AAL Legacy Study

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Executive Summary

1.1. Overview

The Ambient Assisted Living Joint Programme—rebranded in 2014 as the Active Assisted Living (AAL) Programme—operated from 2008 to 2021 under Article 185 of the EU Treaty as a Public–Public Partnership jointly initiated and co-financed by participating states and the European Commission. Up to twenty-three countries contributed national funding, which was matched by the EU to support transnational collaboration. Although legally a public–public initiative, the programme systematically required private-sector participation and co-funding, making it function in practice as a public–private effort. Conceived against the backdrop of rapid population ageing, the programme pursued a threefold mission: **(i)** to enhance autonomy, safety, health and social participation for citizens aged 60 and over, **(ii)** to strengthen Europe's nascent "silver-economy" by accelerating the emergence of globally competitive age-tech enterprises, and **(iii)** to support the sustainability of health and care systems.

Over fourteen annual calls (2008-2021) the programme channelled approximately € 1 billion in combined EU and national funding into more than 300 transnational R&D and innovation projects. These consortia brought together around 2 000 SMEs, 700 research and clinical institutes, and over 100 user-representative organisations, creating one of the largest cross-border networks working on technology for ageing in place. Field activities engaged 60 000+ older adults and 14 000 informal or professional carers in co-design workshops, living-lab pilots and long-term home trials, ensuring that solutions were shaped by real-life needs and constraints from the outset.

The resulting portfolio is intentionally diverse. It spans predictive safety and fall-prevention sensors, AI-enabled chronic-disease self-management platforms, voice-mediated social-connection and cognitive-training tools, smart-home and ambient-automation packages, rehabilitation robotics and mixed-reality physiotherapy suites. Dozens of solutions and technology components developed through the programme have reached the market, contributing to the emergence of a European age-tech sector increasingly recognised as a strategic part of the broader silver economy.

1.2. Challenges addressed and technological evolution

AAL projects consistently converged on **nine inter-related societal challenges**. The most pervasive need proved to be the prevention of social isolation and loneliness, addressed in 43 % of funded projects. Close behind came the preservation of independence in activities of daily living (38 %) and the mitigation of cognitive decline and mental-health problems (28 %). A further quarter of projects targeted physical function and mobility, while sizeable minorities focused on real-time safety and emergency response, care-giver burden reduction, and chronic-disease self-management. Environmental adaptation (smart lighting, barrier-free layouts) and sensory-impairment compensation appeared less frequently yet remained critical in niche deployments. Over time, the thematic mix broadened markedly: early projects clustered around clinical monitoring of heart failure, COPD or diabetes, but later cohorts treated psychosocial wellbeing, functional ability and informal-care resilience as inseparable dimensions of the same ageing journey.

To meet these needs, innovators repeatedly converged on **nine solution archetypes**. The enduring backbone was the monitoring-and-alert system, present in roughly 40 % of all proposals and evolving from simple fall detectors into predictive analytics engines that flag frailty or COPD exacerbations days in advance. Around one-third of projects built social-interaction platforms that blended video calls, storytelling or peer matching with reminders and coaching. Cognitive- and physical-training suites, often delivered through exergames or virtual reality, grew steadily with evidence that activity slows functional decline. Assistive wearables—from tremor-suppressing wristbands to textile ECG patches—became more clinically robust as component costs fell, while smart-home automation systems took on adaptive lighting, energy control and voice-activated appliances. Tele-health and remote-care platforms resurfaced with new urgency during the COVID-19 pandemic, integrating biometric streams with video consultation. More specialised niches were filled by mobility and navigation aids, robotic assistants for therapy or companionship, and medication-management devices that reduce avoidable hospital visits. Whereas first-phase projects typically delivered a single archetype, second-phase consortia increasingly fused two or three into seamless, service-based packages aligned with regional care pathways.

Technological capabilities advanced in parallel. Sensor technologies -ambient motion, pressure pads- were already ubiquitous in 2008, yet the intelligence layer was rudimentary. By 2021 more than three-quarters of projects embedded machine-learning modules for personalisation, risk stratification or intent recognition, and over half processed data through elastic cloud back-ends linked to electronic health-record interfaces. Convergence around open interoperability profiles (FHIR®, universAAL, MQTT) allowed new devices to plug into existing platforms without vendor lock-in, while privacy-preserving architectures and explainability safeguards matured in parallel, enabling consortia to satisfy the emerging EU AI Act and Medical Device Regulation without suppressing innovation. In effect, the programme charted a transition from hardware-centric monitoring toward data-driven, cloud-orchestrated ecosystems capable of anticipating decline, coordinating multi-actor response and learning continuously from real-world use. This techno-social evolution underpins many of the integrated, payer-backed services now scaling in European regions and sets the template for the next generation of healthy-ageing innovation.

1.3. User involvement and stakeholder evolution

From the outset, the AAL Programme treated meaningful end-user engagement as a condition for relevance and adoption. Sixteen years of monitoring show a clear progression: involvement grew from episodic consultation with older adults to continuous, multi-layer collaboration that also embraced caregivers, care professionals, payers and public authorities.

More than 60 000 primary end-users (older citizens) participated across the 300+ projects, but the pattern was far from linear. Early cohorts (2008-2011) typically recruited a few dozen seniors for focus groups and short trials. Two exceptional online platforms inflated totals in 2009 and 2013, yet even after these peaks the trajectory shifted towards *fewer, deeper* engagements. Median participation climbed from 30 persons per project in 2008 to around 70–130 in the mature calls, reflecting a move to longer-term living-lab pilots embedded in real homes and care settings. Just as important was the qualitative change: only 26 % of 2008 projects practiced co-design with older adults, whereas more than half of all projects in the final calls did so, institutionalising iterative workshops and rapid prototype cycles. Temporary dips in 2016 (dementia call, where ethical constraints limited direct co-creation) and 2017 (near-market “package” call) confirm that engagement depth responds to call framing rather than to goodwill alone.

Secondary end-users (Caregivers including family members, volunteers, nurses and therapists) numbered roughly 14 000 participants overall and increasingly shaped solution design. Whereas early projects consulted carers mainly through questionnaires, later cohorts brought them into active testing (about 40 % of projects after 2014) and into joint decision-making on features and evaluation metrics. The share of projects involving carers in formal co-design rose to 41 % by 2020, driven both by the dementia focus (where carers act as proxies for users with cognitive impairment) and by the programme's insistence that solutions reduce caregiver burden, not merely monitor the older person.

Tertiary end-users (organisations that finance or regulate care like municipalities, housing operators, insurers and health systems) evolved from occasional advisers to critical partners. Tertiary participation featured in only a quarter of the first calls but surpassed 50 % in several late-phase calls that demanded ecosystem integration and evidence of economic sustainability. Government and municipal bodies formed the backbone (average 25 % of projects), but healthcare providers and insurers grew fastest, reaching one third and nearly 30 % respectively in the 2019 call. Although most organisations were still consulted rather than co-designing, their earlier presence shortened approval cycles and clarified reimbursement routes, a prerequisite for post-grant uptake.

Across all user groups, *active testing* remained the norm (around 95 % of projects for older adults, 40 % for carers), yet the decisive innovation was the spread of *continuous co-creation*. Projects that scheduled at least two design–feedback–redesign loops before field trials reported lower attrition, fewer costly late changes and stronger reviewer confidence. Living-lab infrastructures—many of them created in AAL's first phase—enabled multi-month home deployments that generated robust data on usability, clinical benefit and cost impact. Conversely, projects that reverted to one-off surveys or that changed scope without renewed consent saw participation thin and evidence weaken.

Support actions such as the annual AAL Forum (later the European Week of Active & Healthy Ageing) and the AAL2Business acceleration pipeline played a crucial enabling role by offering investor coaching, regulatory clinics and matchmaking events that linked innovators with regional procurers. Seventy-two per cent of projects that completed Lean-Start-up academies later secured follow-on finance, compared with less than thirty per cent in the wider field.

Stakeholder evolution also reshaped consortia. By the final calls more than 85 % of projects combined business partners, research bodies and end-user organisations in a single team, often complemented by a public payer. SME participation rose from under forty per cent to consistently exceed that level, and SMEs assumed project coordination in almost two-thirds of late-stage calls once evaluation grids rewarded business planning. Research institutes remained a vital anchor—still present in more than four-fifths of teams—but ceded executive control to market-oriented partners who could drive exploitation. Large industrial multinationals appeared only sporadically, reflecting both the modest budget envelopes per grant and the programme's strategic focus on agile, interoperable solutions rather than proprietary ecosystems.

1.4. Evolution of the programme

When the Active Assisted Living (AAL) Programme opened its first call in 2008 it resembled a classic research scheme: a small central management unit coordinated nationally funded projects, annual calls were framed around narrow technology topics, and success was measured largely in prototypes delivered. This "technology-push" model mobilised excellent research teams, yet it quickly exposed three structural weaknesses—slow contracting arising from divergent national rules, solutions that addressed only fragments of older people's daily-living journeys, and limited prospects for commercial uptake once grants ended.

A mid-term evaluation in 2013 triggered a profound redesign. Phase 2 (2014-2021) replaced single-topic calls with broader, challenge-led calls such as "Living well with dementia" or "Sustainable smart solutions for ageing in place", forcing applicants to assemble multidisciplinary consortia able to tackle clinical, social and economic dimensions in one package. Evaluation grids were rewritten to give substantial weight to business plans, regulatory roadmaps and documented end-user co-creation. At the same time, the Central Management Unit acquired stronger steering powers: a harmonised Manual of Procedures, a Salesforce-based project desk and binding service-level agreements with national agencies cut median time-to-contract from more than twelve months in the first calls to under six months for later ones, and budget underutilization in slower jurisdictions fell sharply.

Instrument diversification underpinned this strategic shift. Standard 30-month collaborative projects were complemented by six- to twelve-month *Small Collaborative Projects* that offered an inexpensive "fail-fast" path for early ideas and a re-configuration window allowed consortia to replace partners or add organisations from low-participation countries without restarting the entire process. Parallel support actions—including the AAL2Business Lean-Start-up Academy, Investor Launchpads and a Market Observatory—provided systematic coaching on intellectual-property management, reimbursement strategies and investor pitching. These horizontal services were increasingly embedded in project lifecycles: business coaching was strongly advised during mid-term reviews, and regulatory guidance was available to help projects anticipate certification needs where relevant.

From 2016 onwards, the programme institutionalised evidence-based learning through a Monitoring–Evaluation–Impact (MEI) framework. A core set of key-performance indicators—such as "time-to-first market" and "private euros leveraged per public euro"—was progressively developed to track project outcomes and inform future call texts. When impact data revealed recurring challenges with medical-device regulation, a dedicated certification clinic was added to AAL2Business; when living-lab pilots emerged as decisive for adoption, user-involvement plans became a formal eligibility criterion.

The programme also demonstrated organisational resilience. Because evaluation and contract workflows were already fully digital, the 2020 call was launched and reviewed on schedule despite the COVID-19 lockdowns, and a rapid shift to hybrid forums quadrupled stakeholder reach at half the cost of previous physical events. Finally, a structured sunset plan ensured that institutional memory did not evaporate: project databases, ethics templates and support-action toolkits were migrated to successor partnerships under Horizon Europe, and regional clusters that matured inside AAL—Central Denmark, Coimbra—continue to act as testbeds for new EU care-technology pilots.

> *In short, the AAL Programme's evolution tracks a deliberate journey from exploratory, nationally fragmented R&D towards an integrated, outcome-oriented, Europe-wide innovation platform. By hard-wiring commercial, regulatory and user-centric requirements into its governance and by coupling grants with agile support instruments, the programme transformed a "market of pilots" into a pipeline that delivered deployable, data-driven services for an ageing continent.*

1.5. Success factors and persistent challenges

A review of more than three hundred AAL-funded projects shows that those which progressed beyond the grant phase shared a common operating formula. The most resilient consortia were mid-sized teams of roughly seven or eight partners: small enough to remain agile, yet sufficiently diverse to cover the full innovation chain. At minimum they paired one SME that owned the commercial roadmap, one research or clinical institute that safeguarded technical and scientific rigour, and one care provider, housing operator or municipal body that could validate the service in real-world settings. When this triad was present, projects were more likely to attract follow-on investment, navigate certification and secure first customers.

Technical architecture proved equally decisive. Solutions built on open interoperability profiles, modular hardware and cloud-edge intelligence layers slotted into heterogeneous regional ICT stacks without expensive rip-and-replace upgrades. As a result, early-adopter regions could start with a single use-case—say, fall detection—and later add medication reminders or cognitive coaching by bolting on new modules. Conversely, prototypes that hinged on proprietary gateways, single-supplier sensors or late-stage GDPR retrofits frequently stalled: user recruitment slowed, ethics boards raised flags, and supply-chain shocks forced costly redesigns. Projects that complemented this technical openness with continuous co-design—iterative living-lab cycles involving older adults, informal carers and payers—generated higher retention rates and smoother procurement because usability flaws, privacy concerns and reimbursement conditions were uncovered early rather than after launch.

Programme-level support amplified these ingredients. Participation in the AAL2Business Lean-Start-Up Academy, investor pitch events and regulatory coaching more than doubled the likelihood of raising post-grant finance, while the annual AAL Forum and regional ecosystem workshops connected innovators to buyers beyond their home countries.

Together, balanced consortia, open architectures, sustained user involvement and structured commercial-readiness support formed a mutually reinforcing success engine.

Yet several systemic obstacles continued to blunt impact. Time-to-contract remained uneven, stretching from under six months in the fastest jurisdictions to more than a year where national procedures were complex. Chronic underspending in some countries also contributed to geographic imbalances in project participation and resource allocation. Roughly one project in six still exited without a clear liability, maintenance or certification pathway, leaving “orphan technologies” despite strong pilot data. Recruitment bias persisted: the frailest, lowest-income and rural seniors were hardest to enrol, and patchy broadband coverage curtailed several remote-care pilots. Finally, rising regulatory and supply-chain pressures—MDR reclassification costs, component shortages—placed a disproportionate burden on SMEs, particularly those operating in small, fragmented national markets.

These lessons underline that technical excellence and user-centred design, while necessary, are not sufficient. Efficient cross-border administration, early regulatory alignment, inclusive recruitment strategies and sustainable service-delivery models remain critical levers if future programmes are to scale age-tech solutions beyond the pilot stage and deliver lasting societal value.

