

# Sustaining Health Over Long Horizons: Integrated Care, Maintenance Burden, and Equity When Ageing Becomes Manageable

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## Abstract

Biomedical advances increasingly target the underlying mechanisms of ageing rather than individual diseases. Even modest success would shift the central challenge of population health from curing discrete conditions to sustaining functional ability over extended horizons. This paper applies the QALY flow framework—which evaluates policy by the long-run rate of health production per unit person-time—to three practical domains: integrated care delivery, maintenance burden assessment, and equity in sustained access. We draw on the UN Decade of Healthy Ageing, the WHO ICOPE implementation guidance, systematic evidence on multimorbidity care models, the health span literature, and equity-focused priority setting frameworks. The result is a research and policy agenda grounded in health systems, delivery science, and existing institutional commitments.

## Key messages

- When health can be maintained rather than merely restored, the policy question shifts from “How much total benefit?” to “What rate of healthy functioning can we sustain, and at what cost?”
- QALY flow—average quality per unit person-time—remains bounded and interpretable as horizons extend, providing a stable basis for long-run planning.
- Maintenance burden, catastrophic risk management, and deliverability at scale become dominant evaluation criteria.
- Equity concerns compound: sustained access gaps accumulate into widening health divides over time.

- The UN Decade of Healthy Ageing and ICOPE implementation guidance already provide the policy platform and delivery architecture for this transition.

# 1 Introduction

The UN Decade of Healthy Ageing (2021–2030) organizes global action around a central insight: healthy ageing means enabling people to “do what they value” through sustained functional ability ([World Health Organization, 2020](#)). The Decade’s four action areas—changing attitudes toward ageing, fostering age-friendly environments, delivering person-centred integrated care, and ensuring access to long-term care—all emphasize continuity over time rather than episodic intervention. This framing already moves public health toward maintenance thinking.

Biomedical research is increasingly organized around the same intuition. Therapies targeting senescence, inflammation, metabolic dysfunction, and other ageing mechanisms aim to slow or partially reverse biological decline rather than cure isolated diseases ([Olshansky, 2022](#)). If these approaches succeed even modestly, they would extend the period during which individuals require ongoing health support. The public health challenge becomes sustaining functional ability over very long periods—potentially decades longer than current planning horizons assume.

The QALY flow framework provides the evaluative structure for this transition ([Goldman, 2026](#)). Where traditional health technology assessment sums quality-adjusted life years over a bounded lifetime, the flow framework defines value as the long-run rate of health production per unit person-time under a continuing regime. This ratio remains bounded and interpretable regardless of how long individuals live. It naturally foregrounds the questions that matter for extended horizons: Can the intervention be delivered continuously? What ongoing resources does it require? Who has sustained access?

This paper translates the flow framework into public health practice. We apply it to three domains: integrated care as the delivery backbone (Section 2), maintenance burden as a policy variable (Section 3), and equity as a structural concern (Section 4). We then ground the discussion in the health span concept (Section 5) and outline a research agenda (Section 6). Throughout, we draw on WHO implementation guidance, systematic evidence on care models for multimorbidity, and the equity literature on priority setting.

## 2 Integrated care as the delivery backbone

### 2.1 The ICOPE continuum

The WHO Integrated Care for Older People (ICOPE) handbook operationalizes healthy ageing through structured workflows rooted in primary care ([World Health Organization, 2024](#)). The second edition (2024) provides step-by-step guidance for implementation across diverse resource settings. Its core elements form a continuous cycle:

1. **Screening and assessment.** Rapid screening for declines in intrinsic capacity (mobility, cognition, sensory, psychological, vitality), followed by comprehensive assessment when indicated.
2. **Person-centred care planning.** Development of individualized care plans oriented toward functional goals that matter to the person, incorporating their preferences and context.
3. **Multidisciplinary care delivery.** Coordination across medicine, nursing, rehabilitation, nutrition, pharmacy, social work, and community health workers, with clear role definitions.
4. **Monitoring and follow-up.** Scheduled reassessment with care plan revision as capacity changes, ensuring continuity across acute episodes and transitions.
5. **Linkage to long-term care.** Pathways to more intensive support (home care, residential care) when functional decline exceeds what community-based services can address.

