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Article

Digital Transformation for an Ageing Nation: The MalaysiaAgeNet Socio-Technical Reference Architecture and Readiness Framework

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Abstract: Malaysia's demographic transition is occurring alongside rapid expansion of digital government, artificial intelligence (AI), digital health, and data-sharing infrastructure. Yet ageing-related initiatives remain vulnerable to fragmented applications, unequal access, weak interoperability, and technology-led scaling without evidence of public value. This study develops MalaysiaAgeNet, a socio-technical reference architecture and readiness framework for national digital ageing transformation. It uses a design-oriented secondary synthesis that re-analyses the authors' published scoping-review corpus of 63 global academic and policy sources and updates the Malaysian context with 12 Malaysian policy, legal, statistical, and administrative instruments and three recent empirical studies. Policy mechanisms were translated into system requirements, architectural layers, maturity anchors, service scenarios, and decision gates. The resulting architecture comprises five operational layers: (1) experience and access; (2) community delivery; (3) domain services; (4) service orchestration and interoperability; and (5) data, analytics, and responsible AI. Two cross-cutting planes provide trust, assurance, observability, and continuous learning. A proposed five-level (0–4) maturity model assesses mission and governance, inclusive delivery, interoperable infrastructure, trust and assurance, and outcome learning. Scenario walkthroughs show how assisted telehealth, care-plan continuity, smart-home alerts, benefit applications, and social participation can traverse the architecture while preserving human responsibility and non-digital alternatives. The framework aligns current Malaysian ageing, health, digital, data-sharing, and AI policies around shared implementation logic. It offers a testable design proposition rather than a validated national system; stakeholder validation, pilot deployment, and longitudinal evaluation remain necessary.

Keywords: ageing society, digital inclusion, digital transformation, information systems architecture, Malaysia, responsible AI

1. Introduction

Malaysia has already crossed the ageing-society threshold under the internationally used measure of people aged 65 years and over. This group reached 8.4% of the population in 2026, and the old-age dependency ratio rose to 11.9 older people for every 100 people aged 15–64 years [1]. The latest national projection indicates that the share aged 65 years and over will rise from 6.8% in 2020 to 9.3% in 2030 and 18.3% in 2060. Malaysia is projected to become an aged society, with at least 14% aged 65 years and over, in 2048 [2]. These figures use a different definition from Malaysian policy, which defines an older person as someone aged 60 years and over and commonly uses a 15% threshold. The age cut-off must therefore be stated when forecasts are compared. Regardless of definition, Malaysia must reorganise health, care, welfare, housing, mobility, employment, and public services for a much older population. Globally, the World Health Organization (WHO) expects the number of people aged 60 years or over to reach 1.4 billion by 2030 and 2.1 billion by 2050 [3]. Fig. 1 summarises the current estimate and projected milestones.

Digital transformation can help address this transition. Telehealth can reduce travel and wait times, sensors can support ageing in place, digital public services can reduce administrative friction, and AI can support risk detection and resource planning. However, the same systems can shift work onto older people and families, exclude people with low connectivity or confidence, and introduce risks related to surveillance, cybersecurity, and automated decision-making. A technology portfolio is therefore not equivalent to a digital-ageing strategy.

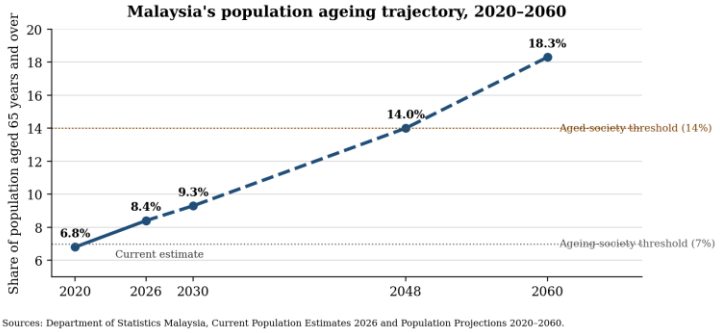

Fig. 1 Malaysia's population ageing trajectory. The solid segment connects the 2020 baseline to the 2026 current estimate; the dashed segment shows projection milestones. The 2048 point marks the projected 14% aged-society threshold [1], [2].

The authors' earlier scoping review mapped 63 global academic and policy sources published between 2015 and 2025. It identified five substantive domains: healthcare digitalisation; social inclusion and active ageing; smart environments and age-friendly cities; governance and data regulation; and economic participation [4]. That review established what governments were addressing but did not provide a sufficiently detailed information-systems design to connect those domains. It did not define a reference architecture, a diagnostic maturity model, service-level decision gates, or traceability from public-value requirements to data, interfaces, controls, and indicators.

This paper addresses a different problem: how can comparative policy lessons be converted into an implementable, accountable, and age-inclusive information-systems architecture for Malaysia? This is a socio-technical problem. Health and care technologies frequently fail not because an algorithm or device is intrinsically unusable, but because value propositions, adopters, organisations, wider systems, and long-term sustainability are misaligned [5]. Technology use in later life (older adulthood) is also relational rather than purely individual, involving family members, community facilitators, caregivers, and service staff who often help older people gain access, solve problems, and build confidence [6]. Comparative European policy research similarly shows that digital ageing redistributes responsibilities among citizens, care organisations, and the state [7]. Socio-technical health information-systems research therefore treats people, workflow, organisations, external rules, hardware, software, data, and measurement as interacting dimensions rather than independent implementation variables [8].

Three research questions guide the study: RQ1, which socio-technical requirements are needed to translate global digital-ageing policy mechanisms into the Malaysian context? RQ2, how can those requirements be organised into a reference architecture and a readiness model? RQ3, which service scenarios, indicators, and decision gates can support responsible implementation and scaling?

The paper contributes (1) a set of traceable system requirements derived from global and Malaysian evidence, (2) the MalaysiaAgeNet layered reference architecture, (3) a five-dimension, five-level readiness model, and (4) a decision-gated implementation and evaluation logic. The contribution is deliberately positioned as a design proposition. No national deployment, causal effectiveness, stakeholder consensus, or predictive accuracy is claimed.