1.6. Strategic lessons, and recommendations for the future

The accumulated learning offers a **powerful template for future initiatives**. First, sixteen years of experimentation leave little doubt that programme design determines programme impact. Calls framed around real-life challenges rather than around specific technologies consistently attracted more diverse consortia and generated integrated solutions that combine social, clinical and economic value. Future partnerships should therefore start from a concrete care or wellbeing gap—such as "maintaining independence for frail, low-income seniors"—and invite applicants to assemble whatever mix of hardware, software and service innovation is required to close it.

Behavioural incentives embedded in the evaluation grid proved equally powerful. When user-centred design, ethical compliance and business readiness were scored explicitly, projects responded by institutionalising living-lab co-creation, drafting GDPR-proof data flows and mapping reimbursement pathways from the first month. Successor programmes should keep these criteria visible and mandatory; doing so shifts practice without imposing prescriptive regulations.

AAL's instrument mix also offers a replicable playbook. Tiered funding pathways—from rapid six-month feasibility vouchers to full-scale innovation actions—created a conveyor belt that balanced experimentation with rigour, allowing weak ideas to fail fast while giving validated concepts room to mature. Complementing this, a ring-fenced "common pot" for horizontal services (regulatory coaching, market intelligence, ecosystem orchestration) delivered outsized returns in project survival and policy alignment for a modest share of the overall budget.

Administrative architecture, however, needs tightening. Divergent national rules stretched time-to-contract and fuelled geographic imbalances. Future multi-country schemes should adopt service-level agreements for funding agencies—for example, a maximum of six months from proposal ranking to grant signature—and explore mechanisms to support more consistent implementation across countries, such as coordination protocols, shared digital tools, or joint training for funding authority staff. This approach preserves subsidiarity while helping prevent administrative drag from eroding SME confidence.

For decision-makers contemplating successor partnerships under Horizon Europe, the AAL legacy demonstrates that a thematic focus on older people can generate deep domain insight, critical mass and user trust, but it also cautions that such focus risks siloed design, unequal reach and high post-grant certification costs if not balanced by cross-sector standards and blended-finance instruments. Equally, a multi-national delivery model unquestionably expands knowledge flows and standard-setting power, yet it must be buttressed by harmonised contracting deadlines, shared compliance templates, and dedicated programme management capacity to prevent administrative fatigue.

In addition to structural enablers, a crucial insight emerging from the AAL experience is that the way solutions are framed—not just their functionality—has a measurable impact on user acceptance. Projects that presented technologies as tools for wellness and independence consistently secured higher engagement than those emphasising risk or decline. Even when technical and linguistic barriers were low, perceived stigma or threats to autonomy suppressed participation. Future programmes must therefore go beyond usability and accessibility to consider the psychological framing of assistive solutions, ensuring that innovation empowers rather than alienates.

Future programmes that absorb these lessons - embedding continuous co-creation, interoperability, procurement approaches that reward real-world outcomes, regional ecosystem orchestration, regional ecosystem orchestration, and empowering framings that support autonomy— will be well placed to move from hundreds of pilots to continent-wide impact, ensuring that demographic change becomes a catalyst for sustainable growth and societal well-being rather than a strain on European care systems.

PART 1 Introduction

The AAL Legacy Study aims to synthesize over a decade of research, innovation, and policy efforts targeting the wellbeing of Europe's ageing population through technological solutions. As the AAL Programme phases out, it is essential to understand not only what has been achieved, but also *how* it was achieved, *what failed*, and *what can be improved*. The findings will serve as an essential learning tool for future initiatives aiming to support healthy ageing, guide public policy, and shape new funding mechanisms in an increasingly critical field of demographic and health-related transformation. Rather than an exercise in accountability, the Legacy Study is a rare opportunity to capture institutional learning and the systemic evolution of a complex research and innovation ecosystem.

1.1. Background and context

The Ambient Assisted Living Joint Programme—rebranded in 2014 as the Active Assisted Living (AAL) Programme, implemented by the AAL Association since 2008, has been a unique European RDI (Research, Development, and Innovation) initiative. Co-financed by national governments and the European Commission under Article 185 TFEU, AAL aimed to enhance the quality of life of older adults while ensuring the long-term sustainability of health and care systems and boosting industrial innovation. It ran through two major phases: AAL1 (2008–2013), focused on topic-based calls, and AAL2 (2014–2021), which shifted to challenge-driven funding.

Across these two periods, over 300 projects were funded, engaging a wide network of stakeholders, from end-users and caregivers to SMEs and public institutions.

With the programme now in its phase-out phase (until 2027), the Legacy Study is launched to reflect on the accumulated experience, changes in approach, and actual impacts—offering a comprehensive view of its journey and its long-term value.

1.2. Objectives of the study

The core objective of the AAL Legacy Study is to document and consolidate the achievements, learning, and transformations brought about by the AAL Programme over time. It seeks to analyse how projects, technologies, partnerships, and support mechanisms evolved and interacted to deliver (or fail to deliver) value for the ageing population and the broader ecosystem. Key questions revolve around the evolution of calls, technology use, end-user engagement, project outcomes, and success factors. Importantly, the study will identify lessons learned—both from successes and failures—highlighting best practices, innovation scaling, business model development, and ecosystem support. The study also aims to extract actionable insights for future funding programmes and partnerships addressing similar societal challenges.

1.3. Study design and rationale

The design of the AAL Legacy Study was grounded in a data-intensive, AI-supported approach, essential for navigating the vast and complex corpus of AAL documentation—comprising over 30,000 files and webpages. Traditional manual review methods would have been insufficient to extract meaningful insights at this scale, while AI methods—particularly large language models—enabled us to systematically process, classify, and synthesise both structured and unstructured content. This approach made it possible to track the evolution of technologies, user involvement, and project outcomes across more than a decade of programme activity, with consistency and depth.

To ensure analytical rigour, we combined AI-generated indicators and summaries with expert review in an iterative cycle, allowing for continuous refinement and validation of findings. Insights were generated both from the bottom up—starting from individual project files—and from the top down, drawing on programme-level documents to address strategic questions. All findings were anchored in verifiable source material and stored in a structured format to support traceability and further synthesis.

Crucially, the study was designed not only to generate knowledge but also to make it accessible. A core part of the work focused on communication and dissemination. In addition to the written report, the study will contribute to the development of an engaging online webpage, ensuring the insights from the AAL Programme can inform future initiatives across policy, research, and industry.

Further details on the methodological framework, data management procedures, and reflections on the developed analytical solution are provided in the Annexes.

PART 2 Evaluation

1 / Overview of the evaluation questions

1.1. Evaluation dimension 1: Evolution of launched calls and AAL funded projects

- **Evaluation Question 1:** What are the challenges addressed by the solutions developed in funded projects?
- **Evaluation Question 2:** What technologies are used within the projects? How has their usage evolved over time?
- **Evaluation Question 3**: Which technologies were used for which solutions, under what conditions and timing?
- **Evaluation Question 4**: How did end-user involvement evolve over time in terms of number and type?
- **Evaluation Question 5:** What factors influenced changes in end-user involvement?
- **Evaluation Question 6:** What are the key learnings on pitfalls and good practices in end-user engagement?
- **Evaluation Question 7:** How did the addressing of the larger ecosystems evolve?
- **Evaluation Question 8:** How did the AAL network evolve over time?
- **Evaluation Question 9**: What was the impact of the AAL programme's shift from a topic-based to a challenge-based approach on proposals, solutions, technologies, stakeholders, and ecosystems?
- **Evaluation Question 10:** What factors indicate a project's likelihood of post-project success?
- **Evaluation Question 11:** What learnings emerge from projects or programme aspects that did not go as planned?
- **Evaluation Question 12:** What are the key learnings about medium-term opportunities, trends, challenges, and risks in the AAL sector?

1.2. Evaluation dimension 2: Lessons for future funding programmes and partnerships

- Evaluation Question 13: What key learnings from the AAL Legacy can improve future programmes' success, management, and support actions?
- Evaluation Question 14: What challenges led to the shift from Phase 1 to Phase 2 of the programme, and what were the resulting learnings and impacts?
- Evaluation Question 15: Has the AAL Programme developed self-assessment or learning models useful for future programmes?
- Evaluation Question 16: What practical learnings (e.g. do's and don'ts) can guide newcomers to the health and care sectors?
- Evaluation Question 17: What are the benefits and risks of a funding programme focused on older people and run by international partners?

1.3. The evaluation questions in the AAL Intervention Logic

- **Evaluation dimension 1, on the evolution of AAL launched calls and funded projects,** concerns evaluation questions related to:
  - AAL-projects’ execution and their outputs, short-term and medium-term outcomes[1] and impacts.
  - In the dimensions of knowledge base & networking, solutions & markets[2] and AAL-programme modalities and framework conditions.

  For example, evaluation question 10/ refers to the outputs, short- and medium-term outcomes and impacts of AAL projects in the dimension of markets and solutions, whereas evaluation questions 4/, 5/ and 6/ refer to the programme modalities in terms of user involvement during the project execution.

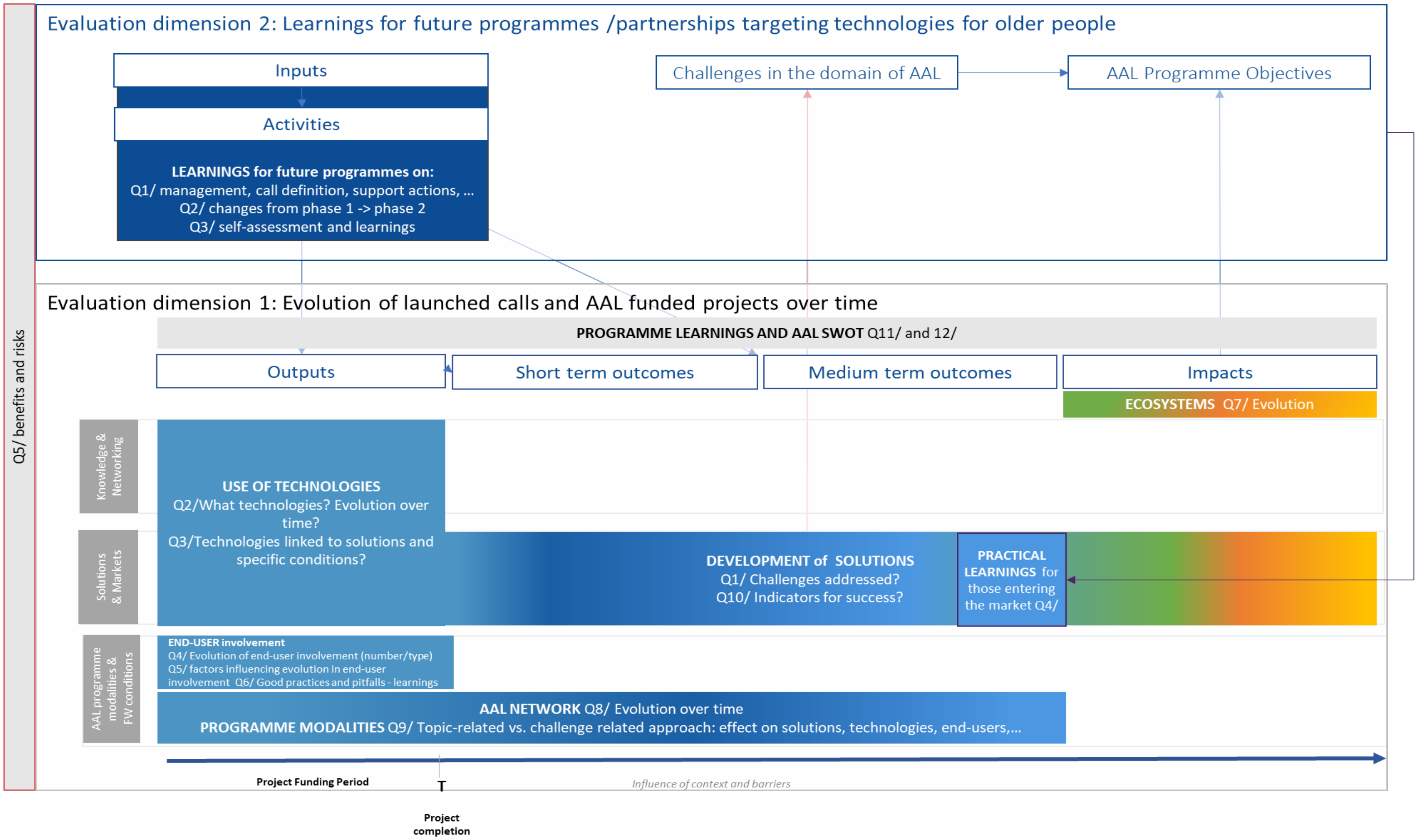
  Overarching, the answers to individual evaluation questions (linked to specific aspects of the intervention logic) will feed the project and programme learnings and SWOT-analysis for the AAL sector in medium run (evaluation questions 11/ and 12/).

- **Evaluation dimension 2, on the learnings for future programmes and partnerships targeting technologies for older people**, relates mainly[3] to:
  - the programmes inputs: AAL management and governance including call definition, (evolution in) development of templates and structures for review, development of self-assessment and learning models….
  - the programme activities: evolution of support actions, developing smart collaborative projects (shift from AAL1 - AAL2), …

  The answers to evaluation question 5/ on the benefits and risks of an AAL funding programme delivered by partners from different nations will be fed by the answers to the other evaluation questions (both in dimension 1 and dimension 2.)

[1] Outputs are defined as the project-level results that are expected to be generated during the project, short-term outcomes are results stemming directly from project completion, mid-term outcomes are results generated more indirectly from AAL project completion.
[2] i.e. commercialisation and adoption of AAL solutions.
[3] There is one evaluation question (evaluation question 4/) in this dimension that is formulated on another level, i.e. on the level of those entering the AAL market/sector – this is visualized in the figure under “solutions and markets”.

Figure 1: Evaluation Questions in the AAL Intervention Logic



2 / Evolution of launched calls and AAL funded projects

2.1. **Q1:** What are the challenges addressed by the solutions developed in funded projects?

2.1.1 Key categories

Over the course of 14 annual calls, the AAL Programme has supported 300+ projects addressing a wide array of challenges faced by older adults and their caregivers. An AI-driven classification of these projects reveals that AAL projects have consistently targeted nine inter-related societal and clinical challenges: reducing caregiver burden, managing chronic diseases, mitigating cognitive decline and supporting mental health, sustaining daily living and personal independence, adapting the built environment, preserving physical function and mobility, improving safety and emergency response, compensating for sensory impairments, and combating social isolation.