This architecture already embodies the flow framework’s logic: value accrues through the ongoing process of maintaining function, and the system’s job is to sustain that process reliably over time. ICOPE provides the delivery infrastructure that any long-horizon intervention—including future ageing-modifying therapies—would require. Novel treatments would be embedded within these workflows, adding new nodes (periodic infusions, genetic monitoring, regenerative procedures) to an existing continuum rather than replacing it.

### 2.2 What the evidence on multimorbidity care reveals

As people live longer, chronic multimorbidity becomes the norm rather than the exception. Managing health for individuals with multiple interacting conditions requires ongoing orchestration across

providers, settings, and time. The evidence base on multimorbidity care models illuminates what sustained delivery demands.

A scoping review of systematic reviews on integrated care for multimorbidity finds wide variation in how models are defined, what components they include, and how outcomes are measured (Rohwer et al., 2023). Models differ in their target populations (disease-specific versus condition-agnostic), care settings (primary care, hospital, community), integration mechanisms (case management, shared records, multidisciplinary teams), and outcome domains (clinical endpoints, patient experience, resource use). This heterogeneity reflects genuine contextual variation, but it also reveals a gap: without standardized descriptions, we cannot reliably predict which models will sustain function over long horizons.

A complementary review focused on low- and middle-income settings emphasizes that outcomes depend heavily on organizational arrangements (Endalamaw Sinshaw et al., 2024). Effective models require:

- **Leadership and governance.** Clear accountability for the care continuum, with authority to coordinate across silos.
- **Workforce design.** Teams with defined roles, training for chronic care competencies, and staffing ratios adequate for follow-up.
- **Financing mechanisms.** Payment structures that reward continuity and outcomes over time rather than episodic throughput.
- **Information systems.** Shared records, registries, and reminder systems that support monitoring and prevent patients from falling through gaps.
- **Patient selection and recruitment.** Systematic identification of individuals who would benefit, with active outreach rather than passive waiting.

These organizational elements determine whether a care model can sustain benefit delivery. An intervention with strong efficacy in controlled conditions may fail in practice if the health system cannot maintain follow-up, coordinate transitions, or retain trained staff. The flow framework captures this directly: QALY flow depends on system sustainability, and system sustainability depends on organizational infrastructure.

## 2.3 Implications for long-horizon planning

Flow-based evaluation reorients planning around delivery sustainability. The key questions shift:

Table 1: Evaluation focus under flow-based thinking

Dimension	Episodic framing	Flow-based framing
Primary outcome	Lifetime QALYs gained	QALY flow rate sustained
Time horizon	Fixed (e.g., 10-year model)	Indefinite regime
Cost metric	Total expenditure	Cost flow (expenditure per person-time)
Success criterion	Positive incremental net benefit	Higher sustained flow at acceptable cost flow
System capacity	Implicit background assumption	Explicit constraint and outcome
Failure modes	Treatment non-response	Discontinuity, dropout, system strain, coverage gaps

This reorientation has practical consequences. Interventions with low maintenance burden become more attractive. Delivery models with strong follow-up mechanisms score higher. Data requirements shift toward persistence, adherence, and long-term safety rather than short-term efficacy alone. Planning must account for workforce pipelines, supply chain resilience, and financing stability over decades.

The ICOPE framework and the multimorbidity evidence base provide the foundation. Extending horizons strengthens and scales the delivery architectures already in development.

## 3 Maintenance burden as a policy variable

### 3.1 What is continuous with current practice

Public health already thinks in maintenance terms. Vaccination programs require boosters. Chronic disease management involves ongoing monitoring and medication adjustment. Nutrition and wellness programs aim to sustain healthy behaviours over years. Screening programs repeat at intervals. The concept of maintenance burden is native to the field.