2. Related Work and Malaysian Policy Context

A. Digital Ageing as a Socio-Technical Public-Value Problem

Individual-level acceptance models are useful for explaining perceived usefulness, ease of use, trust, and intention, but national transformation depends on more than adoption. An older person may accept a telehealth application while the referral workflow, identity process, reimbursement arrangement, consent mechanism, or clinical record exchange remains broken. Conversely, a technically interoperable service may still fail when interfaces are inaccessible, support is unavailable, or participation requires a family member with spare time and digital confidence.

The relevant unit of design is consequently the service ecosystem: the user, helper, organisation, information flow, governance rule, and outcome.

The public-value perspective changes the success criterion. Registration, device distribution, application downloads, and model accuracy are intermediate measures. The desired results are timely access, continuity, autonomy, safety, social connection, caregiver relief, equitable outcomes, and public trust. These outcomes also reveal trade-offs. Continuous monitoring may improve safety but reduce privacy. Digital-by-default delivery may lower transaction costs while increasing administrative burden for citizens, while predictive prioritisation may improve resource allocation while introducing bias or opaque exclusion. A responsible architecture must make these trade-offs visible and governable.

B. Relationship to the Published Scoping Review

The prior review [4] is the evidence inheritance layer of this paper. Its 63 sources were identified through Scopus, Web of Science, IEEE Xplore, ACM Digital Library, PubMed, institutional repositories, and official policy sources. The present study applies design-science principles for translating a relevant problem into an artefact and evaluation agenda [9]. The inherited review followed PRISMA-ScR guidance [10] and methodological guidance that distinguishes broad scoping questions from effectiveness reviews [11]. The present study does not claim a new comprehensive search, does not recompute the published source frequencies, and does not reproduce the earlier country inventory. Instead, it changes the unit of analysis from policies and publications to requirements, components, controls, decision rights, and observable outcomes. Table I distinguishes the analytical contribution.

TABLE I POSITIONING OF THE PRESENT STUDY

Analytical lens	Unit of analysis	Primary output	Unresolved issue
Published scoping review [4]	Policy or publication	Global map of domains, technologies, challenges, and gaps	No implementable information-systems architecture
Technology acceptance	Individual user and technology	Determinants of intention and use	Limited treatment of cross-agency workflow and governance
Digital-health implementation [5]	Technology, adopter, organisation, and wider system	Explanations of non-adoption and failed scale-up	Not tailored to national digital ageing in Malaysia
MalaysiaAgeNet (this study)	Requirement, architecture component, control, owner, and indicator	Reference architecture, readiness model, scenarios, and decision gates	Requires later stakeholder and empirical validation

C. A Rapidly Changing Malaysian Policy Window

Malaysia's policy environment has changed materially since the evidence window of the original review. The WHO Global Strategy on Digital Health frames national digital transformation around leadership, governance, infrastructure, standards, workforce, and people-centred services [12]. Domestically, the National Ageing Blueprint (NAB) 2025-2045 now provides a long-term cross-sector response covering economic security, employment, education, social protection, healthcare, and long-term care. The Older Persons Action Plan (Pelan Tindakan Warga Emas Negara, PTWEN) 2026-2030 was launched in October 2025 and includes stronger ageing awareness and integrated long-term-care governance [13].

The Thirteenth Malaysia Plan, 2026-2030, identifies the transition towards an aged nation as a national challenge while making digital transformation and AI foundations for public-service reform and inclusive development [14]. The Ministry of Health's Digital Strategic Plan 2026-2030 provides a sectoral implementation window for integrated records, applications, infrastructure, data, and digital capability [15]. At the national AI level, AI Nation 2030 emphasizes value-driven and human-centric adoption, governance alignment, critical infrastructure, responsible practice, and measurable outcomes [16]. The Data Sharing Act 2025 creates a formal mechanism for

secure data exchange among federal government agencies [17], while the National Guidelines on AI Governance and Ethics articulate fairness, reliability, safety and control, privacy and security, inclusiveness, transparency, accountability, and human benefit [18].

Recent Malaysian evidence also cautions against treating connectivity as equivalent to inclusion. In a sample of 476 community-dwelling older adults, daily digital use was lower among participants with cognitive frailty than among robust participants, and use varied by age, education, income, and gender [19]. A qualitative study conducted at two Senior Citizens Activity Centre (PAWE) centres in Perak involved 26 older adults and 13 younger instructors; it highlighted the usefulness of hands-on, small-group, intergenerational instruction for engagement and comprehension [20]. A 2026 cross-sectional study of 72 Malaysian caregiver-care-recipient dyads found associations between different dimensions of digital literacy and quality of life, including interdependent actor-partner effects [21]. These findings support architecture at the level of the older-person-caregiver-community-service relationship, not only the individual device owner.

The comparative evidence also identifies mechanisms that can be adapted without copying another country's institutional model. Japan's Society 5.0 links digital capability to an explicitly human-centred social mission [22]. Singapore's Project Wire Up and Australia's Be Connected show that trusted community delivery, continuing support, and attention to low socioeconomic status are as important as connectivity [23], [24]. Finland's Kanta services demonstrate the long time horizon and sustained national funding needed for shared information infrastructure [25]. At the same time, Germany's digital-health reforms show how regulation, reimbursement, standards, and organisational incentives must move together [26]. The European Union AI Act further illustrates a risk-tiered approach in which the burden of evidence and control rises with potential harm [27].

The opportunity is therefore unusually strong: Malaysia now has ageing, health, digital-government, data-sharing, and AI policy instruments that can support implementation. The remaining risk is horizontal fragmentation. Each policy may progress within its own administrative and technical boundary while an older person still encounters separate identity checks, inaccessible interfaces, repeated data entry, unclear legal authority or consent, and inconsistent service pathways. MalaysiaAgeNet supplies the missing integration logic.