Table 1: Key Challenge categories

Challenge	**Meaning / Scope in AAL Context**
Caregiver Burden Reduction	Supporting caregivers by reducing the physical, emotional, and logistical strain of daily care. This includes tools for remote monitoring, assistance with routine tasks, and systems that promote shared responsibility while preserving the autonomy of the person receiving care.
Chronic Disease Management	Helping older adults manage long-term health conditions like diabetes, COPD, or heart disease through personalized monitoring, early warning systems, and digital health coaching that can prevent complications and reduce hospital visits.
Cognitive Decline Reduction & Mental Health	Addressing memory loss, dementia, depression, and emotional wellbeing through cognitive stimulation, therapeutic interfaces, and assistive systems that reduce disorientation and enhance quality of life.
Daily Living & Independence	Enabling older adults to carry out everyday tasks safely and with confidence—such as eating, dressing, and navigating their homes—by providing intuitive technologies that adapt to evolving physical and cognitive abilities.
Environmental Adaptation	Creating safer, more responsive living spaces through technologies like smart lighting, environmental sensors, and accessible layouts that adjust to the user's needs and support aging in place.
Physical Function & Mobility Support	Preserving physical function and mobility with tools that assist movement, support rehabilitation, and prevent falls. This includes wearable devices, robotic supports, and interactive training systems.
Safety & Emergency Response	Detecting and responding to risks such as falls, health crises, or home hazards in real time. Systems in this category provide discreet oversight, alerts, and escalation pathways for timely intervention.
Sensory Impairments	Supporting those with declining hearing, vision, or multi-sensory function through adaptive interfaces, enhanced feedback mechanisms, and assistive technologies that help maintain awareness and interaction.

Social Isolation & Loneliness	Promoting meaningful social connection and emotional wellbeing by fostering communication, community engagement, and shared activities—especially for individuals at risk of being cut off from family or society.

Across the full portfolio of three hundred and five projects, the most commonly addressed challenge was *Social Isolation and Loneliness*, appearing in 131 projects (43%). This consistent focus reflects a widespread recognition of the psychological and emotional dimensions of ageing and the importance of social connectedness for wellbeing.

The second most frequent challenge was *Daily Living and Independence*, targeted by 115 projects (38%), underscoring the Programme's core mission to help older adults maintain autonomy in their everyday lives. *Cognitive Decline Reduction* followed closely, with 86 projects (28%), indicating sustained attention to conditions like dementia, depression, and mental wellbeing.

Physical Function and Mobility Support was addressed in 78 projects (26%), often in conjunction with solutions for independence or safety. Similarly, *Safety and Emergency Response* appeared in 67 projects (22%), demonstrating the importance of real-time monitoring and rapid response systems in supporting ageing in place.

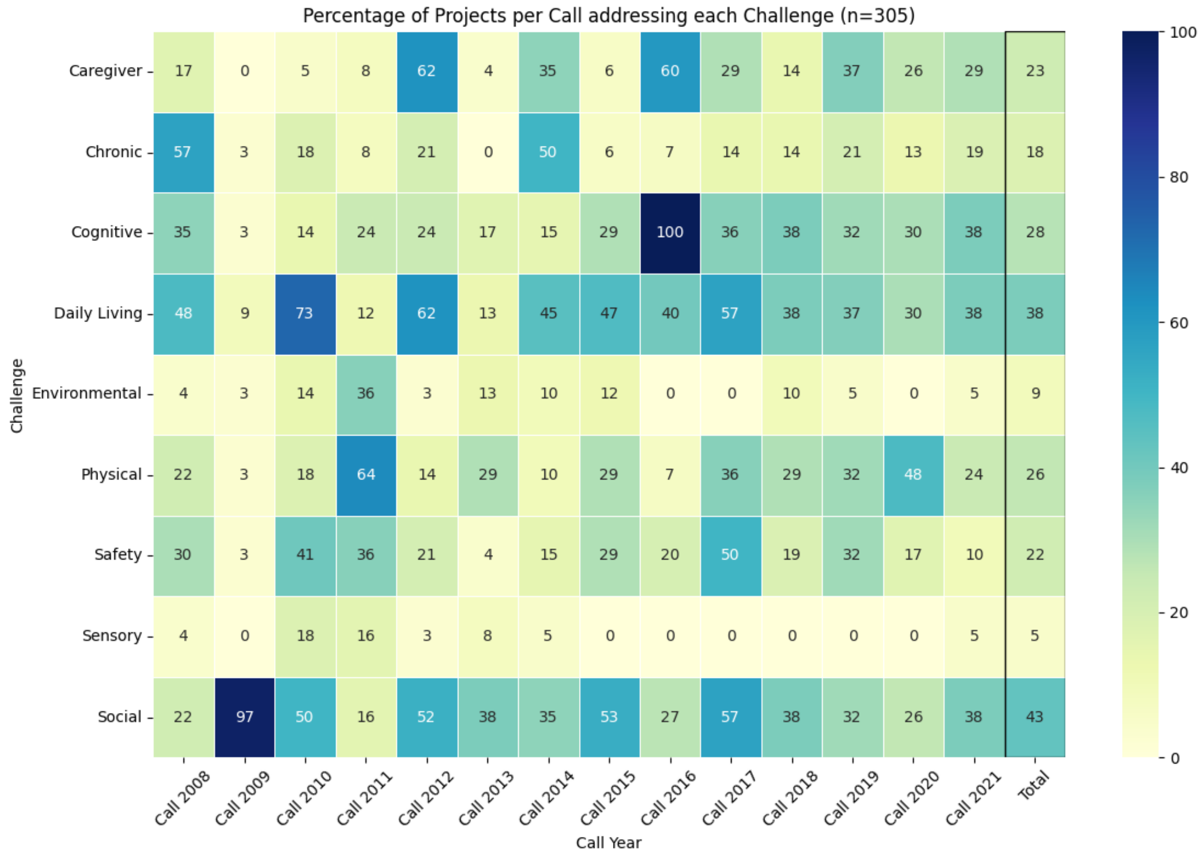
Caregiver Burden Reduction featured in 69 projects (23%), highlighting the Programme's consideration for informal and formal carers alongside older adults. Meanwhile, *Chronic Disease Management* was represented in 54 projects (18%), reflecting a shift from initial health-focused interventions to broader wellbeing objectives over time.

Environmental Adaptation (9%) and *Sensory Impairments* (5%) were among the least frequently addressed challenges, making up a smaller portion of the overall project portfolio.

2.1.2 Evolution of Challenges over the AAL Calls (2008–2021)

From the outset, the first call in 2008, themed *"ICT based solutions for Prevention and Management of Chronic Conditions of Elderly People"*, established a clear emphasis on clinical health, particularly on the management of chronic illnesses. It is unsurprising that Chronic Disease Management was the most prominent challenge addressed in this call with 13 projects (57%), followed by significant attention to Daily Living and Independence, Cognitive Decline Reduction & Mental Health, and Safety and Emergency Response. The focus aligned with EU priorities at the time around chronic disease prevention, early intervention, and reducing long-term healthcare costs.

Figure 2: Heatmap of challenges per call year (a)(b)



(a) Since projects often address multiple needs simultaneously, a single project may contribute to more than one challenge category.
(b) For a full overview of the challenges, we refer to Table 1.

The 2009 topic, "ICT-based solutions for Advancement of Social Interaction of Elderly People", produced a dramatic shift: 31 projects (97%) tackled social isolation, while every other challenge category fell below ten per cent. This stark concentration mirrors the programme's deliberate response to emerging evidence that loneliness is a major determinant of health and that early digital communication technologies could provide scalable relief.

In 2010, "ICT-based solutions for Advancement of Older Persons' Independence and Participation in the Self-Serve Society" restored a broader balance. 16 projects (~75%) focused on daily living and independence, often by embedding transactional and civic functions such as digital banking or travel planning, and forty-one per cent continued to invest in safety features. The pattern fits the call's ambition to equip older citizens for a rapidly digitizing public sphere.

The 2011 call, *"ICT-based Solutions for Advancement of Older Persons' Mobility"*, narrowed its focus again, this time to mobility and physical functioning, with almost 18 projects (66 %) in that category and over one third integrating environmental adaptations for way-finding and safe navigation. The prominence of these themes reflects the call text's emphasis on assistive orientation, navigation aids, and exoskeletal technologies that extend the radius of independent movement.

Call five in 2012, centred on *"ICT-based Solutions for (Self-) Management of Daily Life Activities of Older Adults at Home"*, generated the programme's first major surge in caregiver-oriented innovation: 18 projects (62%) aimed to lighten informal carers' load, matching an equally high share focused on helping older adults manage daily tasks themselves. This twin emphasis mirrors the call's explicit expectation that solutions benefit both primary users and the people who support them.

The 2013 call, titled *"ICT-based Solutions for Supporting Occupation in Life of Older Adults"*, introduced a novel angle by framing occupation—paid or voluntary—as central to healthy ageing. While projects were more moderately distributed across challenges, a notable portion addressed Social Isolation and Loneliness (9 projects, 38%) and Physical Function and Mobility Support (7 projects, 29%). Prevalence of cognitive and mental health support rebounded alongside physical mobility technologies, while projects that addressed work-related motivation and skills transfer contributed to a modest rise in social participation tools. The diversification illustrates how employment and volunteering contexts demand multifaceted assistance.

The 2014 call, *"An Ageing Society Faces an Increasing Need for Care, How Will ICT Contribute to Sustainable Solutions?"*, was the first to explicitly frame its topic as a systemic challenge. Accordingly, the projects funded in that year addressed a broader range of challenges, including Chronic Disease Management (10 projects, 50%), Daily Living and Independence (9 projects, 45%), and Caregiver Burden Reduction (7 projects, 35%). The broad mix echoes the call's systemic outlook on care sustainability and foreshadows later package-based approaches.

Call 2015, under the theme *"Support More Older Adults to Live Longer in Their Homes with the Contribution of ICT Based Solution"*, maintained a similar distribution but saw gains in cognitive support and in assistive home technologies, anticipating market-ready smart-home offerings. At the same time, projects supporting social connectedness remained above fifty per cent (9 projects), reinforcing the enduring link between ageing-in-place and meaningful social roles.

The 2016 call, *"Living Well with Dementia"*, introduced a specific clinical focus that had a profound impact on challenge distribution. All 15 projects that year addressed Cognitive Decline Reduction & Mental Health, with 9 of them (60%) also addressing Caregiver Burden Reduction. This single-topic call generated the most concentrated response of any year, with a strong ethical orientation and focus on holistic dementia care, reflecting parallel developments in EU dementia strategy and caregiver policy.

In 2017, the call focused on *"Packages Integrating Different Solutions Based on ICT to Support Active, Healthy and Independent Living of Older Adults"*. This was a strategic step toward service integration. Challenge coverage reflected this ambition: projects often addressed multiple categories, particularly Daily Living and Independence (8 projects, 57%), Social Isolation and Loneliness (also 57%), and Safety and Emergency Response (7 projects 50%). The shift away from fragmented solutions toward modular, interoperable services highlighted growing attention to ecosystem-level innovations and standardization.

The 2018 and 2019 calls, respectively *"SMART Solutions for Ageing Well"* and *"Sustainable Smart Solutions for Ageing Well"*, adopted a more open-ended format, giving applicants broader thematic freedom. This openness resulted in balanced coverage across challenge categories, though no single area overwhelmingly dominated. The call in 2018 continued this integrative pattern but within looser parameters, enabling experimentation via the new Small Collaborative Project instrument. Challenge prevalence flattened: cognitive support, daily living, physical function, and social participation each appeared in roughly equal proportions, suggesting that consortia used the flexible format to target niche combinations rather than one dominant need. “Sustainable Smart Solutions for Ageing Well” in 2019 sustained balanced diversification while modestly increasing chronic disease and physical function shares, a reflection of the call’s alignment with the WHO Decade of Healthy Ageing and its encouragement of evidence-based preventative tools such as AI-driven cardiology or frailty prediction.

Call 2020, titled *“Healthy Ageing with the Support of Digital Solutions”*, was issued under the shadow of the COVID-19 pandemic. Although no single challenge was emphasized in the theme, the year saw a surge in Physical Function and Mobility Support - 11 projects (48%), reflecting increased interest in rehabilitation, remote monitoring, and maintaining function during periods of isolation. Other challenge areas remained relatively balanced, though Sensory Impairments and Environmental Adaptation were absent. COVID-related constraints also brought innovation in project formats and remote deployment models.

Finally, the 2021 call, *“Advancing Inclusive Health & Care Solutions for Ageing Well in the New Decade”*, introduced a comprehensive framework for inclusive, ecosystem-based, and digitally accessible care. Projects that year reflected balanced attention to several persistent challenges: Daily Living and Independence, Cognitive Decline Reduction and Mental Health, and Social Isolation and Loneliness. Each appeared in 8 projects (38%).

> *The diversity and relative evenness of challenge coverage suggest the culmination of a decade-long evolution toward integrated, person-centred, and adaptive care models.*

2.2. **Q2:** What technologies are used within the projects? How has their usage evolved over time?

In developing solutions to meet the needs of older adults and their caregivers, AAL projects have drawn upon a broad range of enabling technologies. An AI-supported review of these projects reveals a consistent use of nine core technology categories that underpin most solutions. These technologies serve as building blocks for diverse applications—powering everything from health monitoring to social interaction—and reflect the evolution of the AAL innovation ecosystem over time.

2.2.1 Key categories

Each category below captures a set of fundamental technological components used in AAL solutions, from sensors and connectivity infrastructure to intelligent algorithms and immersive user interfaces.