What extended horizons change is the quantitative weight of maintenance considerations, not their qualitative character. Three differences matter:

**Duration amplification.** A recurring cost that consumes 1% of a person’s health budget annually represents 10% of lifetime resources over ten years but 50% over fifty years. Burdens that are tolerable over current planning horizons can become dominant as horizons extend. The same intervention that appears cost-effective in a ten-year model may appear unsustainable in a fifty-year model.

**Cumulative risk.** A low-probability adverse event that occurs with 0.5% annual probability produces a 5% cumulative risk over ten years but a 22% risk over fifty years. Events that are rare in current time frames become likely or near-certain as horizons extend. Pharmacovigilance, redundancy, and fail-safe design become more consequential.

**System scaling.** Current wellness and chronic care infrastructure is sized for populations that require support for roughly forty years of adult life. If healthy adulthood extends to eighty or one hundred years, the same per-person-year burden produces twice or more the aggregate system demand. Workforce pipelines, training capacity, and capital investment must scale accordingly.

The contribution of the flow framework is to make these duration effects explicit in evaluation. Cost flow (expenditure per person-time) and QALY flow (health per person-time) remain stable metrics as horizons vary, allowing comparisons that do not depend on assumptions about when life ends.

### 3.2 Components of maintenance burden

Every intervention that requires repetition imposes ongoing demands on patients, caregivers, health workers, and systems. These demands constitute maintenance burden, and they enter the flow framework directly as cost flow: the resource expenditure per unit person-time required to sustain a given level of QALY flow.

Maintenance burden spans multiple domains:

**Clinical encounters.** Visits for monitoring, re-dosing, imaging, laboratory work, and specialist consultation. A therapy requiring quarterly infusions imposes four clinical encounters per year; over a thirty-year maintenance horizon, that amounts to 120 infusion visits per patient, each consuming clinical time, supplies, and scheduling capacity.

**Adherence requirements.** Medication regimens, dietary protocols, exercise programs, behavioural commitments. Complex regimens with multiple daily doses, timing constraints, or dietary restrictions increase the cognitive and logistical load on patients. Adherence declines predict treatment failure; supporting adherence requires counselling, reminders, and sometimes technology.

**Supply chains.** Manufacturing capacity, distribution networks, cold chains for biologics, consumables. Supply disruptions can interrupt treatment for entire populations. Rare or expensive inputs create vulnerability. Generic availability and local production capacity affect long-run sustainability.

**Workforce.** Specialists to prescribe, generalists to monitor, nurses to administer, pharmacists to dispense, care coordinators to follow up, community health workers to bridge gaps. Workforce training pipelines, retention, and geographic distribution constrain what can be delivered at scale.

**Information systems.** Electronic health records, registries for tracking eligible populations, scheduling systems, alert mechanisms for overdue follow-up, decision support for care transitions. Robust information infrastructure prevents patients from being lost to follow-up and supports coordination.

**Patient and caregiver time.** Travel to appointments, waiting, recovery from procedures, administrative tasks. For conditions requiring ongoing management, these time costs accumulate. They fall disproportionately on those with fewer resources, less flexible employment, and weaker social support.

### 3.3 Compounding over extended horizons

Small recurring burdens compound. An intervention requiring one additional specialist visit per year appears modest over a five-year trial horizon. Over a fifty-year maintenance horizon, it represents fifty visits for each patient—and the associated infrastructure, workforce, and financing demands multiplied across the covered population.

The flow framework surfaces this compounding automatically. High maintenance burden appears as high cost flow. Interventions with low efficacy relative to their maintenance demands produce

poor cost-effectiveness ratios when evaluated as flow, even if they appeared acceptable under finite-horizon summation.

This has implications for technology assessment. Interventions should be evaluated in terms of the sustained rate of benefit they produce (QALY flow) relative to the sustained rate of resources they consume (cost flow). The ratio is the flow-based incremental cost-effectiveness ratio: ongoing cost per unit of ongoing benefit. This metric remains stable as horizons extend, enabling comparison across interventions with different durability profiles.