3. Materials and Methods

A. Study Design

The study used a design-oriented secondary synthesis. It draws on design-science principles in which a relevant problem is translated into objectives, an artefact is designed, its internal logic is demonstrated, and an evaluation agenda is specified [9]. The artefacts are conceptual rather than software implementations such as a requirements set, reference architecture, maturity model, scenario walkthrough, and decision-gated roadmap. Reporting of the inherited review remains governed by the original PRISMA-ScR account [10] and guidance distinguishing broad scoping questions from effectiveness reviews [11].

B. Evidence Inheritance and Targeted Malaysian Update

Phase 1 inherited the extraction categories from the 63-source review [4]: jurisdiction, policy objective, technology, delivery mechanism, governance mechanism, implementation challenge, and reported gap. This prevented selective reconstruction of global lessons. Only findings necessary for design translation were used.

Phase 2 updated the Malaysian context through a targeted search completed on 1st August 2026. Official portals of the Department of Statistics Malaysia, Ministry of Women, Family and Community Development Malaysia (KPWKM), Ministry of Economy, Ministry of Health (MOH), Ministry of Digital, Personal Data Protection Commissioner, and National AI Office were searched for documents published or in force from January 2025 to July 2026. Publisher and bibliographic pages were searched for Malaysian studies of older adults, digital literacy, digital-technology use, PAWE, caregivers, telehealth, and interoperability. The update retained 12 Malaysian policy, legal, statistical, and administrative instruments and three recent Malaysian empirical studies that directly altered requirements, institutional fit, or implementation timing.

Sources were retained when they were issued by an authoritative Malaysian body or published in a peer-reviewed outlet, directly relevant to population ageing or the delivery and governance of digital services for older adults, and capable of changing a requirement, architecture component, safeguard, indicator, or implementation sequence. News commentary and documents that only repeated another source were excluded. The update was purposive rather than exhaustive and was not used to calculate prevalence or effect estimates.

C. Requirement Derivation

Phase 3 translated policy mechanisms into system requirements using four questions: (1) which public problem is being addressed; (2) which actor and workflow must change; (3) which information capability or control is required; and (4) which observation would show that the change generated public value. Candidate requirements were grouped under mission and governance, inclusive delivery, interoperability, trust and assurance, and outcome learning. A requirement was retained only when it could be mapped to an architectural component, a responsible role, a control or fallback, and at least one observable indicator.

D. Architecture Synthesis and Analytical Demonstration

Phase 4 organised the requirements into layers that separate user interaction, community mediation, domain services, orchestration, and data-intensive capabilities. Cross-cutting trust and observability planes were added because accessibility, privacy, cybersecurity, assurance, and evaluation cannot be confined to a single application. Internal consistency was checked through traceability: every retained requirement had to be represented by one or more architecture elements, and every architecture layer had to support a stated requirement.

Analytical demonstration used five service scenarios selected to span different risk and coordination profiles: assisted telehealth referral, care-plan and medication continuity, smart-home safety alerts, assisted benefit applications, and social participation. For each scenario, the analysis identified the entry channel, necessary exchange, human decision point, failure-safe or non-digital alternative, and outcome indicator. This walkthrough tests completeness and exposes missing responsibilities; it does not establish clinical effectiveness, usability, or national feasibility.

E. Proposed Readiness Maturity Model and Decision Gates

The readiness component was developed as a study-specific maturity model rather than adopted as an established measurement scale. Its ordered progression draws on capability-maturity logic [28] and procedural guidance for developing IT maturity models [29]. The five readiness dimensions were derived from the socio-technical requirements identified in Phase 3, and five common anchors were defined to represent increasing institutional capability: 0-fragmented, 1-initiated, 2-demonstrated, 3-integrated, and 4-adaptive. Before assessment, the unit of analysis must be stated, such as a service pathway, participating organisation, region, or national programme, and every rating must be supported by observable evidence. The model is proposed for diagnostic use and has not been psychometrically or empirically validated.

The two decision gates adapt Cooper's Stage-Gate principle [30] to responsible digital public-service implementation. Gate 1 assesses whether a demonstrated service is ready for operational integration, while Gate 2 assesses whether an integrated service is ready for wider institutionalisation.

F. Ethics and Reproducibility

The study used published literature and publicly available policy documents; no human participants, identifiable personal data, or private records were involved. The inherited review corpus is identified in [4], and all sources used for the targeted Malaysian update are cited in this paper. The new framework tables, mappings, figures, and prose were developed for this study.

4. Results

This section reports the design artefacts produced by the synthesis. They are conceptual results derived from the evidence base, not statistical findings from a national deployment or stakeholder-validation study.

A. Socio-Technical Design Requirements

Table II presents the ten requirements and shows, for each one, what must be established, the failure it is intended to prevent, and the corresponding MalaysiaAgeNet response.

Digital inclusion means more than an easy-to-use screen. Older adults also need affordable connectivity and devices, continuing help when needed, and a genuine choice of app, web, telephone, face-to-face, assisted, or offline service.

Interoperability likewise means more than moving data between systems. Participating agencies must interpret information consistently, have lawful authority for access or obtain consent where applicable, know who owns the next action, and maintain reliable end-to-end operations.

AI can support staff by searching, translating, recommending, or prioritising; it must not erase accountability. For decisions that materially affect health, welfare, eligibility, or surveillance, a named official or professional must remain accountable, have authority to review and intervene, and provide an understandable route for correction, complaint, or challenge.

