pandemics and, eventually, Jenner's cowpox-based smallpox vaccination[21].

The same transition exerted a genetic selection pressure through recurrent food scarcity: the "thrifty genotype" hypothesis proposes that alleles enhancing fat storage and insulin efficiency conferred survival advantage under feast-famine conditions but become maladaptive amid today's caloric abundance, contributing directly to Thailand's obesity and type 2 diabetes burden[22]. A complementary "thrifty phenotype" pathway operates through fetal programming, whereby prenatal undernutrition reprogrammes glucose-insulin metabolism in ways that become detrimental when postnatal nutrition is abundant[23]. This genetic legacy shows evolutionary public health is not solely an environmental or behavioural framework: heritable variation shaped by ancestral selection is itself a determinant of present-day NCD susceptibility. Together, these hypotheses show that both germline genetic adaptation and epigenetically mediated developmental plasticity link Thailand's agrarian and nutritional history to its present NCD burden evidence that should inform, not sit peripheral to, precision public health strategy.

### Cultural evolution of disease explanations

Explanatory models of disease evolved alongside biological threats. Hippocratic writings shifted emphasis toward air, water, place, and lifestyle rather than divine punishment[24, 25]. Fracastoro's 16th-century theory of contagious "seeds" and Leeuwenhoek's 17th-century microscopy provided an early agent-based view of disease before germ theory was understood [26-28]; and population-level interventions, quarantine, sanitation, variolation, and eventually Jenner's vaccination were adopted based on observed patterns of spread well before mechanisms were confirmed [29-31].

### Evolutionary mismatch and the rise of NCDs

Rapid urbanisation creates profound mismatches between the environments for which humans were selected — high physical activity, whole-food diets, tight social groups, diverse microbial exposure — and the novel niches modern cities impose: sedentary routines, energy-dense ultra-processed food[32], social fragmentation, and sanitised built environments [13, 17]. The consequences are visible in Thailand's NCD burden, where cardiovascular disease, cancer, diabetes, and chronic respiratory disease are leading causes of death, and premature-mortality risk has declined only marginally[33, 34].

As mortality from infections declined, chronic conditions became dominant causes of death and disability[35]. Evolutionary mismatch traits adaptive in ancestral environments becoming maladaptive in novel ones is a key framework for understanding obesity, type 2 diabetes, cardiovascular disease, and aspects of mental health, arising from the conflict between physiological systems calibrated for intermittent scarcity and high activity, and modern diets, inactivity, and chronic stress[36, 37]. Notably, total energy expenditure among contemporary hunter-gatherers is not necessarily higher than in sedentary populations, suggesting the salient mismatch lies less in caloric expenditure than in activity pattern and diet composition[38].

Social inequality and chronic stress become biologically embedded through neuroendocrine and epigenetic pathways, contributing to health disparities across socioeconomic groups, public health, from this standpoint, is the management of co-evolving genes, pathogens, behaviours, and institutions rather than simply service delivery [39, 40]. Early developmental exposures, captured in the Developmental Origins of Health and Disease (DOHaD) framework, can programme lifelong vulnerability and may be transmitted intergenerationally [41, 42], though true transgenerational inheritance — effects persisting in descendants never themselves exposed to the initial trigger remains considerably more contested in humans than intergenerational transmission[43].

### Niche Construction and the Stratification of Health Risk

Human niche construction describes how societies actively shape the environments — land use, housing, food systems, transport, social protection — that then feedback on biology and health, rather than simply adapting to fixed surroundings[44, 45]. This population-level framing echoes Rose's distinction between causes of individual cases and causes of a population's incidence rate: high-risk-only strategies are undermined by a constantly replenished pool of new cases if the population-wide

exposure generating that risk is left unaddressed — a logic an evolutionary niche-construction lens operationalises by targeting the constructed exposure itself, not just downstream individual risk[46].

These constructed niches are not shared equitably: niche construction becomes inequitable when powerful groups shape environments that protect their own health while externalizing risk onto others — gated communities with good services versus settlements beside factories or flood-prone land. Wealthier urban residents typically inhabit neighborhoods with cleaner air, safer streets, and easy access to fresh food and exercise, while the urban poor and many older Thais are confined to niches of cheap ultra-processed food, crowded streets, and chronic psychosocial stress — visible in the contrast between Bangkok's transit-connected commercial districts and its informal canal-side and industrial-zone settlements [47-50]. Once built, these niches lock in behaviour: policies and markets construct environments, environments constrain everyday choices, and choices in turn shape bodies and disease patterns over time, a dynamic in which social position, more than genetic difference, drives divergent NCD trajectories[12, 47, 51-53]. This extends to the deliberate marketing of health-harming commodities, tobacco, alcohol, ultra-processed food by commercial actors whose incentives are structurally misaligned with population health, now analysed under the "commercial determinants of health[54]."