### 3.4 Catastrophic risk and truncation

Long horizons magnify the importance of low-probability, high-severity events. These include:

- Adverse events from repeated treatment (cumulative toxicity, rare but severe reactions)
- Discontinuities in coverage (insurance gaps, migration across health systems, policy changes)
- Supply disruptions (manufacturing failures, geopolitical shocks, pandemic-related shortages)
- Coordination failures (missed handoffs, fragmented records, provider turnover)
- Abrupt transitions to severe disability (stroke, major injury, rapid cognitive decline)

In the flow framework, catastrophic events truncate the cycle: when catastrophe occurs, the individual's contribution to health production ends. For the metric to behave well, policies must attend to catastrophe rates. Reducing the probability of truncation increases expected cycle length, which—for a given quality level—increases QALY flow.

Catastrophe prevention thus becomes a first-order policy objective. This includes pharmacovigilance for long-term treatment effects, redundancy in supply chains, portability of coverage across jurisdictions, robust handoff protocols, and prevention of disabling events (falls, cardiovascular events, cognitive decline). These are core determinants of long-run health production.



## 4 Equity in sustained access

### 4.1 How inequity compounds

When benefits accrue episodically, the maximum equity gap is the difference in outcomes from one episode. When benefits accrue as a continuous stream, inequity compounds. Those with sustained access accumulate healthy person-time over years and decades; those without access fall progressively further behind.

Current disparities in chronic disease management already demonstrate compounding. Populations with poor access to primary care accumulate preventable complications: uncontrolled hypertension leads to stroke, unmanaged diabetes leads to nephropathy, missed cancer screenings lead to late-stage diagnosis. Each missed opportunity for intervention narrows future options. Extended horizons amplify these dynamics: a twenty-year gap in access to an ageing-modifying therapy could produce a difference of twenty healthy years.

### 4.2 Priority setting under extended horizons

Priority setting frameworks that incorporate equity become more salient when horizons extend. Traditional cost-effectiveness analysis treats a QALY as a QALY regardless of who receives it. Equity-weighted approaches assign greater value to health gains for worse-off individuals or groups.

The proportional shortfall approach provides one vocabulary for these debates ([Mahdiani et al., 2024](#)). Severity is measured as the proportion of expected healthy lifetime that a person will lose due to their condition. Interventions that address greater proportional shortfall receive higher priority weight. This approach has been adopted in several national priority-setting contexts and connects to broader debates about fairness in health resource allocation.

Under extended horizons, proportional shortfall gains new dimensions. If healthy life expectancy itself becomes a function of access to maintenance therapies, then shortfall calculations must account for the treatment landscape. Someone denied access to an effective ageing-modifying intervention would experience a larger shortfall than someone with access. Equity-weighted evaluation would assign greater priority to ensuring access for excluded groups.

The flow framework supports explicit equity weights. Define QALY flow for each population subgroup. Apply distributional weights that reflect social priority for improvements in worse-off

groups. Aggregate weighted flows. Evaluate policies by their impact on the weighted aggregate and on the distribution (e.g., the minimum flow across groups).

### 4.3 Structural commitments for equity

Equity in flow-based evaluation requires structural commitments that go beyond individual coverage decisions:

**Floor guarantees.** Establish minimum QALY flow levels below which no population subgroup should fall. This operationalizes a commitment to ensuring that everyone reaches a threshold of sustained health, regardless of ability to pay or geographic location.

**Access universality.** Design maintenance systems for population coverage rather than market segmentation. If an intervention requires ongoing delivery, access must be continuous. Gaps in coverage interrupt treatment and undermine health production.

**Continuous eligibility.** Enrollment structures should avoid periodic requalification requirements that create administrative barriers and dropout. Once someone is on a maintenance regimen, continuity should be the default.

**Explicit priority weights.** Cost-effectiveness analysis should incorporate explicit equity weights. The Netherlands, Norway, and other jurisdictions have implemented severity-weighted priority setting ([Mahdiani et al., 2024](#)). Extended horizons make these weights more consequential and require updating them to reflect the new stakes.