TABLE II TRACEABLE SOCIO-TECHNICAL REQUIREMENTS

ID	Requirement	Failure avoided	MalaysiaAgeNet Architecture response
R1	Shared public-value mission and accountable portfolio governance	Disconnected projects optimised for agency outputs	Cross-ministerial outcomes, owners, dependencies, and funding logic
R2	Accessible multichannel and assisted access	Digital-only exclusion and administrative burden	Web apps, voice, telephone, PAWE assistance, proxy rules, and offline fallback
R3	Continuing community capability	One-off training without sustained use	PAWE hubs, facilitators, caregiver support, scam awareness, and escalation paths
R4	Cross-domain service orchestration	Health, welfare, housing, and mobility silos	Shared service directory, referral workflow, case status, and accountable hand-offs
R5	Semantic and technical interoperability	Repeated data entry and incompatible records	Open APIs, event exchange, common identifiers, FHIR where applicable, and versioned profiles
R6	Lawful, purpose-bound data access and identity management	Unlawful or excessive sharing and over-centralization	Lawful authority or consent as applicable, granular permissions, audit trails, revocation where applicable, role-based access, data minimization, and federated patterns
R7	Risk-tiered AI with accountable human oversight	Opaque or biased consequential decisions	Use-case classification, evidence requirements, explanation, meaningful review, complaint or appeal routes, and model monitoring
R8	Secure, reliable, and recoverable operations	Service failure, breach, and safety incidents	Cybersecurity controls, incident response, continuity, uptime targets, and manual fallback
R9	Equity-aware observability	Success reported only through national activity counts	Disaggregated access, completion, outcome, harm, cost, and experience indicators
R10	Portability and sustainable scale	Vendor lock-in and pilots without recurrent capacity	Data portability, open standards, exit clauses, workforce, maintenance, and total-cost review

The control vocabulary was aligned with recognised technical and policy resources in a deliberate sequence: NIST's AI risk-management cycle [31] and WHO's ethical guidance for AI in health [32]; HL7 FHIR for health-information exchange where applicable [33]; WCAG 2.2 as a minimum web-accessibility baseline [34]; the WHO-ITU mAgeing implementation handbook for mobile-enabled healthy-ageing programmes [35]; and the WHO Decade of Healthy Ageing baseline's emphasis on functional ability, age-friendly environments, integrated care, and long-term care [36]. These resources inform requirements and controls, but local legal fit and co-design remain necessary.

B. The MalaysiaAgeNet Reference Architecture

Fig. 2 presents the architecture. Its organising principle is mediated access to shared capabilities, not a single national super-application or unrestricted central database. The architecture can be implemented through federated systems, provided that participating services use agreed identity and authorisation, lawful authority or consent where applicable, common meaning, accountable workflows, assurance, and observability rules.

Layer 1 - Experience and access. Older people and their authorised helpers enter through accessible web or mobile interfaces, voice and telephone channels, kiosks, or assisted/offline routes. Conformance with Web Content Accessibility Guidelines (WCAG) is necessary but insufficient. Services should be tested with people who have visual, hearing, motor, cognitive, language, and literacy differences.

Layer 2 - Community delivery. PAWE, clinics, libraries, local authorities, civil-society organisations, universities, caregivers, and trained facilitators provide trusted mediation. This layer supports learning, device use, scam awareness, service navigation, and escalation. It should also capture qualitative evidence about confusion, dignity, burden, and trust that transaction logs cannot reveal.

Layer 3 - Domain services. Health and long-term care, welfare, housing, mobility, emergency support, social participation, lifelong learning, and work remain owned by their responsible agencies or providers. The architecture does not erase domain accountability. It makes common capabilities reusable and supports coordinated pathways around a person rather than forcing a new monolithic organisation.

Layer 4 - Service orchestration and interoperability. This layer connects identity and authorisation, lawful authority or consent where applicable, service directories, referrals, eligibility checks, notifications, case status, and secure data exchange. Health exchanges can use internationally recognised resources and profiles such as HL7 Fast Healthcare Interoperability Resources (FHIR) [33], while non-health services require their own agreed vocabularies and contracts. An API or event gateway should enforce authentication, rate limits, logging, and version management. Interoperability succeeds only when the receiving organisation understands the information and can act on it through an accountable workflow.

Layer 5 - Data, analytics, and responsible AI. Federated data products, operational dashboards, planning analytics, and approved AI services operate above governed source systems. Data lineage, quality, provenance, lawful purpose, and retention are prerequisites.

Cross-cutting trust planes involve governance, privacy, cybersecurity, accessibility, audit, procurement, incident response, and exit controls that apply across every layer. WCAG 2.2 provides a technical accessibility baseline [34], but meaningful accessibility also includes language, comprehension, assistance, and task completion. The cross-cutting observability and learning plane connects system telemetry with public-value outcomes, equity gaps, incidents, user feedback, total cost, and model drift. It creates a feedback loop for redesign, scale, or withdrawal rather than assuming that every pilot should become permanent. Table III links each architecture element to the requirements it serves, its illustrative components, and the primary accountability question.

Fig. 2 MalaysiaAgeNet socio-technical reference architecture. The layered design separates interaction, community mediation, domain services, orchestration, and data-intensive capabilities while applying trust and learning across the system.

TABLE III ARCHITECTURE TRACEABILITY AND PRIMARY ACCOUNTABILITY

Architecture element	**Requirements served**	**Illustrative components**	**Primary accountability question**
Layer 1 - Experience and access	R2, R6, R8	Accessible channels, proxy support, authentication, offline route	Can a diverse older person complete the task safely with or without assistance?
Layer 2 - Community delivery	R2, R3, R9	PAWE hub, facilitator, caregiver support, help and escalation	Who provides trusted continuing support and records lived-experience problems?
Layer 3 - Domain services	R1, R4, R10	Health, care, welfare, housing, mobility, social and work services	Which organisation owns the outcome and the final decision?
Layer 4 – Service Orchestration and interoperability	R4-R6, R8, R10	Identity, authorisation, lawful authority or consent where applicable, directory, referral, API/event gateway, and profiles	Can information trigger an accountable cross-provider action?
Layer 5 - Data, analytics, and responsible AI	R6-R9	Federated data, dashboards, models, audit, and accountable human review	Is the data fit for purpose, and is a named person accountable for consequential use?

Cross-cutting Trust Plane	All	Governance, security, accessibility, outcomes, equity, cost, incidents	Are service operations lawful, safe, accessible, auditable, and accountable?
Cross-cutting observability and learning plane	All	Outcomes, equity gaps, costs, incidents, user feedback, service performance, and model drift.	What evidence supports continuation, adaptation, or withdrawal?