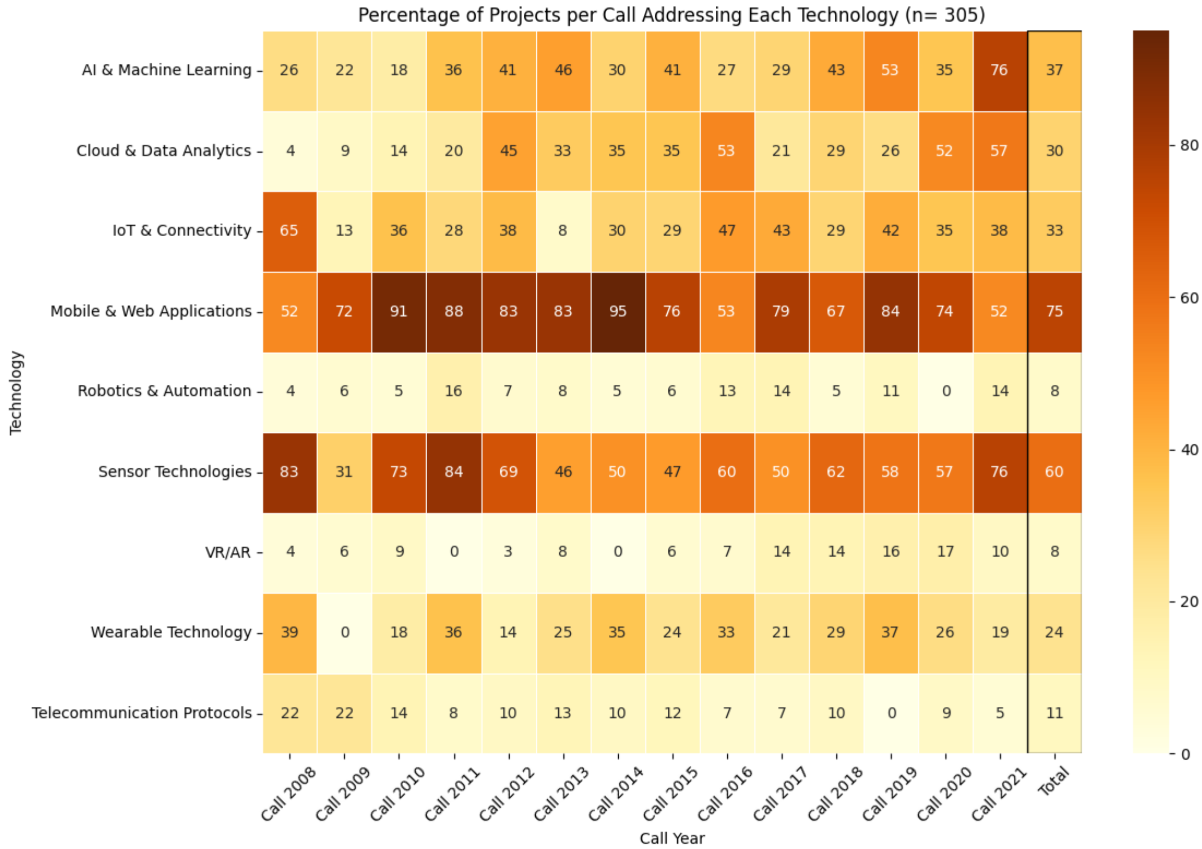
Table 2: Key Technology categories

Category	**Meaning / Scope in AAL Context**
Sensor Technologies	Devices that capture physical or biological signals—motion, temperature, pressure, or activity (e.g., accelerometers, biosensors, 3D depth cameras). These form the foundation of real-time monitoring and environmental context.
AI & Machine Learning	Algorithms that learn from data to enable prediction, classification, personalization, or automation. Includes NLP (natural language processing), computer vision, and behavioural pattern recognition.
IoT & Connectivity	Networking technologies that allow distributed devices to communicate, often wirelessly. Includes Zigbee, LoRaWAN, Bluetooth mesh, and device-to-cloud protocols.
Mobile & Web Applications	Front-end systems (apps, dashboards) that interact with users or caregivers. These platforms integrate services like reminders, monitoring, or scheduling in accessible formats.
Wearable Technology	Devices worn on the body to track activity, health status, or environmental interaction. Examples include ECG patches, smartwatches, or inertial sensors.
Robotics & Automation	Physical devices or systems that perform tasks autonomously or semi-autonomously. Includes care robots, robotic limbs, haptic interfaces, and ROS-based systems.
VR/AR (Virtual & Augmented Reality)	Immersive interfaces for training, therapy, or interaction. Mixed reality platforms often support cognitive rehabilitation or social engagement through gamified experiences.
Telecommunication Protocols	Standards and channels for secure and structured data transmission. HL7, WebRTC, HTTPS/HL7 are used in healthcare to ensure interoperability, privacy, and real-time communication.
Cloud & Data Analytics	Backend services for storage, computation, and integration. Encompasses AWS/Azure microservices, FHIR-compliant health data systems, and machine learning pipelines.

2.2.2 Evolution of Technologies over the AAL Calls (2008–2021)

Sensor technologies provided the indispensable substrate for virtually every call. In 2008 more than four-fifths of projects already relied on ambient motion detectors, wearable ECG patches or capacitive arrays to capture vital signs and daily-living events, and the share never fell below half thereafter.

Figure 3: Heatmap of technologies per call year (a)(b)



(a) Projects typically involve many sets of technologies.
(b) For a full overview of the technologies, we refer to Table 2.

Artificial-intelligence and machine-learning components were initially exploratory, appearing in only one quarter of 2008 projects (6 projects), typically as pattern-recognition engines grafted onto single devices. From 2012 onward, the proportion rose steadily, reaching three quarters of all initiatives in the 2021 call (16 projects). This shift coincided with the spread of cloud infrastructure, which rose from only one project in 2008 to 12 in 2021 (57%).

IoT and connectivity technologies experienced an initial surge—two thirds of the 2008 cohort (15 projects) experimented with ZigBee, RFID or DVB-based set-top boxes—followed by a temporary consolidation as mobile broadband became ubiquitous and proprietary gateways were phased out. Their share stabilized around one third of projects, but the underlying protocols kept pace with the state of the art: Bluetooth Low Energy enabled energy-constrained wearables, 6LoWPAN and CoAP supported large sensor meshes in social housing, while NB-IoT and LoRa extended monitoring coverage beyond the home for wander management and hydration tracking. The challenge moved from “can devices talk to each other?” to “can heterogeneous devices remain online for years without maintenance and exchange data securely?”. Most recent calls therefore emphasize standardization layers and open APIs, allowing municipalities or care providers to plug new devices into existing AAL ecosystems without vendor lock-in.

Mobile and web applications have been the constant front-end of AAL, accounting for at least half of every call and peaking at 95 percent in 2014. Their function evolved with user familiarity: early tablet and Smart-TV dashboards substituted PCs; subsequent progressive-web apps, voice assistants and avatar-based companions lowered the threshold for cognitively impaired or visually impaired users.

Wearable technology followed a different curve. After an enthusiastic start (9 projects -39%- in 2008) and a lull when smartphones absorbed many sensing tasks, interest rebounded in 2018–2020 when smartwatches, textile electrodes and instrumented insoles matured.

Robotics and automation remained a niche—never exceeding 16 percent of projects—yet the use cases became more sharply defined.

Virtual and augmented reality applications, marginal in the first calls, grew gradually with hardware affordability. Immersive technologies matured from experimental Kinect-based exergames to fully fledged virtual- and mixed-reality rehabilitation suites.

Telecommunication protocols lost visibility in percentage terms as interoperability standards matured and were absorbed into middleware layers. Their impact, however, endures: early insistence on HL7, Continua or RESTful design paved the way for today’s seamless data exchange between AAL platforms, electronic health records and public-sector clouds.

Finally, cloud and data-analytics capabilities have progressed from peripheral enablers in the first call to a structural backbone of AAL solutions. In 2008 barely one project stored or processed data off-device, typically through bespoke servers attached to a single home-gateway. As internet bandwidth and pricing improved, consortia began to migrate back-end functions to commercial platforms such as Azure or AWS, raising the share of cloud-enabled projects to one in three by 2012 and to well over half (57 percent) by 2021.

> *The fourteen calls trace a clear evolution from **hardware-centric monitoring** prototypes to **data-driven, person-centred service platforms**.*

2.2.3 Evolving toward integrated ecosystems

Across the programme’s timeline, the funded projects did not deploy single, isolated technologies; rather, they assembled layered stacks in which hardware, connectivity, data platforms and intelligent services reinforced one another. The empirical co-usage analysis[4] already shows increasing entanglement around Cloud & Data Analytics and AI. Examination of the concrete technical bill-of-materials reported by consortia confirms and contextualizes that trend, revealing how successive

[4] To better understand how funded projects evolved technologically over time, we carried out a comparative analysis of technology co-usage patterns between two periods: early calls (2008–2014) and late calls (post-2014).

generations of projects built progressively richer vertical stacks while retaining a core trio of sensing, communication and analytic layers.

Early-call solutions (2008-2010) typically blended local sensor networks with gateway-centred middleware and rudimentary rule engines.

By the *2009–2012 calls, cloud adoption had accelerated* and began to reshape the whole stack.

The late-call period (post-2014) shows the *maturation of fully elastic, data-driven stacks in which intelligence is distributed between edge and cloud*.

AI & Machine Learning consequently evolved from experimental add-ons to structural components. Early uses—artificial neural networks classifying stuntman-generated falls or gesture-recognition algorithms driving set-top-box remotes—operated in isolation and on limited datasets. By 2020 radar-derived respiration signals and ultra-wide-band localization streams were feeding explainable boosting models that predicted COPD exacerbations or fall risk in near-real time; rule-based engines became fallback layers for safety, not the primary focus of decision-making. Importantly, many projects coupled this intelligence with explicit governance features such as GDPR-compliant proxy re-encryption or user-controlled privacy dashboards, indicating that ethical and regulatory considerations have become integral to the technical stack rather than post-hoc add-ons.

Connectivity and sensing layers also specialized. Zigbee and Bluetooth Low Energy retained prominence for in-home body-area networks but were increasingly complemented by UWB for centimetre-level indoor positioning or by NB-IoT for nationwide coverage of wandering-prevention wearables. Sensor modalities diversified from accelerometers and heart-rate belts to pressure-sensitive insoles, radar arrays, depth cameras, and even nano-spectrometers for transcutaneous biomarker detection. Yet these additions did not fragment the ecosystem; middleware such as universAAL, openHAB and later micro-service gateways abstracted transport specifics, enabling sensors to publish uniform events that upstream analytics could consume agnostically.

User-facing layers followed a similar trajectory. Mobile and web applications shifted from being monolithic endpoints to thin interaction layers backed by cloud services, while VR/AR and robotic interfaces branched into more specialized roles—rehabilitation training, immersive reminiscence, remote presence—often powered by the same back end that served smartphone or smart-TV clients.

For instance, a rehabilitation platform developed in 2021 used wearable devices to stream physiological signals to a centralized cloud-based system. This system not only analysed the data in real time but also coordinated feedback across multiple interfaces—including immersive VR exercises for patients and mobile alerts for caregivers—demonstrating how a unified backend can power diverse, role-specific user experiences.

2.3. **Q3:** Which technologies were used for which solutions, under what conditions and timing?

2.3.1 Key Solution Archetypes

The analysis of AAL-funded projects reveals how technological innovation intersects with the complex realities of ageing, yielding nine distinct solution archetypes that address physical, cognitive, and social challenges. Through iterative AI-assisted pattern recognition across 300+ projects spanning 16 years, these archetypes emerged as consistent frameworks for delivering targeted support to older adults. Each archetype represents not just a set of technological components, but a response to systemic gaps in ageing societies—from mitigating isolation to redefining chronic disease management. The classification process prioritized functional purpose (what problems solutions address) and delivery mechanisms (how they interface with users), while tracing technological maturation across hardware, connectivity, and intelligence layers.

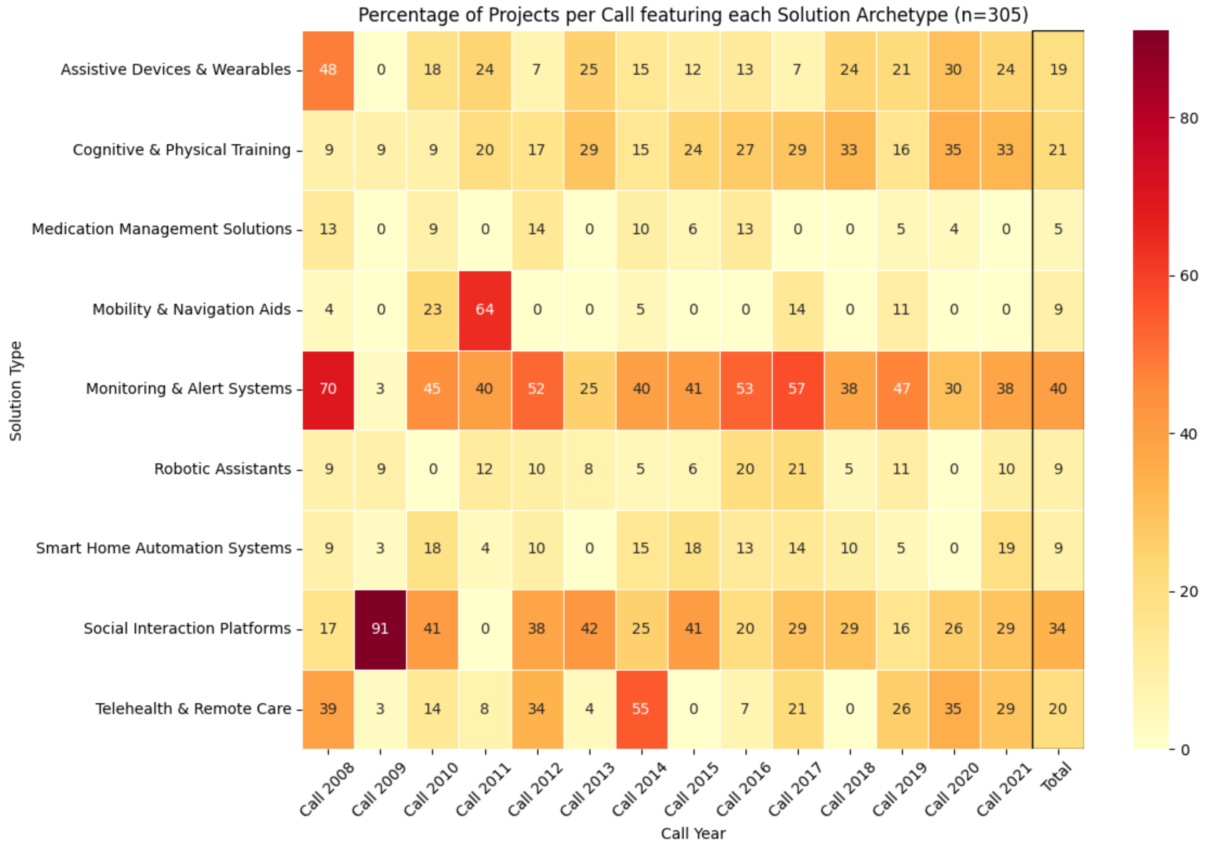
Table 3: Key AAL Solution Archetypes

Category	Meaning / Scope in AAL Context
Robotic Assistants	Physical or virtual robots that provide care, mobility support, or companionship (e.g., exoskeletons, avatars).
Telehealth & Remote Care	Platforms for remote consultations, symptom tracking, or chronic care via video, chat, or biometrics.
Assistive Devices & Wearables	Hardware designed to support specific needs (e.g., tremor-reducing gloves, smart prosthetics, fall-detecting watches).
Cognitive & Physical Training	Solutions offering therapeutic exercises, often gamified, using VR, AR, or sensor-based feedback.
Social Interaction Platforms	Tools to maintain or build social ties—TV-based chats, virtual communities, or storytelling platforms.
Smart Home Automation Systems	Adaptive technologies for safer, more responsive home environments (e.g., voice-activated appliances, lighting).
Mobility & Navigation Aids	Tools to support safe movement indoors/outdoors, including GPS, smart walkers, or real-time guidance.
Medication Management Solutions	Systems to help users remember, organize, and take medication correctly, including smart reminders and dispensers.
Monitoring & Alert Systems	Real-time monitoring (e.g., movement, heart rate) with alert mechanisms for caregivers or emergency services.