In Thailand, this is acute for the urban poor and older adults, who may be financially independent yet unable to walk safely, reach green space, or access affordable whole food, a form of "choice poverty" created by the built niche rather than income alone[48, 50, 55]. Empirical studies confirm pro-rich health inequality has persisted throughout the UHC era, with urban residence and household wealth, not genetics, the dominant drivers of disparity in older Thais' self-rated health[56]. A historical precedent predates niche-construction theory: Koos's 1954 Regionville study found poorer households showed "marked indifference" to symptoms wealthier households treated as signals to seek care, because a constrained niche made acknowledging sickness a functional impossibility, a stratifying logic that persists today, though the binding constraint has shifted from caregiving obligation to transport access[57-59].

**Thai Food Policy, Diet, and the Double Burden of Malnutrition**

Thailand's food environment illustrates how niche-level dietary risk can become the target of deliberate policy correction. Since 2017, Thailand has levied a tiered sugar-sweetened-beverage tax; in 2019 it banned partially hydrogenated oils; and the Healthier Choice logo (2016) provides front-of-pack nutrient signalling, interventions coordinated in part through the Thai Health Promotion

Foundation and the Health in All Policies mechanism institutionalised under the National Health Act B.E. 2550 [60-62].

Two further features of Thailand's nutritional niche warrant evolutionary framing. Rice, the dominant dietary staple, carries a high glycemic load and is associated with increased type 2 diabetes risk, plausibly interacting with thrifty-genotype/phenotype susceptibility to amplify cardio metabolic risk[63]. Thai and other Asian populations also develop diabetes and cardiovascular disease at lower BMI thresholds than WHO's global reference cut-offs, prompting WHO's own Asia-Pacific consultation to recommend lower action points for overweight (≥23 kg/m2) and obesity (≥27.5 kg/m2).[94] Precision public health screening in Thailand should apply these Asian-specific thresholds rather than importing thresholds calibrated to different populations.

Infant feeding offers a further developmentally proximal example: only around one in three Thai mothers currently achieve exclusive breastfeeding for six months, well short of the 2025 Global Nutrition Target, despite improvement from 14% in 2019 — a direct, evolutionarily informed lever for reducing developmental-programming risk that SHPH-VHV teams, already embedded in routine antenatal contact, are well placed to support[64].

Figure 1 summarises the proposed causal chain linking deep-time selection pressures to contemporary syndemic clustering in Thailand, together with candidate intervention points at each stage.

Table 1 translates each evolutionary concept discussed above into its Thai empirical manifestation, relevant existing policy instrument, and a proposed SHPH-VHV action, to support practical application by provincial health managers