**Governance for the long run.** Commitments must be durable. Policies that promise maintenance access but are vulnerable to budget cycles, political transitions, or institutional change will fail to deliver sustained benefit. Governance structures—constitutional protections, independent health authorities, long-term funding mechanisms—matter for equity.

## 5 Health span as the grounded endpoint

### 5.1 From life span to health span

Public health audiences reasonably resist claims of radical life extension. The history of longevity science includes cycles of hype and disappointment. A constructive alternative is to focus on health span: the period of life spent in good functional health.

The health span concept has gained traction in mainstream gerontology. Olshansky and colleagues argue that major gains in life expectancy have already been achieved through public health and medicine, and that the priority now should be extending the healthy portion of life rather than total survival ([Olshansky, 2022](#)). Compressing morbidity into a shorter period at the end of life would improve quality of life and reduce the burden of disability and dependency.

This framing aligns naturally with the UN Decade’s emphasis on functional ability ([World Health Organization, 2020](#)). Success is measured by what people can do, by their capacity to engage in valued activities, by their participation in community life. Biological markers of ageing are relevant only insofar as they predict functional outcomes.

### 5.2 QALY flow as health span production

QALY flow, when quality is interpreted as functional capacity, measures exactly what the health span concept targets: the sustained rate at which a population produces healthy, functional person-time. High flow means that, on average, individuals spend their time in high-function states. The policy objective is to maximize this rate.

This interpretation has several advantages:

**Connects longevity science to public health.** Framing the goal as health span production makes clear that longevity research and public health share a common objective. Both aim to extend the period of functional health. The difference is in the tools (biomedical versus environmental, clinical versus population-level).

**Avoids hype.** Targeting health span requires only the plausible claim that the ratio of healthy to unhealthy years can be improved. This is already happening: age-specific disability rates have

declined in many countries, and active life expectancy has increased ([Olshansky, 2022](#)).

**Centers lived experience.** Functional ability is about what people can do: move, see, hear, think, remember, engage. This is the substance of quality of life. Biomarkers are proxies; function is the outcome that matters.

**Connects to disability and rehabilitation.** The health span frame naturally incorporates disability prevention, rehabilitation, assistive technology, and supportive environments. These are core public health and health systems functions. Extending health span means reducing the incidence of disabling conditions, improving recovery when they occur, and providing support that maintains function despite impairments.

### 5.3 Reframing ageing-modifying interventions

Future ageing-modifying therapies—senolytic drugs, NAD<sup>+</sup> precursors, cellular reprogramming, gene therapies—can be evaluated within this frame. The question is: Does this increase QALY flow? An intervention that extends survival while maintaining or improving average quality increases flow. An intervention that extends survival in low-quality states may not.

This provides a principled basis for evaluation. It also connects novel therapies to existing health technology assessment methods. Cost-effectiveness analysis using QALY flow ratios can compare an ageing-modifying therapy to conventional preventive interventions, chronic disease treatments, or care model improvements. All are evaluated by the same metric: sustained health per unit of resources.

## 6 A research agenda

### 6.1 Measurement and surveillance

Flow-based planning requires indicators that track durable functional ability at the population level. The UN Decade framework identifies domains for measurement: intrinsic capacity (physical, cognitive, sensory, psychological), functional ability (mobility, self-care, communication, learning, social participation), and environments that support ability ([World Health Organization, 2020](#)).

Current surveillance systems emphasize point-in-time prevalence: the proportion of the population with a condition at a given moment. Flow-based thinking adds emphasis on rate measures: how much functional person-time is the population producing per unit of calendar time? This requires longitudinal data on health states, transitions, and durations.

System indicators are equally important. Can the health system sustain delivery? Key metrics include continuity of care (proportion of patients with a regular source of care, follow-up rates), access (wait times, geographic coverage, financial barriers), workforce capacity (provider ratios, vacancy rates, burnout), and supply chain resilience (stockout rates, supplier diversity).