2.3.2 Evolution of Solutions over the AAL Calls (2008–2021)

The portfolio of the AAL Programme shows that European innovators have used successive calls to respond to a relatively stable set of societal challenges—frailty, chronic disease, cognitive decline, loneliness and safety—while progressively refining the technological mix through nine recurrent solution types. *Monitoring and alert systems* constitute the backbone of almost every call: they appear in 40 per cent of all funded projects (122 projects in total) and dominated the first call in 2008, when 70 per cent of proposals (16 projects) embedded passive sensors or computer-vision fall detection. Their share remained the highest in almost every subsequent call, reflecting policymakers' insistence on preventing avoidable emergencies and providing objective data for care pathways. From 2018 onwards, the category broadened from simple “safe at home” functions towards predictive analytics, a fusion of wearables and environmental data or a nocturnal radar aimed at COPD exacerbations, indicating a shift from reactive alerting to anticipatory care.

Figure 4: Heatmap of AAL Solutions by call year (a)



(a) Projects typically involve many sets of technologies.
(b) For a full overview of the technologies, we refer to Table 3.

Social interaction platforms emerged as the second most frequent response (104 projects, 34 per cent overall) but followed a different trajectory. After a wave of social-network prototypes in the 2009 call—when 29 projects framed loneliness as an urgent public-health issue—their relative share subsided as basic connectivity became mainstream. Later calls moved from generic networks to embedded social layers inside multi-purpose solutions, coupling messaging or video calls with medication reminders or wellbeing dashboards, illustrating how social connectedness is now treated as a design principle rather than a standalone product.

Cognitive and physical training tools grew steadily in both absolute and relative terms, rising from two projects in 2008 (9%) to eight in 2020 (35%) and maintaining one-third of projects in the most recent call. Early pilots used bespoke hardware and avatars to motivate exercise; ten years later projects relied on low-cost motion sensors and cloud-based exergames that can be prescribed by therapists. This expansion mirrors evidence that activity slows functional decline and the political priority to compress morbidity rather than simply extend life expectancy.

Assistive devices and wearables begin strongly (eleven instances -48%- in 2008) with hardware prototypes, e.g. a tongue-controlled computer interface for users with severe hand impairment. A lull follows while miniaturization and component costs catch up, then adoption rises again from 2018 onwards with sensor-rich but consumer-styled products such as tremor-suppressing wristband or the clinically certified bulb dynamometer. The trajectory suggests that early engineering feasibility has evolved into medically validated, market-ready devices, aligning with policy objectives on self-management of chronic conditions.

Telehealth and remote-care platforms followed a pendular pattern. They were prominent in 2008 when some projects demonstrated remote vital-sign transmission; interest waned in 2009–2011 as connectivity costs and standards posed barriers, then surged again with two peaks in 2012 and 2014, corresponding to widespread broadband adoption, as exemplified by heart-failure telemonitoring. A second rise in 2020–2021, featuring contactless COPD monitor and mixed-reality remote-assist service, is clearly associated with the wider health-system shift toward virtual care accelerated by the COVID-19 pandemic. The resilience of this category aligns with wider digital-health adoption and with the Programme's objective of supporting integrated, home-centred care models.

Smart-home automation systems accounted for roughly one in ten projects across the calls (28 in total). Early concepts framed the smart home as an enabling infrastructure, but it was not until IoT platforms that adaptive energy management or rule-based lighting reached technical maturity. By 2020, solutions used only a single smart-meter sensor combined with load-disaggregation algorithms, illustrating how the cost of deploying a safety net has dropped while respecting privacy.

Robotic assistants were always a visible, if small, strand with a total of 26 projects (9 per cent overall). First-generation companions emphasized mobility support and social presence; the middle calls switched to telepresence and therapy robots. The plateau of three funded robots per call from 2016 to 2018 suggests that technical and economic constraints still limit large-scale uptake, yet the category continues to serve as an experimental arena for high-acceptance interfaces.

Mobility and navigation aids exhibited strong thematic clustering: two-thirds of all such projects (16 in total) were funded in the 2011 call when the topic of outdoor independence was prioritised. Later calls returned to the theme in more specialized contexts— for dementia wandering and for driver assistance—indicating that the core algorithms matured during the dedicated call and are now reused where clinically relevant.

Medication management solutions remained comparatively scarce (only sixteen projects overall - 5 %) but strategically significant. From integrated dispensers in CCE (2008) to the big-data-oriented and the low-cost displays (2019), the evolution demonstrates a gradual convergence toward lightweight, interoperable reminders that fit into wider care ecosystems rather than requiring dedicated infrastructure.

Foundational layers—monitoring, social connectivity, and wearable sensing—appear in almost every call, ensuring that basic safety and engagement needs are met. Topic-specific surges, such as mobility in 2011, allow the programme to probe new gaps as they emerge. The steady rise of data-driven coaching solutions in recent calls points to a future in which personalised prevention, rather than crisis response, becomes the dominant paradigm.

2.3.3 Technology deployment across AAL Solution Archetypes

2.3.3.1 Overview

The cross-tabulation of 305 AAL projects shows that each solution archetype gravitates toward a distinctive but overlapping technology mix, revealing how functional aims shape technical choices.

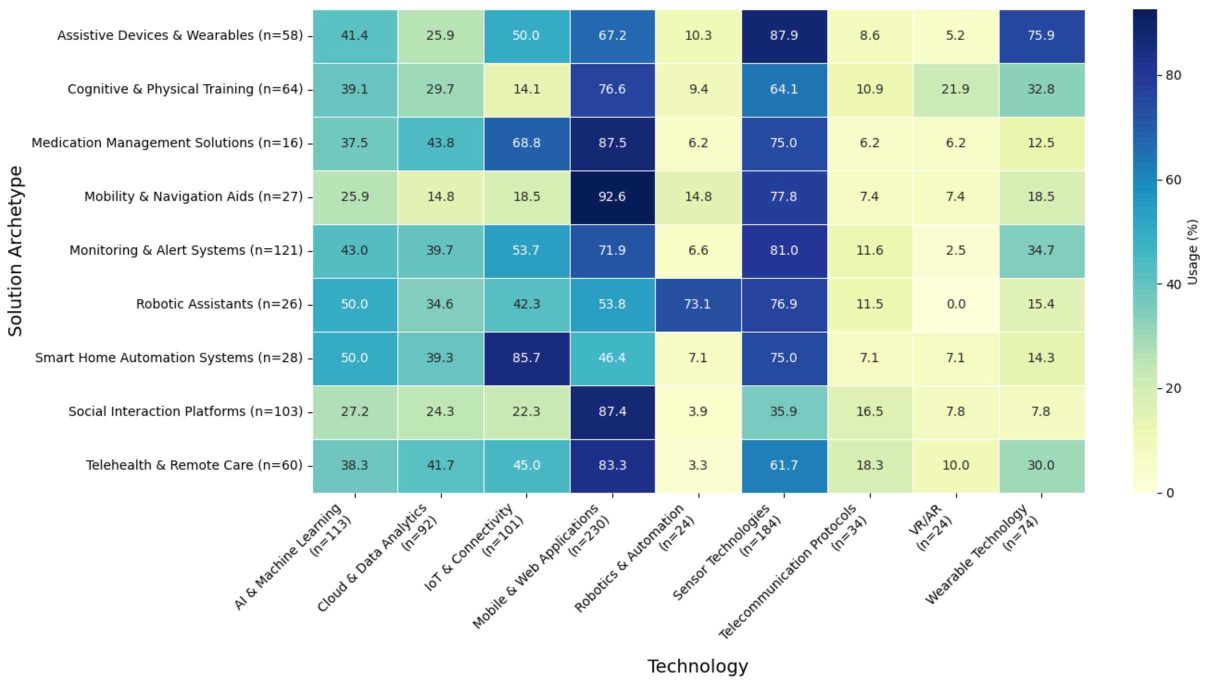
Assistive devices and wearables (58 projects) rely above all on sensor technologies, which feature in almost nine out of ten projects. Half are already Internet-of-Things enabled, allowing data to leave the device and flow into broader care pathways, and two-thirds offer companion mobile or web applications for configuration or coaching. Artificial-intelligence modules are present in more than forty per cent, typically for real-time pattern recognition (tremor suppression or gait analysis) rather than for cloud-heavy analytics.

Cognitive and physical training (64 projects) solutions are the most software-centric of the portfolio. More than three-quarters deliver their interventions through mobile, or web apps and one-fifth employ virtual or augmented reality to provide immersive feedback. Although only one project in seven embeds IoT, almost two-thirds still incorporate on-body or environmental sensors to personalize exercise intensity, and four in ten apply AI for adaptive difficulty curves or personalised coaching.

Medication-management systems (16 projects) show the deepest penetration of cloud services: almost forty-five per cent use remote analytics to reconcile regimens and flag interactions, and two-thirds integrate IoT so that dispensers or smart blister packs can log every intake event. Nearly nine in ten deploy companion apps, reflecting the central role of smartphones and tablets in adherence reminders and caregiver oversight, while three quarters embed sensors for pill count or compartment status.

Figure 5: The technology Stack behind each Solution Archetype

> *Share of projects using each technology, by solution type (multiple technologies per project possible)*



Mobility and navigation aids (27 projects) are dominated by location-aware mobile applications—over ninety per cent of projects adopt this channel—supported by dense sensor use for indoor localization, fall detection or obstacle recognition. AI and robotics remain minority features, appearing only where autonomy or dynamic barrier avoidance is required; their place is largely taken by crowd-sourced map updates and cloud routing.

Monitoring and alert systems (121 projects) form the sensor powerhouse of the programme, with eighty-one per cent embedding environmental or physiological sensing and more than half coupling those sensors to IoT backbones for continuous streaming. Artificial intelligence is applied in more than forty per cent of projects, chiefly for anomaly detection and risk scoring, while three-quarters add mobile dashboards for caregivers.

Robotic assistants (26 projects) unsurprisingly concentrate on the highest share of robotics and automation (over seventy per cent) but they are also the most AI-intensive cohort alongside smart homes. Half of all robotic projects incorporate machine-learning algorithms for intent recognition or social interaction, three-quarters embed multi-modal sensing and more than forty per cent integrate with IoT ecosystems—evidence that robots in AAL increasingly function as nodes in wider service networks rather than as stand-alone devices.

Smart-home automation systems (28 projects) represent the purest expression of IoT, with almost eighty-six per cent of projects networking appliances, sensors and actuators through local gateways or cloud hubs. Half employ AI for context inference, and two-fifths leverage cloud analytics to refine automation rules, whereas mobile interfaces remain less common because many interactions are executed ambiently or by voice.

Telehealth and remote-care solutions (60 projects) combine high mobile-app penetration (more than eighty per cent) with strong engagement in cloud analytics and IoT connectivity, enabling continuous acquisition and medical interpretation of multi-parameter data streams. Over sixty per cent incorporate sensing and close to forty per cent employ AI, often for risk stratification or clinical decision support, indicating convergence between consumer AAL and regulated digital health.

Social-interaction platforms (103 projects) embody a software-first strategy: almost eighty-seven per cent are delivered through mobile or web clients, and one quarter exploit cloud analytics to match peers, surface relevant content or moderate communities. Sensor and IoT adoption are modest, underscoring the primacy of psychological and communicative rather than physiological data, yet emerging voice assistants and mixed-reality tools begin to blur this boundary.

2.3.3.2 Breakdown by Archetype

This section builds on the previous technology overview. It drills into each archetype, tracing how early prototypes addressing single AAL challenges have evolved into multi-service platforms, and how their technological stacks have migrated from bespoke hardware to cloud-native, AI-enhanced architectures.