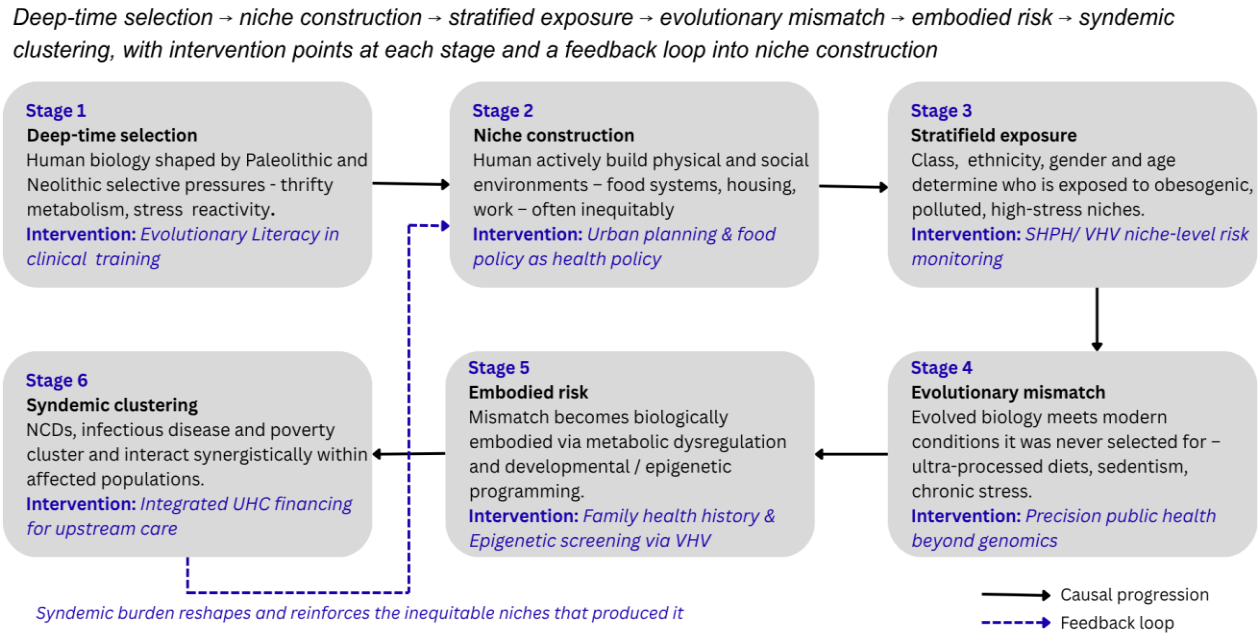



**Figure 1.** Evolutionary causal chain in Thai NCD syndemics

*Note: solid arrows indicate the proposed causal progression from deep-time selection pressures to contemporary syndemic clustering; the dashed arrow indicates the proposed feedback loop whereby syndemic burden reshapes the niches that produced it. Intervention points are annotated within each stage. Figure prepared by the authors.*

## Intergenerational Health Beliefs and Double Mismatch

Human health behaviour is also shaped by beliefs transmitted across generations — cultural inheritance rooted in agrarian rhythms, village-based support, and traditional medicinal knowledge[66, 67]. Rapid urbanisation disrupts this transmission, separating younger generations from traditional knowledge holders while replacing the environments in which those beliefs were adaptive, producing a cognitive mismatch that reduces biomedical health literacy and weakens sense of coherence. Bridging these belief systems with contemporary evidence-based practice, rather than dismissing them, is essential for culturally sustainable public health[68, 69].

**Table 1.** Mapping evolutionary concepts to Thai policy and SHPH-VHV action

| Evolutionary concept | Thai empirical manifestation | Existing policy instrument | Proposed SHPH-VHV action |
|---|---|---|---|
| **Thrifty phenotype / metabolic mismatch** | Rising obesity and T2DM alongside rapid dietary transition in urban/peri-urban populations | National NCD Prevention and Control Plan; sugar-sweetened beverage tax | VHV-led household metabolic risk screening in transitioning peri-urban communities |
| **Niche construction (built environment)** | Sedentary urban lifestyles; stratified access to green space and safe walking infrastructure | "Active City" campaigns; NHSO fitness-fee subsidy proposals | SHPH-coordinated community exercise programmes linked to VHV outreach |
| **Inequitable niche exposure** | Concentration of pollution, unsafe streets, and food deserts in informal settlements and ageing housing | Urban planning and housing policy (limited pro-poor design) | VHV mapping of niche-level risk by household/community |
| **Cultural mismatch in health beliefs** | Declining intergenerational transmission of traditional health knowledge among urban youth | Traditional medicine integration policies (limited scale) | SHPH-VHV programmes bridging traditional health beliefs with biomedical health literacy |
| **Syndemic clustering** | Co-occurrence of NCDs, mental health conditions, and social isolation among urban poor and older adults | UCS/UHC service integration (siloed by condition) | Cross-trained VHVs conducting integrated multi-condition household assessments |
| **Fragmented informational niche (institutional discontinuity)** | Community hospitals and Sub-district Health Promoting Hospitals (SHPHs) each maintain their own computerised basic health databases, but routine, systematically updated linkage between them remain limited in practice, fragmenting referral and emergency care information flow[23]. | Health Data Centre (HDC); Health Link nationwide health information exchange; Refer referral data exchange standard; 1669/ NIEM emergency medical service[65]. | Routine, protocol driven bi-directional data sharing between SHPHs and community hospitals to build a knowledge-based health system, strengthen referral accuracy, connect with 1669 emergency response, and build care access confidence among elderly and vulnerable residents. |