C. Service-Scenario Walkthrough

The walkthrough in Table IV demonstrates how the architecture preserves both integration and human responsibility. It also shows why a single user interface is not the central innovation. Each scenario depends on an end-to-end chain of assisted access, shared meaning, authorised exchange, accountable action, fallback, and outcome measurement.

TABLE IV ANALYTICAL SERVICE-SCENARIO WALKTHROUGH

Scenario	**Critical exchange or component**	**Human safeguard and fallback**	**Outcome-oriented evidence**
Assisted telehealth referral	PAWE/clinic referral, identity and consent, appointment and summary exchange	Facilitator support; clinician retains triage authority; telephone/in-person route	Completion time, missed appointments, travel avoided, clinical escalation, equity gap
Care-plan and medication continuity	Standards-based summary, medication list, role-based access, update notification	Clinician/pharmacist reconciliation; correction route; break-glass access with audit	Reconciliation errors, duplicated tests, adverse events, provider and patient experience
Smart-home safety alert	Sensor event, confidence level, escalation workflow, caregiver/service notification	Configurable consent; human verification; emergency override; non-camera option	False alarms, response time, avoided harm, privacy complaints, continued use
Assisted benefit application	Eligibility data, document reuse, case status, notification	Officer decides disputed cases; appeal; counter/telephone option; authorised proxy	Task completion, processing time, repeat submissions, appeals, income/rural gap
Social participation and digital learning	PAWE directory, accessible enrolment, learning record, feedback	Facilitator-led small groups; choice of non-digital activity; safeguarding	Sustained participation, confidence, social connection, scam resilience, dropout reasons

D. Proposed Readiness Model

The reference architecture specifies the capabilities that a digital-ageing service should contain, whereas the readiness model asks whether those capabilities are sufficiently established to work reliably in practice. It evaluates the implementation capability of a clearly defined service, organisation, region, or programme, not the digital ability

of individual older adults. Its purpose is diagnostic: to identify weaknesses that must be addressed before a pilot is integrated or scaled. Table V defines the common meaning, evidence, and decision implications of maturity Levels 0–4.

TABLE V COMMON MATURITY ANCHORS FOR EACH READINESS DIMENSION

Level	Meaning in practice	Observable evidence	Decision implication
0 - Fragmented	The capability is absent, isolated, or inconsistent; ownership and intended outcomes are unclear.	Application inventories or procurement records only; no stable owner, baseline, or operating control.	Do not scale; define the service problem, accountable owner, baseline, dependencies, and risks.
1 - Initiated	Intent, named owners, and preliminary policies or standards exist, but the capability is not yet operating and tested.	Mandate or policy statement; named lead; draft architecture, controls, indicators, and implementation plan.	Select a bounded pilot; establish baselines, safeguards, responsibilities, and evidence-collection methods.
2 - Demonstrated	The capability operates in a coordinated pilot with safeguards, users, staff, and evaluation arrangements.	Task, access, safety, incident, experience, workflow, cost, and subgroup data from the pilot.	Pass Gate 1 only when usefulness, accessibility, safety, operational feasibility, and early public value are supported.
3 - Integrated	The capability works routinely across participating organisations or regions using agreed processes and standards.	Operational agreements and exchange logs; service-level performance; outcome, equity, cost, and incident reporting.	Pass Gate 2 only when outcomes, equity, total cost, security, workforce, and organisational readiness justify wider scale.
4 - Adaptive	The capability is institutionalised, sustainably funded, monitored over time, and improved when evidence or needs change.	Routine funding and public reporting; audits; longitudinal outcomes; documented adaptations, withdrawals, and updated controls.	Continue learning; optimise effective services, correct inequities, retire weak services, and update standards and controls.

To use the model, assessors first define the unit being assessed, gather evidence for each dimension using the indicative anchors in Table V, assign a 0-4 rating to each dimension, and report the complete five-dimension profile. Gate passage should be determined from dimension-level evidence and critical safeguards.

Assessment therefore produces a five-dimension readiness profile, not a single pass mark. For example, an assisted telehealth pilot may have a named lead, funding, and accessible support channels but still lack tested consent, audit, incident-response, or complaint arrangements. Its mission-and-governance and inclusive-delivery ratings may therefore be higher than its trust-and-assurance rating. The weaker trust capability remains a barrier to wider implementation. This is the model's non-compensatory rule: a high average cannot cancel a critical weakness. A high-risk AI or monitoring service should not proceed while trust and assurance remain at Levels 0 or 1, and national readiness should not be claimed while inclusive delivery is weak. The dimensions, evidence definitions, thresholds, and weights remain proposals requiring stakeholder and empirical validation.

E. Decision-Gated Implementation Roadmap

Fig. 3 shows how implementation can progress from a bounded demonstration to integration and, only when stronger evidence is available, to wider institutionalisation. Table VI explains the three stages, their deliverables, the

evidence examined at each gate, and the evaluation emphasis for subsequent scaling or continued improvement. Together, they make progression conditional: an initiative may proceed, be redesigned, remain limited, or be stopped according to the evidence collected. The time horizons are indicative planning ranges, not empirically validated schedules, and should be adjusted to the risk and capacity of each service.

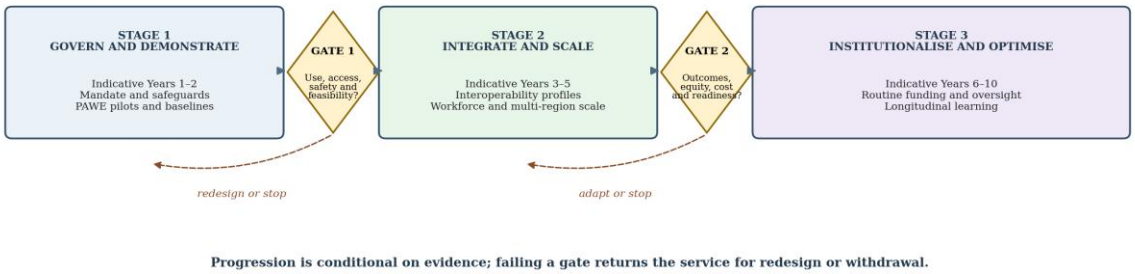

Fig. 3 Decision-gated roadmap. Progression is conditional: services return for redesign or stop when public-value and readiness criteria are not met.