## 6.2 Evaluation design

Flow-based evaluation requires evidence on persistence and sustainability. Current trial designs typically assess efficacy at fixed endpoints (one year, three years). Long-horizon planning requires:

- **Long-term follow-up extensions.** Continuing trials beyond the primary endpoint to observe durability, waning, and long-term safety.
- **Pragmatic evaluations.** Embedding trials in routine practice to assess effectiveness under real-world delivery conditions, including adherence, dropout, and system constraints.
- **Real-world evidence.** Using registries, claims data, and electronic health records to track outcomes over years and decades, with attention to discontinuation, switching, and loss to follow-up.
- **Explicit maintenance burden measurement.** Systematically measuring all resource categories (clinical encounters, patient time, supply requirements, workforce) required to sustain treatment.
- **Failure mode analysis.** Studying what causes treatment discontinuation, coverage gaps, and adverse outcomes over extended periods.

## 6.3 Implementation science for integrated care

The evidence base on integrated care for multimorbidity reveals wide variation in model components, contexts, and outcomes ([Rohwer et al., 2023](#)). This variation must be reduced to enable planning.

Research priorities include:

- **Standardized model description.** Taxonomies and reporting standards that specify what an integrated care model includes: target population, setting, team composition, coordination mechanisms, information systems, financing.
- **Context documentation.** Systematic description of the implementation context: health system structure, resource levels, workforce, policy environment.
- **Scalability and sustainability research.** Studies that focus on what happens when models are scaled beyond pilot sites and maintained over years.
- **Adaptation research.** How models developed in high-income settings can be adapted for low- and middle-income contexts, where the majority of the world’s ageing population lives ([Endalamaw Sinshaw et al., 2024](#)).

The ICOPE framework provides a starting point for standardization ([World Health Organization, 2024](#)). Implementation research can build on this foundation to identify which elements are essential, which are adaptable, and which contextual factors determine success.

## 6.4 Governance and legitimacy

Extended-horizon interventions raise questions that technical evaluation cannot answer:

- **Intergenerational fairness.** Who pays now for benefits that accrue over decades? How should costs and benefits be distributed across age cohorts?
- **Commitment credibility.** Will governments, insurers, and health systems honour long-term access commitments? What institutional arrangements make promises durable?
- **Eligibility boundaries.** Who qualifies for maintenance therapies? How are decisions revisited as technology evolves?
- **Public trust.** How do populations come to trust that long-term commitments will be kept? What transparency and accountability mechanisms are required?

These require deliberative processes: citizen panels, ethics committees, legislative debate, and international coordination. Public health institutions should engage these questions early, before policy becomes reactive to hype or backlash.

## 7 Conclusion

A future in which ageing becomes more manageable deepens the relevance of public health. The central challenge shifts from curing conditions to sustaining functional ability fairly over long horizons. Meeting that challenge requires:

- **Integrated care systems designed for continuous delivery.** The ICOPE framework and multimorbidity care evidence provide the architecture ([World Health Organization, 2024](#); [Endalamaw Sinshaw et al., 2024](#)).
- **Explicit accounting for maintenance burden.** Every repeating intervention imposes ongoing demands; flow-based evaluation surfaces these costs.
- **Equity structures that prevent compounding disadvantage.** Floor guarantees, universal access, continuous eligibility, explicit priority weights ([Mahdiani et al., 2024](#)).
- **Research that tracks persistence and sustainability.** Long-term follow-up, pragmatic trials, real-world evidence, failure mode analysis.
- **Governance that can make and keep long-term commitments.** Deliberative processes, durable institutions, public trust.

The QALY flow framework provides the evaluative language for this transition ([Goldman, 2026](#)). The UN Decade of Healthy Ageing provides the policy platform ([World Health Organization, 2020](#)). The health span concept provides the grounded endpoint ([Olshansky, 2022](#)). The work ahead is to build the systems, generate the evidence, and establish the governance structures that can deliver sustained health over extended horizons.

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