With Thailand's old-age dependency ratio rising, millions of older persons in isolated, resource-poor niches face severely constrained capacity to exercise "healthy choices" even when motivated and informed [50, 70]. An evolutionary lens reframes debates about "health behaviour" as questions about who has power to shape health-relevant niches, and how intentional niche modification — through urban planning, housing, and age-friendly design — can reduce NCDs and health inequities [52, 53, 70]

## Precision Public Health and Universal Health Coverage

### Precision Public Health: Beyond Genes

Precision public health (PPH) extends precision approaches from individual clinical care to population-level intervention, using genomic, digital, and environmental data to stratify populations and tailor prevention[71, 72]. In Thailand, PPH holds particular promise given the NCD burden's heterogeneity by geography, ethnicity, and socioeconomic status[12, 37]. An evolutionary lens enriches PPH by identifying which subpopulations carry the greatest mismatch burden — not only genomically, but in niche exposure, developmental programming, and inherited health beliefs — moving beyond genetic risk scores to the full complexity of gene-environment interaction across the life course[36, 73, 74].

This enthusiasm should be tempered: critics warn that resource-intensive genomic and digital-precision infrastructure risks diverting investment from population-wide structural interventions that have historically delivered the largest, most equitable health gains, and may reach wealthier populations before Thailand's heaviest-burden rural and low-income communities. Precision tools are most defensible when deployed to prioritise underserved populations for upstream intervention, not to substitute for it.

Thailand has taken concrete steps toward individual precision medicine: in 2026, Ramathibodi Hospital's Centre for Medical Genomics began working with the National Health Security Office to bring prenatal testing, BRCA1/2 testing, and pharmacogenomics screening under the Universal Coverage Scheme[75] welcome, but still condition-specific, hospital-based, and untested at population scale or at the sub-district level. For the SHPH-VHV network, a more immediately actionable resource is epigenetic and family-history information: DNA methylation links social adversity to later disease risk and identifies modifiable rather than fixed targets [76], and a structured family health history collected during routine VHV household visits could flag elevated inherited risk for diabetes,

hypertension, or cardiovascular disease well before genomic testing is feasible at scale, provided this proceeds under the informed-consent and data-security safeguards required for health and genetic data under Thailand's Personal Data Protection Act [77].

## Universal Health Coverage: Strengths and Limits

Thailand's UHC scheme, established in 2002, is widely recognised as one of the most successful health-financing reforms in the developing world, achieving near-universal coverage and dramatically reducing catastrophic health expenditure among the poor[78-80]. Yet UHC is fundamentally a coverage mechanism: it ensures access without financial ruin but does not by itself address the upstream determinants that generate illness[74]. Persistent inequalities between Bangkok and rural provinces, and between formal and informal-sector workers, reveal the limits of a service-delivery model without an explicit niche-level framework, UHC can treat the diseases that inequitable niches produce, but cannot alone modify those niches[56, 81].

A related limitation concerns older Thais' living arrangements: the share living alone rose from 6.3% in 2002 to 12.8% in 2021[82], and national data show they experience significantly higher unmet health-care needs than those living with others, driven less by cost than by the absence of a caretaker to arrange transport or navigate treatment[83], a gap the household-level SHPH-VHV network may be well placed to address.

## Syndemics, Salutogenesis, and System Design

Inequitable niches do not produce single diseases in isolation. When poverty-driven niches concentrate infectious-disease exposure, NCD risk factors, and psychosocial stress in the same communities, the three interact synergistically — a syndemic, in which diseases cluster and mutually reinforce one another under shared adverse social conditions[7, 84]. In Thailand, this is compounded by exposure to volatile global food and energy markets and climate-related disasters, which disproportionately burden communities already confined to health-damaging niches[85, 86], while the same niches intensify human-animal-environment contact, making the risk of emerging zoonotic infection itself a niche-constructed outcome to be monitored within the same community-level systems[8].

## Salutogenesis, Decentralization, and Community Resilience

Addressing inequitable niche construction requires more than treating disease downstream. A salutogenic strategy, building a community-level sense of coherence[87] works upstream by modifying the niche itself: strengthening social support, restoring agency, and enabling communities to absorb shocks, aligned with calls for decentralised health governance and community-level health-information systems. In Thailand, the Sub-district Health Promoting Hospital (SHPH) and village health volunteer (VHV) network provides the groundwork[88-90] front-line nodes that, equipped with simple digital tools, could monitor NCD-relevant signals such as falls, isolation, heat stress, and food insecurity among older adults, turning Thailand's primary-care network into an early-warning system for niche-level risk [91, 92].