TABLE VI STAGED IMPLEMENTATION AND EVALUATION LOGIC

Stage	Core deliverables	Gate	Evaluation emphasis
1. Govern and demonstrate (indicative Years 1–2)	National mandate, portfolio inventory, common principles; risk taxonomy; PAWE-linked pilots; baselines; facilitator capability	Gate 1: usefulness, accessibility, safety, operational feasibility, and early public value	Task completion, non-use reasons, incidents, experience, workflow fit, initial cost, subgroup gaps
2. Integrate and scale (indicative Years 3–5)	Interoperability profiles; identity and authorisation; lawful authority or consent where applicable; service directory; multi-region expansion; operations; procurement and exit controls	Gate 2: outcomes, equity, total cost, security, workforce and organisational readiness	Comparative implementation, service levels, outcome trends, distributional effects, sustainability
3. Institutionalise and optimise (indicative Years 6–10)	Routine funding and roles; regulatory oversight; mature data products; selectively approved AI; longitudinal public reporting	Continuous retain/adapt/retire review	Healthy and independent living, caregiver burden, trust, avoidable use, cost per outcome, long-term equity

5. Discussion

A. Contribution to Information-Systems Research

The framework advances the earlier policy map in four ways. First, it converts themes into requirements that can be tested against an implementation. Second, it separates architectural layers while retaining cross-cutting governance and learning. Third, it treats community mediation as a system component rather than an informal workaround. Fourth, it introduces explicit decision gates so that scaling is earned through evidence rather than assumed after pilot completion.

This architecture also clarifies the boundary between platform thinking and platform overreach. Shared identity, authorisation, consent where applicable, directories, profiles, audit, and observability can reduce duplication. They do not require every agency to surrender its statutory role or every dataset to be copied into one repository. Federated exchange can preserve domain stewardship while enabling coordinated pathways. The design objective is actionable interoperability like information reaches an authorised actor is understood consistently, and leads to a traceable service response.

The readiness model complements the architecture. Architecture describes what capabilities and relationships should exist, while readiness describes how reliably and institutionally those capabilities operate. This distinction is important for public-sector digital transformation, where installed technology is often easier to count than end-to-end capability.

B. Alignment with Malaysia's Current Institutions

MalaysiaAgeNet is feasible only if it strengthens existing institutions. KPWKM provides ageing and long-term-care policy leadership like the Thirteenth Malaysia Plan supplies cross-government reform priorities. MOH governs health-sector digital systems and the Ministry of Digital and AI Malaysia provide data-sharing, GovTech, and AI-governance mechanisms [13][18]. The framework does not create a substitute ministry, hence it supplies shared outcomes, interoperability rules, portfolio governance, and evaluation language across these mandates.

PAWE is a particularly useful delivery base. An official November 2025 ministerial statement reported 193 centers serving more than 50,000 older persons and noted that programs include health and digital-literacy activities [37]. The centers are community activity hubs rather than clinical facilities or residential care institutions. Their digital role should therefore be bounded with assisted access, learning, navigation, social connection, basic device support, scam awareness, and referral.

The study conducted at two PAWE centres in Perak [20] provides an important implementation clue. Intergenerational, hands-on, small-group learning may be developed as a repeatable service pattern with facilitator preparation, accessible materials, task-based practice, escalation, and outcome capture. The caregiver-dyad evidence [21] further suggests that digital capability may sometimes need to be assessed and supported at household or dyad level. This does not remove the older person's autonomy, but it recognises the practical interdependence of technology use in older adulthood.

C. Data Governance Across Legal and Organisational Boundaries

The Data Sharing Act 2025 strengthens lawful exchange among federal agencies [17], but a national ageing ecosystem also includes state entities, private healthcare and care providers, NGOs, universities, technology firms, and families. Malaysia's Personal Data Protection Act regulates personal data in commercial transactions, and the 2024 amendments introduce updated controller, processor, breach-notification, and data-protection responsibilities [38]. Public and private actors therefore do not operate under one identical legal regime. Architecture cannot substitute for legal analysis. For each pathway, participating organisations must establish the lawful basis or statutory authority, use consent where applicable, define purpose and retention, apply security controls, and assign accountability.

The Health White Paper calls for systemic reform and greater use of digital health for data, monitoring, and evidence-informed action [39]. MalaysiaAgeNet extends that logic across health and non-health determinants of later life. It recommends minimum necessary exchange and federated data products rather than indiscriminate linkage. For example, a welfare referral may need confirmation that a care assessment occurred, not the full clinical record. A social-participation programme may need accessibility preferences and emergency contact arrangements, not diagnostic history. Purpose limitation should shape the data model before implementation, not be added after integration.

D. Responsible AI: From Principles to Service Controls

Malaysia's AI governance principles and AI Nation 2030 create a strong policy foundation [16][18]. The implementation challenge is to connect principles to a specific use case. An AI-assisted service search or plain-language translation tool is materially different from a model that predicts frailty, prioritises home-care visits, flags alleged fraud, or recommends benefit eligibility.

E. Measurement as an Architectural Capability

Measurement is usually treated as a reporting task after deployment. MalaysiaAgeNet places it in the architecture because baseline definitions, identifiers, event capture, feedback routes, and data-quality controls must be designed before outcomes can be evaluated. A national dashboard dominated by registrations and transaction volume would reward digitalisation without demonstrating value. A balanced evidence set includes access and completion, outcome and safety, user and caregiver experience, equity, total cost, security and reliability, and organisational learning.

Indicators should be disaggregated where lawful and statistically responsible by age band, gender, disability, geography, income proxy, language, living arrangement, and assistance status. Assisted completion should not be coded as failure; it is a legitimate service mode. Non-use should also be interpreted carefully. It may reflect exclusion, an inaccessible design, a trusted alternative, or a reasoned preference not to be monitored. Qualitative accounts are required to distinguish these explanations.