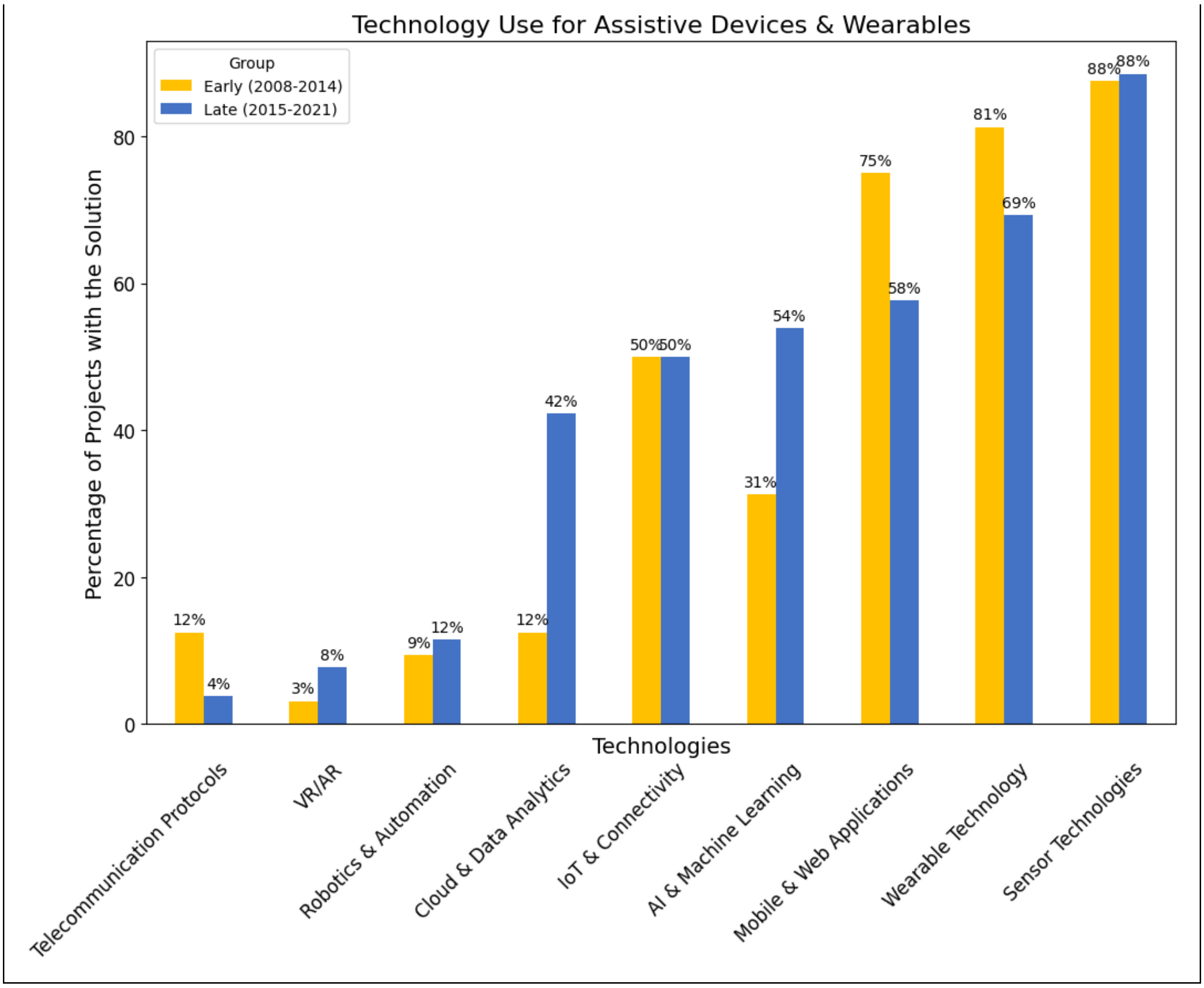
2.3.3.2.1 Assistive Devices & Wearables

Assistive Devices & Wearables for ageing populations focus on creating technologies that blend seamlessly into daily life while addressing specific challenges of physical decline, cognitive changes, and social isolation. These solutions often take the form of discreet wearables like smartwatches, robotic exoskeletons for mobility support, and connected home systems that monitor safety. For instance, projects developed lower-body exoskeletons to help users navigate stairs and uneven terrain, directly tackling age-related mobility limitations. Cognitive support tools used wrist-worn devices and tablets to provide memory prompts for people with dementia, addressing the frustration of forgotten routines. Other systems combined ambient home sensors with emergency call smartwatches to balance independence with fall detection – a critical concern given that falls are a leading cause of injury for older adults.

The technology stack reveals why certain components are vital for these solutions. Sensor Technologies (87.9% importance) act as the nervous system of assistive devices, with projects embedding textile sensors in garments to continuously monitor heart rhythms. Wearable Technology (75.8%) provides the physical interface between users and systems, where a robotic glove used force sensors to assist grip strength. Mobile & Web Applications (67.2%) serve as control hubs –a platform used smartphone interfaces for outdoor navigation guidance tailored to users with mild dementia. IoT & Connectivity (50%) enables devices to "talk" to each other and caregivers, which use ultra-wideband radio to track indoor movements. While AI/Machine Learning (41.3%) plays a growing role in personalization, early projects laid groundwork by using basic activity recognition algorithms to distinguish between normal movement and potential falls.

Evolution Early (2008-2014) vs Late (2015-2021)

Assistive Devices & Wearables solutions demonstrate a clear shift toward data-driven personalization. While sensor technologies remained foundational (87.5-88.5% adoption across periods), late-stage projects increasingly incorporated AI/ML (31.2% to 53.8%) and cloud analytics (12.5% to 42.3%). This evolution enabled systems to transition from basic activity tracking to cognitive support through machine learning analysis of behavioural patterns. The decline in pure wearable technology adoption (81.2% to 69.2%) coincides with smarter integration – some projects embedded sensors into everyday accessories while using cloud-connected AI for Parkinson's tremor detection.



Concrete examples show how these technologies evolve together. A 2010 project pioneered video-based mirror neuron stimulation combined with basic wearable sensors to encourage physical activity in dementia patients – a precursor to modern AI-driven behavioural nudges. By 2013, a system demonstrated more sophisticated integration, using ambient home sensors and emotion recognition to create a social network that adapted to users' moods. A 2020 workplace safety initiative exemplified this convergence by integrating pressure-sensitive wearables with low-power wide-area connectivity to deliver real-time feedback on lifting posture. This combination of IoT, data analytics, and ergonomic monitoring showcased how digital technologies can proactively reduce injury risks in physically demanding environments. Later innovations added medical-grade precision, using inertial sensors and machine learning to detect Parkinson's tremors while delivering nerve stimulation through the same wearable device.

Temporal analysis reveals shifting priorities. Early projects (2008-2012) focused on vital sign monitoring through wearable sensors and basic telemedicine gateways. The mid-2010s saw a surge in mobility solutions, some combined GPS with indoor Wi-Fi mapping for navigation support, while others brought robotic assistance into mainstream consideration. Recent developments (2018 onward) emphasize AI integration and ecosystem approaches. A platform used deep learning to analyse movement patterns for fall prediction, while another platform created holistic health dashboards by aggregating data from multiple wearable and environmental sensors.

Social and cognitive support has emerged as a critical frontier. Where early projects focused narrowly on interface adaptations for online banking, modern systems employ multimodal sensing to detect social isolation patterns. A project represents a paradigm shift – rather than just assisting care recipients, its AI-driven platform supports informal caregivers through personalized training content and wearable-based monitoring of dementia patients' health indicators. Even cultural engagement is being reimagined through technology, which combines tactile tablets with sign language avatars to make museum experiences accessible for older adults with sensory impairments.

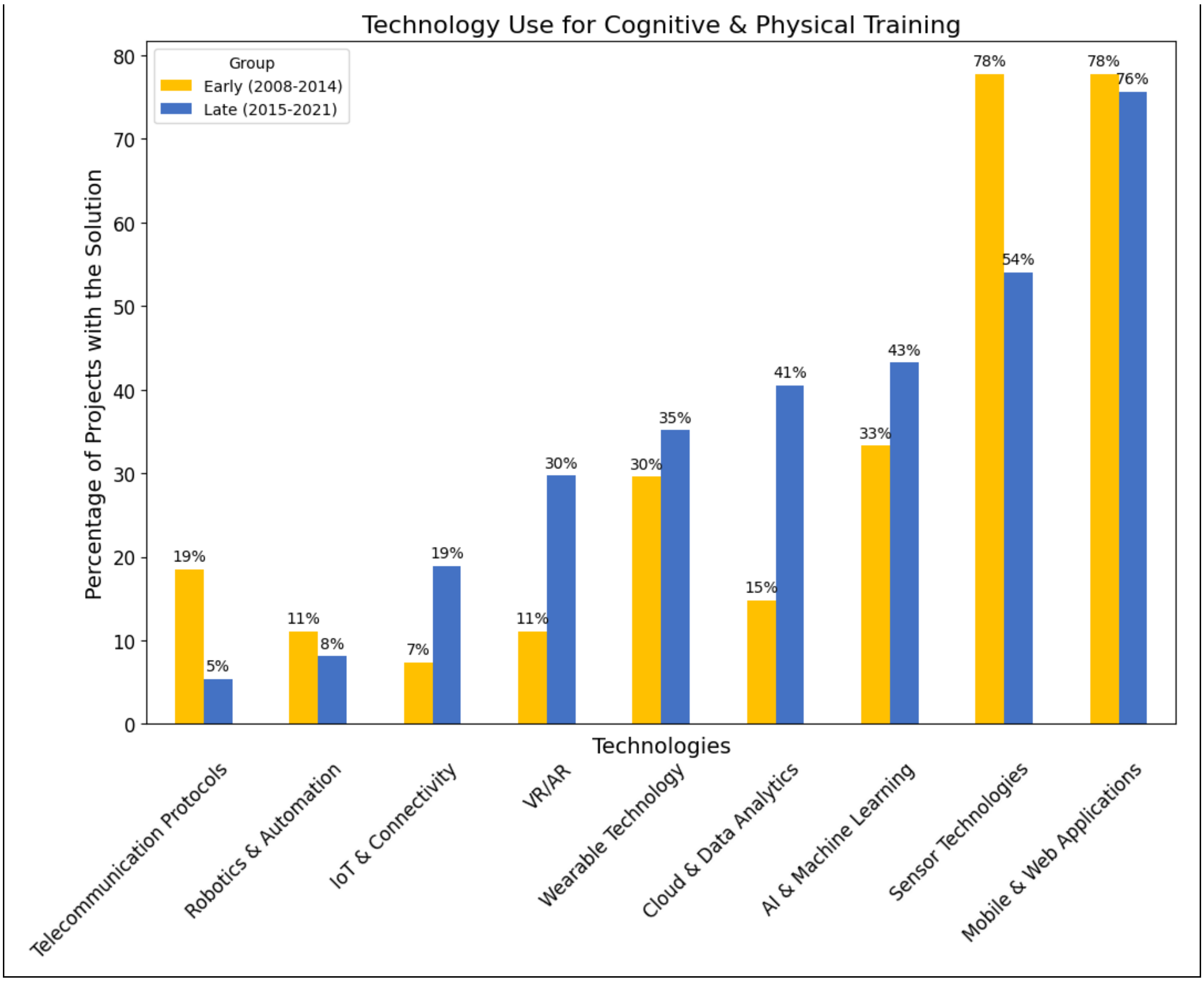
2.3.3.2.2 Cognitive & Physical Training

Cognitive and physical training solutions for older adults primarily focus on maintaining independence, slowing age-related decline, and enhancing quality of life through interactive technologies. These systems often address intertwined challenges: cognitive impairments like memory loss (common in dementia), reduced physical mobility, increasing fall risks, and social isolation exacerbating mental health issues. For instance, some projects combine cognitive stimulation games with motion sensors to simultaneously train memory and balance, recognizing that physical activity benefits brain health. Other solutions, tackle loneliness by creating digital social hubs where seniors engage in multiplayer games or intergenerational activities, blending leisure with cognitive challenges. Fall prevention systems use wearable sensors to detect gait abnormalities while offering personalized exercise programs, addressing both physical frailty and the anxiety that often accompanies mobility limitations.

The technology stack reflects a pragmatic balance between user accessibility and advanced functionality. Mobile and web applications (76.56% importance) serve as universal interfaces, adapting complex systems to familiar devices like tablets or smart TVs. Sensor technologies (64.06%) form the backbone of real-time health monitoring, whether tracking arm movements through a stroke rehab bracelet (2020) or analysing sleep patterns via a smartwatch (2018). AI/machine learning (39.06%) enables personalization at scale, like dementia care simulations that adapt to caregiver strategies or digital coach tailoring health recommendations. Notably, VR/AR (21.88%) and wearable tech (32.81%) work synergistically – the former creates immersive cognitive training environments, while the latter provides continuous physiological data to adjust difficulty levels.

Evolution Early (2008-2014) vs Late (2015-2021)

Cognitive & Physical Training solutions (21%) reveal growing sophistication in engagement strategies. While mobile interfaces remained crucial (77.8-75.7%), later projects combined VR/AR adoption (11.1% to 29.7%) with AI-powered adaptive training programs. The tripling of cloud platform usage (14.8% to 40.5%) facilitated solutions, which correlates sensor data from multiple devices to create personalized cognitive exercise regimens. This period also saw an emerging focus on emotional wellbeing, with systems employing biometric sensors and machine learning to adjust social interaction patterns based on mood indicators.



Early projects laid groundwork for sensor integration, as seen in 2010 wearable gait monitors and Kinect-based movement analysis – technologies now ubiquitous in modern systems. By 2012, projects demonstrated machine learning's potential, using skeleton tracking algorithms to assess daily living activities through Microsoft Kinect. A project marked a shift toward multi-sensory immersion, combining projectors, scent dispensers, and tactile interfaces to stimulate dementia patients' memories. Recent innovations showcase mature AI applications, where algorithms analyse fall risk factors across European populations to generate personalized rehab plans. This evolution reflects a trend from single-purpose devices toward interoperable ecosystems – a platform integrates medication dispensers, GPS trackers, and another bedroom sensors into a unified dashboard.

Two decades of projects reveal how technologies converge to address complex ageing challenges. A project exemplified early exergaming by pairing Microsoft Kinect's motion tracking with basic step counters, while another advanced this concept with laser-projected immersive environments and ceiling-mounted safety harnesses. Similarly, video communication tools have evolved from basic virtual interactions to sophisticated 3D and avatar-based training environments for caregivers... Cloud infrastructure transitioned from simple data storage in early platforms predictive analytics engine that cross-references medication adherence with sleep patterns. Crucially, these technologies maintain accessibility – even advanced systems care robot use tablet interfaces familiar to non-technical users.

The interplay between physical and cognitive training drives technological choices. Exergames embed cognitive challenges within physical routines – matching colours during tai chi moves or solving math problems while cycling. Sensor networks in projects simultaneously monitor grip strength (physical frailty indicator) and game performance (cognitive function). This dual focus reaches its zenith in AI-driven platforms, where machine learning correlates IoT sensor data about daily activities with cognitive decline patterns, triggering social robot interventions. Such integrations acknowledge that ageing challenges rarely exist in isolation – a fall risk might stem from weakening muscles, distracted attention, or both.