## Limitations

This article has several limitations. It is a conceptual, narrative review rather than an empirical study: the evolutionary-mismatch and niche-construction mechanisms discussed are inferred from international evidence rather than directly measured in Thai populations, and the proposed SHPH-VHV applications are illustrative rather than piloted, requiring empirical evaluation of feasibility, financing, and data governance before implementation. Source selection followed purposive rather than systematic methods, and claims regarding epigenetic and transgenerational inheritance draw on an evolving, partly contested evidence base warranting specialist review. Finally, evolutionary explanations of disease carry a risk of adaptationist overreach and biological determinism; the framework proposed here is intended as a complementary causal layer alongside, not a replacement for, conventional social-determinants and political-economy explanations of Thai health inequities.

## Feasibility, Financing, and Data Governance of SHPH-VHV Proposals

Expanding SHPH-VHV roles to include real-time niche-level monitoring raises three practical questions. Financing would likely require dedicated budget combining NHSO capitation-linked primary-care funds, Thai Health Promotion Foundation grants, and Local Administrative Organization health budgets now responsible for SHPH operating costs under decentralization, rather than a single national funding line. Feasibility requires structured training, appropriate incentives given VHVs' existing volunteer workload, attention to variable digital literacy, and routine data-quality auditing, with expanded monitoring piloted at small scale before wider rollout. Data governance requires compliance with Thailand's Personal Data Protection Act, a defined data custodian, explicit consent

architecture, and validated instruments such as the FAO's Food Insecurity Experience Scale rather than ad hoc checklists, with attention to the trust relationship between VHVs and communities, since household surveillance of food insecurity or isolation carries different social meaning and different risk of perceived intrusion than routine clinical visits[93]. These considerations reflect the established framework of community-oriented primary care, which integrates population-level surveillance with primary-care delivery to a defined community, and do not undermine the proposed framework but define its necessary next steps[94].

## Conclusion

Achieving equitable UHC in Thailand requires evolutionary-informed strategies that recognise the triple burden of infectious disease, NCDs, and poverty as products of inequitable human niche construction[4, 95], and that harness salutogenic approaches to build resilient, community-governed responses to global syndemic risk[7, 84]. With NCDs killing more than 1,000 Thais daily[2, 3], and inequities in urban and rural niches persisting despite UHC[56, 81], the case for reorienting Thai public health policy around evolutionary principles is strong. This framework is intended to complement, not replace, conventional public health practice by making explicit the long-arc biological and cultural origins of disparities that current service-delivery models do not directly address.

For Thai policy, this points to four implications: SHPH and VHV networks should monitor niche-level risk indicators — food insecurity, isolation, heat stress — not only individual clinical risk, with systematic database linkage supporting community-oriented primary care[94], improving referral accuracy and connection to the 1669 emergency service;[96, 97], precision-public-health initiatives should incorporate environmental exposure and developmental history alongside genomic data; urban planning, housing, and food-system policy should be core health-policy instruments; and UHC financing reform should pair with upstream, community-level investment. These implications carry added urgency given Thailand's ongoing decentralization of primary-care governance: since 2022, SHPH responsibility has progressively transferred to Provincial Administrative Organisations, with over 43% of the national total already under local government management by 2024 [65], meaning these recommendations must now be adopted at the provincial and sub-district level, not treated as an exclusively national framework.

Future priorities include empirical testing of these frameworks against Thai population data, pilot evaluation of expanded SHPH-VHV roles, and collaboration with evolutionary biologists and

epigeneticists to strengthen the evidence base for developmental claims. A concrete entry point is Thailand's disease-surveillance infrastructure: the national 2022 comparative risk assessment identifies overweight and obesity as the leading contributor to disability-adjusted life years lost [98], and provincial-level life-expectancy data[99] offer an unexploited opportunity to test whether early-life nutritional stress and pollution exposure explain Thailand's subnational health gaps — treating its regions as a natural experiment in developmentally-programmed disparity rather than assuming genetic causation.

## Author Contributions

CC conceptualised the study, developed the methodology, wrote the original draft and supervised the project. RI contributed to data curation, assisted in drafting the manuscript, and performed review and editing. All authors reviewed, edited, and approved the final version of the manuscript prior to submission for publication.

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## Conflicts of Interest

None declared.

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