F. Transferability

Although designed for Malaysia, the framework is relevant to other middle-income countries facing compressed demographic and digital transitions. The transferable elements are the layered separation of channels, community mediation, domain services, orchestration, and data-intensive capability. Country-specific elements include Malaysia's ministries, PAWE, legal regime, languages, federal structure, health system, and national plans. Transfer should therefore preserve the design questions rather than copy the institutional labels.

G. Limitations and Validation Agenda

The study has four principal limitations. First, it inherits the coverage limitations of the 2015-2025 scoping review, including English-language bias and uneven policy documentation [4]. Second, the targeted Malaysian update was purposive rather than systematic. Third, the requirements, mappings, maturity anchors, and gates were developed through author-led synthesis and analytical walkthrough; these methods do not provide independent stakeholder consensus, psychometric validation, or field-performance evidence. Fourth, publication of a policy does not demonstrate its implementation or effectiveness. The proposed weights, thresholds, time horizons, costs, usability, interoperability, security, workforce feasibility, and national reach of PAWE-linked delivery therefore remain to be tested.

The next phase should use a modified Delphi or nominal-group process with older persons, caregivers, PAWE representatives, clinicians, social-care and welfare practitioners, local authorities, system architects, cybersecurity and data-governance specialists, regulators, NGOs, and industry. Validation should examine relevance, clarity, completeness, feasibility, and priority of requirements.

6. Conclusions

Malaysia's demographic transition and digital-policy expansion create both urgency and opportunity. The challenge is not a shortage of promising technologies. It is the absence of a shared implementation logic that connects accessible interaction, trusted community support, accountable domain services, interoperable workflow, governed data and AI, and measurable public value.

MalaysiaAgeNet addresses this gap through a socio-technical reference architecture, traceable requirements, service scenarios, a readiness model, and a decision-gated roadmap. It proposes that PAWE and other community institutions serve as assisted-access and learning channels, while national actors provide standards, governance, infrastructure, assurance, and evaluation. It also makes a critical boundary explicit, which advanced analytics and AI should follow mature data, service, inclusion, and accountability capability rather than compensate for their absence.

The framework is not yet a validated national blueprint. Its value is that it turns broad policy ambition into an artefact that stakeholders can challenge, refine, implement, and measure. Success should ultimately be judged not by the number of applications, sensors, or models deployed, but by whether diverse people can age with greater health, agency, safety, participation, and trust.

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References

1. Department of Statistics Malaysia, Current Population Estimates, Malaysia, 2026, Putrajaya, July 31, 2026. Available: https://www.dosm.gov.my/portal-main/release-content/current-population-estimates-2026 (accessed Aug. 2, 2026).

2. Department of Statistics Malaysia, Population Projections, Malaysia, 2020-2060, Putrajaya, 2025. Available: https://storage.dosm.gov.my/demography/population_projection_2060.pdf (accessed Aug. 1, 2026).
3. World Health Organization, 'Ageing and health,' Oct. 1, 2024. Available: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health (accessed Aug. 1, 2026).
4. A. W. Selamat and S. A. Ariffin, 'Scoping Review on Global Digital Policies and Transformation Strategies for Ageing Societies: Implications for Malaysia,' International Journal of Advanced Computer Science and Applications, vol. 17, no. 5, pp. 435-444, 2026.
5. T. Greenhalgh et al., 'Beyond Adoption: A New Framework for Theorizing and Evaluating Nonadoption, Abandonment, and Challenges to the Scale-Up, Spread, and Sustainability of Health and Care Technologies,' Journal of Medical Internet Research, vol. 19, no. 11, e367, 2017, doi: 10.2196/jmir.8775.
6. B. B. Neves and G. Mead, 'Digital Technology and Older People: Towards a Sociological Approach to Technology Adoption in Later Life,' Sociology, vol. 55, no. 5, pp. 888-905, 2021, doi: 10.1177/0038038520975587.
7. H. Valokivi, S. Carlo, E. Kvist, and M. Outila, 'Digital ageing in Europe: a comparative analysis of Italian, Finnish and Swedish national policies on eHealth,' Ageing & Society, vol. 43, no. 4, pp. 835-856, 2023, doi: 10.1017/S0144686X21000945.
8. D. F. Sittig and H. Singh, 'A new sociotechnical model for studying health information technology in complex adaptive healthcare systems,' Quality & Safety in Health Care, vol. 19, suppl. 3, pp. i68-i74, 2010, doi: 10.1136/qshc.2010.042085.
9. K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, 'A Design Science Research Methodology for Information Systems Research,' Journal of Management Information Systems, vol. 24, no. 3, pp. 45-77, 2007, doi: 10.2753/MIS0742-1222240302.
10. A. C. Tricco et al., 'PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation,' Annals of Internal Medicine, vol. 169, no. 7, pp. 467-473, 2018, doi: 10.7326/M18-0850.
11. Z. Munn, M. D. J. Peters, C. Stern, C. Tufanaru, A. McArthur, and E. Aromataris, 'Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach,' BMC Medical Research Methodology, vol. 18, art. 143, 2018, doi: 10.1186/s12874-018-0611-x.
12. World Health Organization, Global Strategy on Digital Health 2020-2025, Geneva, 2021. Available: https://www.who.int/publications/i/item/9789240020924 (accessed Aug. 1, 2026).
13. Ministry of Women, Family and Community Development Malaysia, 'Parliamentary reply no. 47: National Ageing Blueprint 2025-2045 and Older Persons Action Plan 2026-2030,' Oct. 13, 2025. Available: https://eparlimen.kpwkm.gov.my/arkib/arkib/soalan_luar?id=0000000162 (accessed Aug. 1, 2026).
14. Ministry of Economy Malaysia, Thirteenth Malaysia Plan, 2026-2030: Executive Summary, Putrajaya, 2025. Available: https://rmk13.ekonomi.gov.my/wp-content/uploads/2025/09/Executive_Summary_Thirteenth_Malaysia_Plan.pdf (accessed Aug. 1, 2026).
15. Ministry of Health Malaysia, Digital Strategic Plan Ministry of Health Malaysia 2026-2030, Putrajaya, 2026. Available: https://www.moh.gov.my/en/publications-and-reports/policies-act-policies-guide-lines/strategic-plan/list-of-strategic-plans/digital-strategic-plan-ministry-of-health-malaysia-2026-2030 (accessed Aug. 1, 2026).
16. AI Malaysia Berhad (National AI Office), AI Nation 2030: National AI Action Plan 2026-2030, Kuala Lumpur, 2026. Available: https://ai.gov.my/ (accessed Aug. 2, 2026).
17. Ministry of Digital Malaysia, 'Data Sharing Act 2025 comes into effect today - set to enhance government services, protect personal data,' Apr. 28, 2025. Available: https://www.digital.gov.my/en-GB/siaran/Akta-Perkongsian-Data-2025-Berkuat-Kuasa-Hari-Ini%3BTingkatkan-Perkhidmatan-Kerajaan%2CLindungi-Data-Peribadi (accessed Aug. 2, 2026).
18. Ministry of Science, Technology and Innovation Malaysia, The National Guidelines on AI Governance & Ethics, Putrajaya, 2024. Available: https://mastic.mosti.gov.my/storage/2024/09/THE-NATIONAL-GUIDELINES-ON-AI-GOVERNANCE-ETHICS.pdf (accessed Aug. 1, 2026).
19. N. H. Md Fadzil et al., 'Digital technology usage among older adults with cognitive frailty: A survey during COVID-19 pandemic,' Digital Health, vol. 9, 2023, doi: 10.1177/20552076231207594.
20. N. A. Ahmad et al., 'Intergenerational instructional strategies and elderly preferences for digital applications: A Malaysian case study,' PLOS ONE, vol. 20, no. 8, e0328481, 2025, doi: 10.1371/journal.pone.0328481.
21. F. Mohammadzadeh Yazd, H. F. Foong, R. Ibrahim, P. Kunasekaran, and A. Ashari, 'Multidimensional Digital Literacy and Quality of Life Among Informal Care Dyads in Malaysia: Cross-Sectional Survey,' JMIR Aging, vol. 9, e86561, 2026, doi: 10.2196/86561.
22. Cabinet Office, Government of Japan, 'Society 5.0,' [Online]. Available: https://www8.cao.go.jp/cstp/english/society5_0/index.html (accessed Aug. 2, 2026).
23. N. H. W. Ngiam et al., 'Building Digital Literacy in Older Adults of Low Socioeconomic Status in Singapore (Project Wire Up): Nonrandomized Controlled Trial,' Journal of Medical Internet Research, vol. 24, no. 12, e40341, 2022, doi: 10.2196/40341.
24. A. McCosker et al., Improving the Digital Inclusion of Older Australians: The Social Impact of Be Connected, Swinburne University of Technology, 2020, doi: 10.25916/5ed5b6e204a95.
25. V. Jormanainen, 'Funding Nationwide HIE and HIS: Case Kanta Services 2003-2024 in Finland,' Studies in Health Technology and Informatics, 2025, doi: 10.3233/SHTI250134.
26. S. Gerke, A. D. Stern, and T. Minssen, 'Germany's digital health reforms in the COVID-19 era: lessons and opportunities for other countries,' npj Digital Medicine, vol. 3, art. 94, 2020, doi: 10.1038/s41746-020-0306-7.