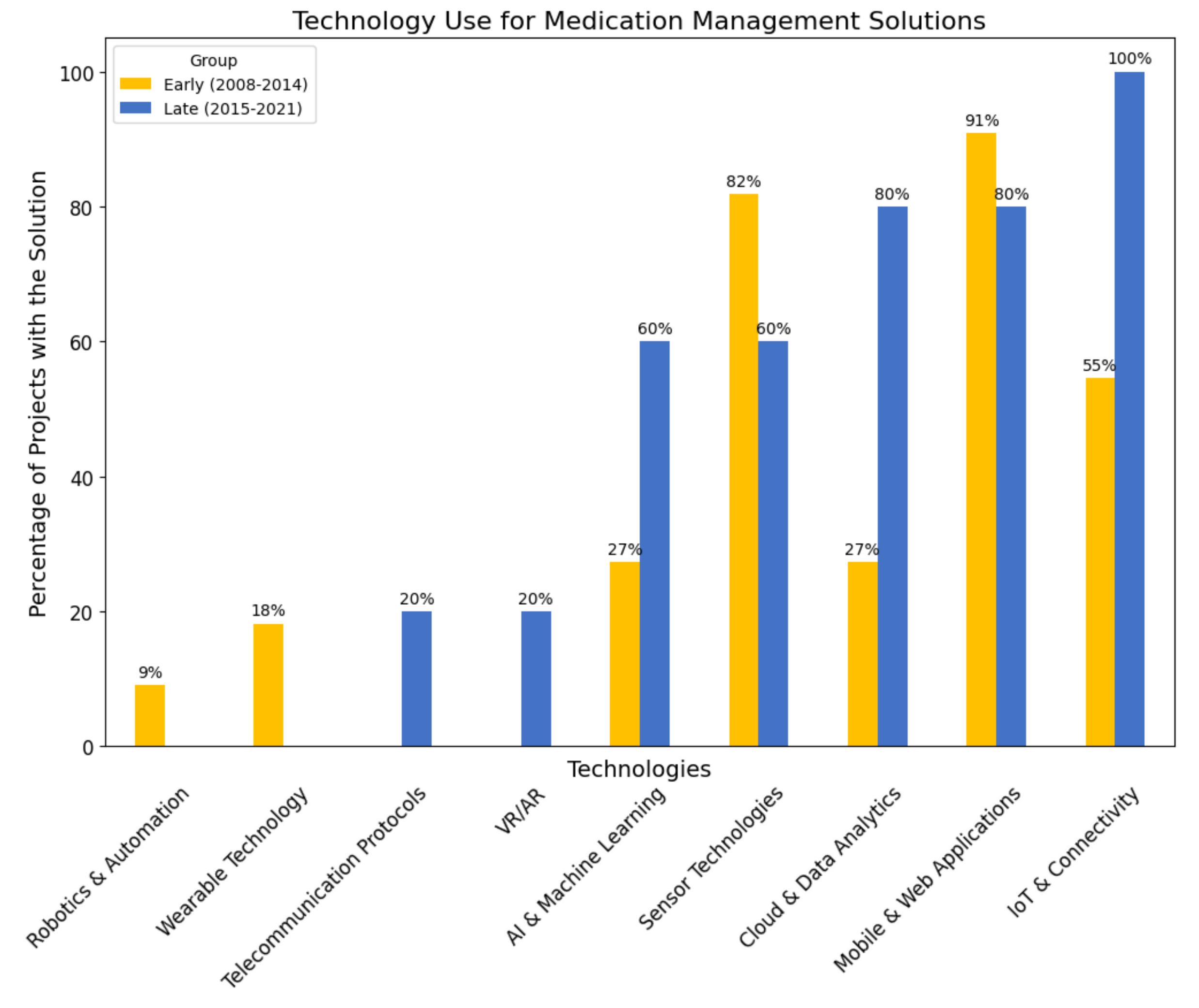
2.3.3.2.3 Medication Management Solutions

Medication management solutions for older adults primarily focus on overcoming age-related barriers to safe and consistent medication use. These systems address challenges like forgetfulness, complex drug regimens, physical limitations (e.g., vision impairment or dexterity issues), and the need for caregiver coordination. Solutions range from simple reminder systems to comprehensive platforms that detect swallowing difficulties and automatically adjust dosages. For instance, projects tackled Parkinson's medication timing through sensor-controlled pumps, while another project created voice-activated assistants that coordinate pill schedules with doctor appointments. At their core, these innovations aim to balance independence with safety – helping users maintain control over their health while ensuring someone gets alerted if pills are missed or taken incorrectly.

The technology priorities reveal a clear pattern – mobile apps and sensor networks form the backbone of modern medication systems. Smartphones and tablets (87.5% importance) serve as natural interfaces for older adults, transforming familiar devices into medication coaches that speak reminders aloud or display pill schedules in large fonts. Sensor technologies (75%) like smart pillboxes track whether lids open at scheduled times, while IoT devices (68.75%) enable automatic refill requests to pharmacies. Cloud systems (43.75%) act as invisible safety nets, quietly analysing whether a missed blood pressure reading might indicate medication side effects. Even less prominent technologies like augmented reality find niche roles – a project used AR to help users scan medicine bottles for instant audio instructions.

Evolution Early (2008-2014) vs Late (2015-2021)

Medication Management (5.2%) underwent pronounced technological transformation, particularly in IoT integration reaching 100% adoption in late-stage projects. Where early systems used isolated sensor networks, later implementations created medication ecosystems through AR interfaces connected to cloud-based prescription databases. The surge in AI adoption (27.3% to 60%) enabled predictive capabilities – a project analysed usage patterns to distinguish between forgetfulness and adverse reactions, while maintaining high mobile app utilization (90.9% to 80%) for caregiver coordination.



Early projects demonstrated how basic sensor networks could prevent medication errors. Their RFID-enabled pill trays detected if users forgot doses and alerted caregivers through TV interfaces. This evolved into more sophisticated systems, which combined cloud-connected dispensers with telepresence robots – if Grandma missed her afternoon pills, the robot could initiate a video call showing exactly where she left the medication bottle. Another project took this further, using AI to analyse patterns in both pillbox sensor data and daily activity levels, helping distinguish between dementia-related forgetfulness and medication-induced drowsiness.

Recent innovations show how technologies converge to create adaptive solutions. An ecosystem integrates sleep sensors with medication schedules – if AI detects poor sleep patterns, it might suggest adjusting diuretic timing with the doctor's approval. Meanwhile, projects reimagined medication management as part of holistic daily support, where a friendly avatar reminds users to take pills while also suggesting water intake based on smart cup sensors. Even television has become a care tool, transforming medication alerts into part of a familiar viewing routine.

The progression from standalone devices to interconnected systems reveals healthcare's digital transformation. Early solutions osmotic pumps focused on precise drug delivery, while in 2020 an ecosystem uses machine learning to predict how medication changes might affect weekly grocery shopping habits. This shift from treating medication as isolated events to understanding it as part of life patterns shows how technologies mature – not just reminding someone to take pills but understanding how those pills help them garden independently or visit grandchildren safely.

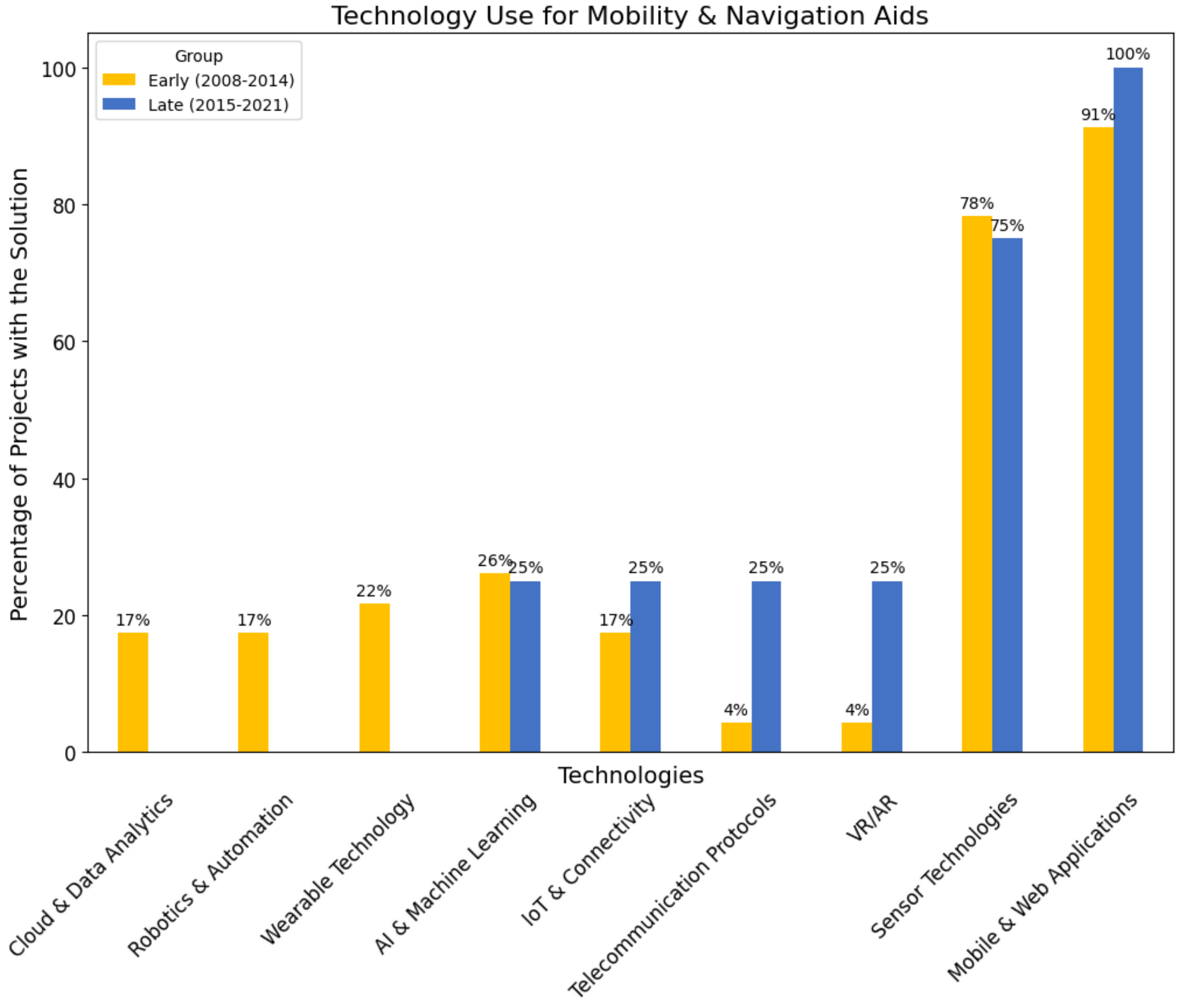
2.3.3.2.4 Mobility & Navigation Aids

Mobility and navigation aids for older adults focus on maintaining independence and safety through technologies that adapt to age-related physical, sensory, and cognitive challenges. Solutions range from smartphone apps guiding outdoor trips to wearable devices offering tactile navigation cues, all addressing core barriers like disorientation, vision loss, or anxiety in unfamiliar environments. For instance, some systems help visually impaired users detect obstacles through real-time camera analysis and audio alerts, while other projects blend GPS tracking with caregiver networks to support people with dementia during walks. Indoor navigation tools use foot-mounted sensors and Wi-Fi beacons to guide users through stores when GPS fails, demonstrating how solutions bridge the gap between outdoor mobility and complex indoor spaces. These tools often integrate fall detection, emergency alerts, and route customization—features that collectively reduce reliance on caregivers while encouraging social participation.

The technology stack reflects the need for real-time adaptability and accessibility. Mobile and web applications dominate (92.59%) as primary interfaces due to their ubiquity and capacity to deliver personalized guidance, where seniors plan barrier-free trips via tablet apps. Sensor technologies (77.78%) underpin safety features: a project uses GPS to create dynamic "safe zones" for dementia patients, while another project' s motorized walkers (2011) deploy laser scanners to avoid collisions. AI/machine learning (25.93%) enables predictive capabilities, navigation system tailoring driving routes based on cognitive assessments. IoT integration (18.52%) supports device interoperability, where ZigBee sensors monitor home movements to trigger medication reminders. These technologies converge to create systems that "think ahead" for users, compensating for declining physical or cognitive abilities.

Evolution Early (2008-2014) vs Late (2015-2021)

Mobility & Navigation Aids (8.9%) maintained strong mobile/web integration (91.3-100%) while exploring new sensory paradigms. Projects exemplified this dual approach, combining GPS with dementia-friendly smartphone interfaces. The emergence of AI-driven predictive navigation, despite static AI adoption rates (26.1-25%), reflects maturing algorithms capable of real-time route optimization based on user capability assessments. Interestingly, complete abandonment of wearable-specific solutions in later periods (21.7% to 0%) suggests focus shifted toward ambient smart environment integration.



Projects from different eras reveal evolving tech applications. Early initiatives combined basic mobile apps with Smart TV interfaces for shopping support, relying on barcode scanning and static transport data. By 2011, solutions introduced AI-driven route replanning during transit disruptions, while others integrated robot operating systems (ROS) for semi-autonomous wheelchairs. Later projects leveraged advancements in connectivity: a project used augmented reality overlays to simplify medication management and indoor navigation, while another one employed video calling chains for emergency support. Sensor fusion became more sophisticated over time. A project blended Bluetooth beacons with satellite positioning for seamless hospital navigation, whereas another combined force-sensitive rollator handles with crowd-sourced trail maps. This progression shows a shift from reactive tools to proactive, context-aware systems.

Accessibility drives design choices across technologies. Text-to-speech and high-contrast interfaces cater to users with mild cognitive decline, while haptic wristbands provide discreet navigation cues for those overwhelmed by visual stimuli. Projects increasingly prioritize multimodal interaction. A project offered instruction through video, audio, and text based on user profiles; a concept expanded in AR-guided menus. Crucially, many systems avoid stigmatization: a project embedded navigation into a cane's tactile disc, while another framed location sharing as "virtual companionship" rather than surveillance. This user-centric approach ensures technologies feel empowering rather than intrusive.

Interoperability remains a recurring theme. A platform (2008) connected RFID-tagged objects to a central sensor network, while another (2011) bundled 10 services—from geofenced security alerts to transit timetables—into a single TV-and-smartphone interface. Later projects unified driving behaviour sensors with personalized navigation, illustrating how layered technologies create holistic support. Even simple features, like wrong-way alerts using Wi-Fi triangulation, demonstrate how combining basic components (GPS, beacons) can yield sophisticated safety nets. This modularity allows solutions to scale from individual assistance (e.g., finding lost keys) to community-wide mobility ecosystems.