27. European Parliament and Council of the European Union, 'Regulation (EU) 2024/1689 laying down harmonised rules on artificial intelligence,' Official Journal of the European Union, 2024.
28. W. S. Humphrey, 'Characterizing the software process: A maturity framework,' IEEE Software, vol. 5, no. 2, pp. 73-79, 1988, doi: 10.1109/52.2014.
29. J. Becker, R. Knackstedt, and J. Pöppelbuß, 'Developing maturity models for IT management: A procedure model and its application,' Business & Information Systems Engineering, vol. 1, no. 3, pp. 213-222, 2009, doi: 10.1007/s12599-009-0044-5.
30. R. G. Cooper, 'Stage-Gate systems: A new tool for managing new products,' Business Horizons, vol. 33, no. 3, pp. 44-54, 1990, doi: 10.1016/0007-6813(90)90040-I.
31. National Institute of Standards and Technology, Artificial Intelligence Risk Management Framework (AI RMF 1.0), NIST AI 100-1, 2023, doi: 10.6028/NIST.AI.100-1.
32. World Health Organization, Ethics and Governance of Artificial Intelligence for Health: WHO Guidance, Geneva, 2021. Available: https://www.who.int/publications/i/item/9789240029200 (accessed Aug. 1, 2026).
33. Health Level Seven International, FHIR Release 5, 2023. Available: https://hl7.org/fhir/ (accessed Aug. 1, 2026).
34. World Wide Web Consortium, Web Content Accessibility Guidelines (WCAG) 2.2, W3C Recommendation, 2023. Available: https://www.w3.org/TR/WCAG22/ (accessed Aug. 1, 2026).
35. World Health Organization and International Telecommunication Union, Be He@lthy, Be Mobile: A Handbook on How to Implement mAgeing, Geneva, 2018.
36. World Health Organization, Decade of Healthy Ageing: Baseline Report, Geneva, 2020.
37. Ministry of Women, Family and Community Development Malaysia, '2026 Supply Bill winding-up speech: PAWE service coverage,' Nov. 3, 2025. Available: https://kpwkm.gov.my/uploads/content-downloads/file_20251105113556.pdf (accessed Aug. 1, 2026).
38. Malaysia, Personal Data Protection (Amendment) Act 2024, Act A1727, 2024. Available: https://www.pdp.gov.my/ppdpv1/wp-content/uploads/2024/11/Act-A1727.pdf (accessed Aug. 1, 2026).
39. Ministry of Health Malaysia, Health White Paper for Malaysia, Putrajaya, 2023. Available: https://www.moh.gov.my/images/04-penerbitan/kertas-putih/Kertas_Putih_Kesihatan_ENG_compressed.pdf (accessed Aug. 1, 2026).