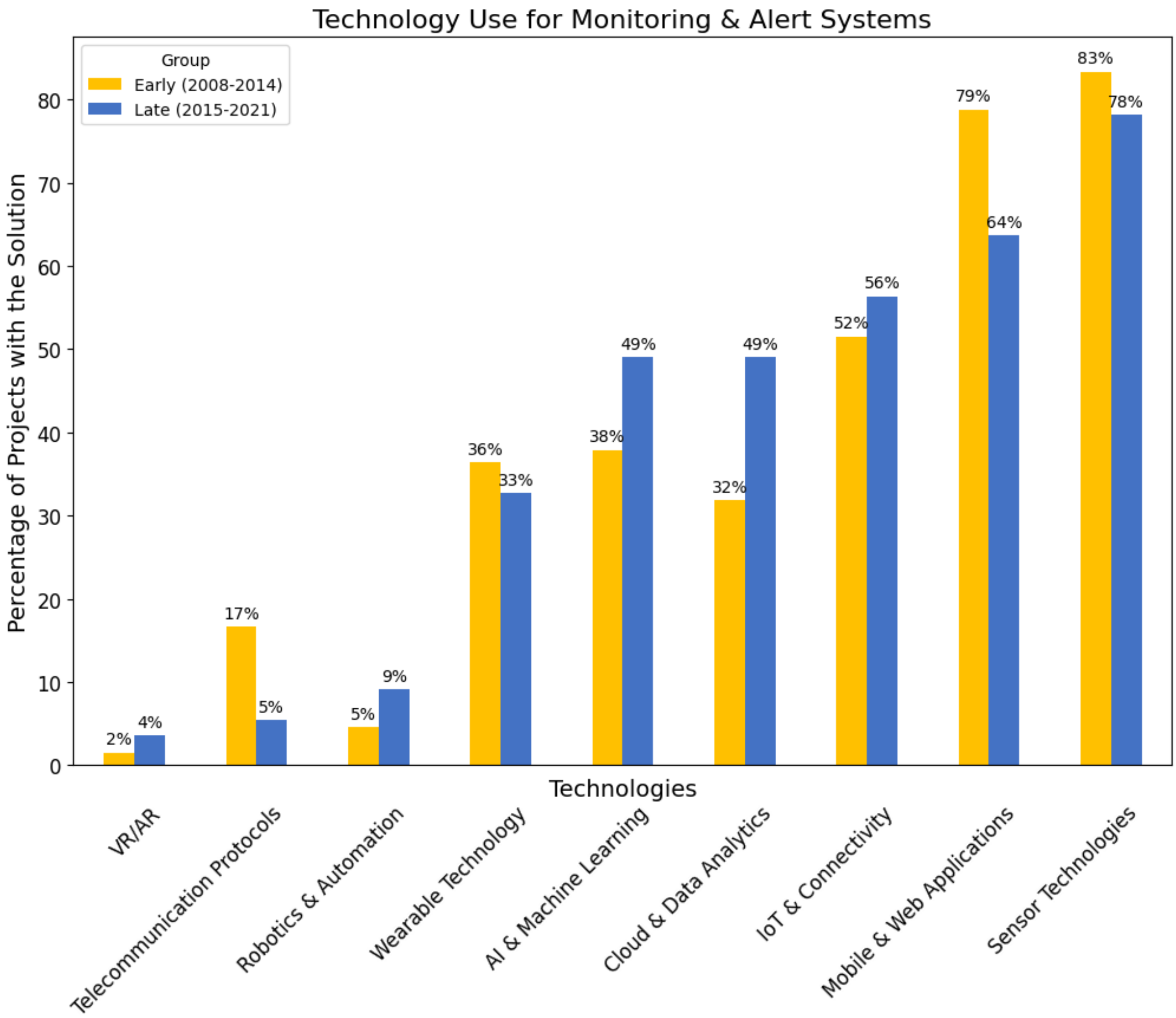
2.3.3.2.5 Monitoring & Alert Systems

Monitoring & Alert Systems for older adults focus on enabling safe, independent living by detecting risks and facilitating timely interventions. These solutions address challenges like falls, disorientation, medical emergencies, and social isolation through continuous observation and smart notifications. For instance, wrist-worn devices combined GPS and RFID to locate users indoors/outdoors while detecting falls, directly connecting them to emergency services. Later systems evolved this concept using ambient sensors to track daily activity patterns, alerting caregivers about unusual behaviours that might indicate health decline or cognitive impairment. Social isolation is countered through platforms, which transformed TVs into communication hubs for video calls and health monitoring, blending safety features with social connectivity.

The technology stack reveals why certain tools dominate this field. Sensor technologies (81% importance) form the foundational "eyes and ears" of these systems – from basic motion detectors to advanced 3D cameras analysing gait patterns. Mobile/web applications (72%) serve as the interaction layer, allowing both seniors and caregivers to view alerts, share updates, or video chat through familiar devices. IoT connectivity (54%) weaves these components into a responsive network, enabling real-time data flow between wearable devices, home sensors, and cloud platforms. While AI/ML (43%) plays a growing role in interpreting complex data patterns, some projects demonstrated early versions of this by using rule-based systems to distinguish normal activities from potential emergencies in dementia patients.

Evolution Early (2008-2014) vs Late (2015-2021)

Monitoring & Alert Systems evolved from reactive to predictive models through enhanced AI/ML adoption (37.9% to 49.1%) and cloud analytics (31.8% to 49.1%). Where early projects (2008) focused on vital sign tracking, later systems (2021) employed machine learning to detect subtle behavioral changes predictive of health declines. The maintained high sensor utilization (83.3-78.2%) combined with growing IoT connectivity (51.5-56.4%) enabled comprehensive environmental monitoring ecosystems, as seen in another project (2018) which integrated motion, acoustic, and visual sensors for fall prediction.



Early projects laid the groundwork through focused device integration. A project created a smart kitchen system where Zigbee sensors monitored appliance use and food inventory, combining this data with a tablet interface to prevent cooking accidents and nutritional neglect. By 2012, solutions began incorporating machine learning to analyse caregiver stress patterns through home sensor data, illustrating the shift from reactive alerts to predictive support. A system marked another evolution, using Wi-Fi-connected sensors and cloud analytics to detect subtle changes in daily routines that might indicate emerging health issues, moving beyond immediate danger detection to long-term wellbeing monitoring.

Recent innovations showcase sophisticated technology fusion. A platform combines motion sensors, health devices, and cognitive games to holistically assess users' physical and mental capabilities, using AI to recommend personalized care plans. Projects employ radar technology to monitor COPD patients' breathing during sleep without physical contact, demonstrating how sensor innovation expands monitoring possibilities. Meanwhile, systems address the human factor by simplifying smartphone interfaces for seniors while maintaining backend connectivity to caregivers, balancing technological capability with accessibility.

Temporal comparisons reveal shifting priorities. Where a 2008 project focused solely on motion sensors to detect Alzheimer's warning signs, a 2019 project introduced multi-modal emergency triggers – including gesture recognition and automatic seizure detection – for people with communication impairments. The progression from 2008 projects basic fall alerts to a 2021's system shows maturation in data interpretation: later platforms analyse aggregated sensor data through machine learning to identify gradual wellbeing declines rather than just acute incidents. This evolution mirrors broader healthcare trends toward preventative care and personalized interventions.

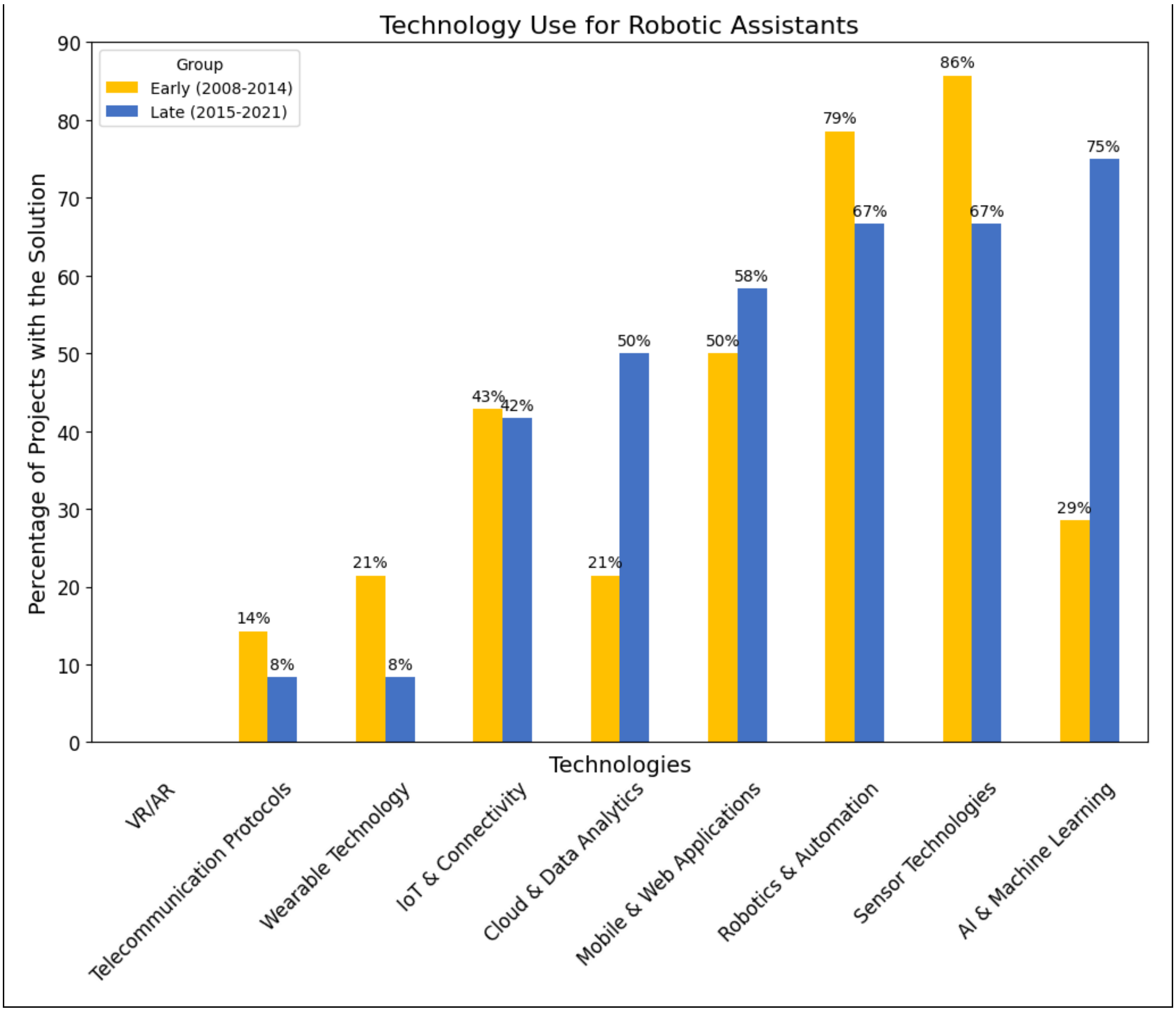
2.3.3.2.6 Robotic Assistants

Robotic assistants for ageing populations have evolved into diverse forms, each targeting specific challenges faced by older adults. Mobility support address physical decline through robotic walkers and wearable exoskeletons, helping users navigate environments and maintain strength. Social companion robots combat loneliness through conversational interfaces and activity prompts, while telepresence solutions enable virtual family visits. Cognitive support tools take multiple approaches. A tablet-based avatar (2012) provides memory aids, while another project combines IoT sensors with Pepper robots to deliver drama therapy for cognitive stimulation. Safety remains a universal focus, with projects using wearable sensors and smart medication dispensers to detect falls and prevent emergencies, creating an ecosystem where physical assistance, emotional connection, and risk mitigation coexist.

The technology stack reveals why certain tools dominate this field. Sensor technologies (77% prevalence) act as the nervous system of these solutions—force sensors in exoskeletons detect movement intent, while ambient sensors in systems monitor home environments. Robotics & Automation (73%) provides the physical embodiment of assistance, whether through ISO-certified care robots or navigating humanoid. AI/ML (50%) brings adaptability, letting solutions learn user preferences and analyse emotions through facial recognition. Mobile/Web Apps (54%) serve as critical bridges—the Serenity App gave caregivers remote control, while tablet interfaces (2014) helped users manage health data. Even lower-weighted technologies play niche roles: wearable tech enabled mobility assistance, while cloud systems (2012) synchronized recipe data across devices.

Evolution Early (2008-2014) vs Late (2015-2021)

Robotic Assistants underwent an intelligence revolution, with AI/ML adoption skyrocketing from 28.6% to 75%. This enabled transitions from scripted interactions in early projects to adaptive systems, where robots adjust therapeutic activities based on real-time emotion recognition. While core robotics utilization decreased slightly (78.6-66.7%), integration with wearable biosensors and IoT networks created more context-aware assistants. A project (2014) marked a turning point, combining robotic mobility support with AI analysis of wearable health data.



Early projects demonstrated foundational integrations. A 2008 project combined three robotic interfaces with Bluetooth medical sensors and haptic feedback, showing how physical automation could coexist with health monitoring, a blueprint still used in modern exoskeletons. By 2012, another project illustrated the cloud's growing role, connecting telepresence robots with medication dispensers and caregiver dashboards through centralized data platforms. A 2014 project marked a shift toward AI-driven ecosystems, using machine learning to correlate Fitbit data with home sensor inputs for personalized health plans. These examples reveal an evolution from hardware-centric solutions to intelligent, connected systems.

Later innovations leveraged advancing AI capabilities. A 2016 project fused lifestyle sensors with social robots, using pattern recognition to convert passive activity data into proactive care suggestions—a concept expanded in a 2019 project through emotion-detection algorithms. Recent projects exemplify convergence, pairing IoT sleep monitors with robot-led drama therapy sessions, creating interventions that adapt to both physical metrics and cognitive needs. Even seemingly peripheral technologies find renewed purpose— basic facial recognition (2012) evolved into another projects real-time mood analysis using Linux-adapted Face Reader SDK.

User interface design emerged as critical across eras. Early touchscreen systems (2009) prioritized simplicity with large buttons, while later solutions (2016) incorporated natural language processing for voice commands. The evolution from a basic virtual coach (2009) to a GDPR-compliant AI avatar (2015) shows increasing sophistication in personalization—later systems could interpret emotional cues through voice tonality analysis. Crucially, mobile apps transitioned from mere control panels to bidirectional communication hubs (2017), where seniors could access cognitive games alongside vital sign data.

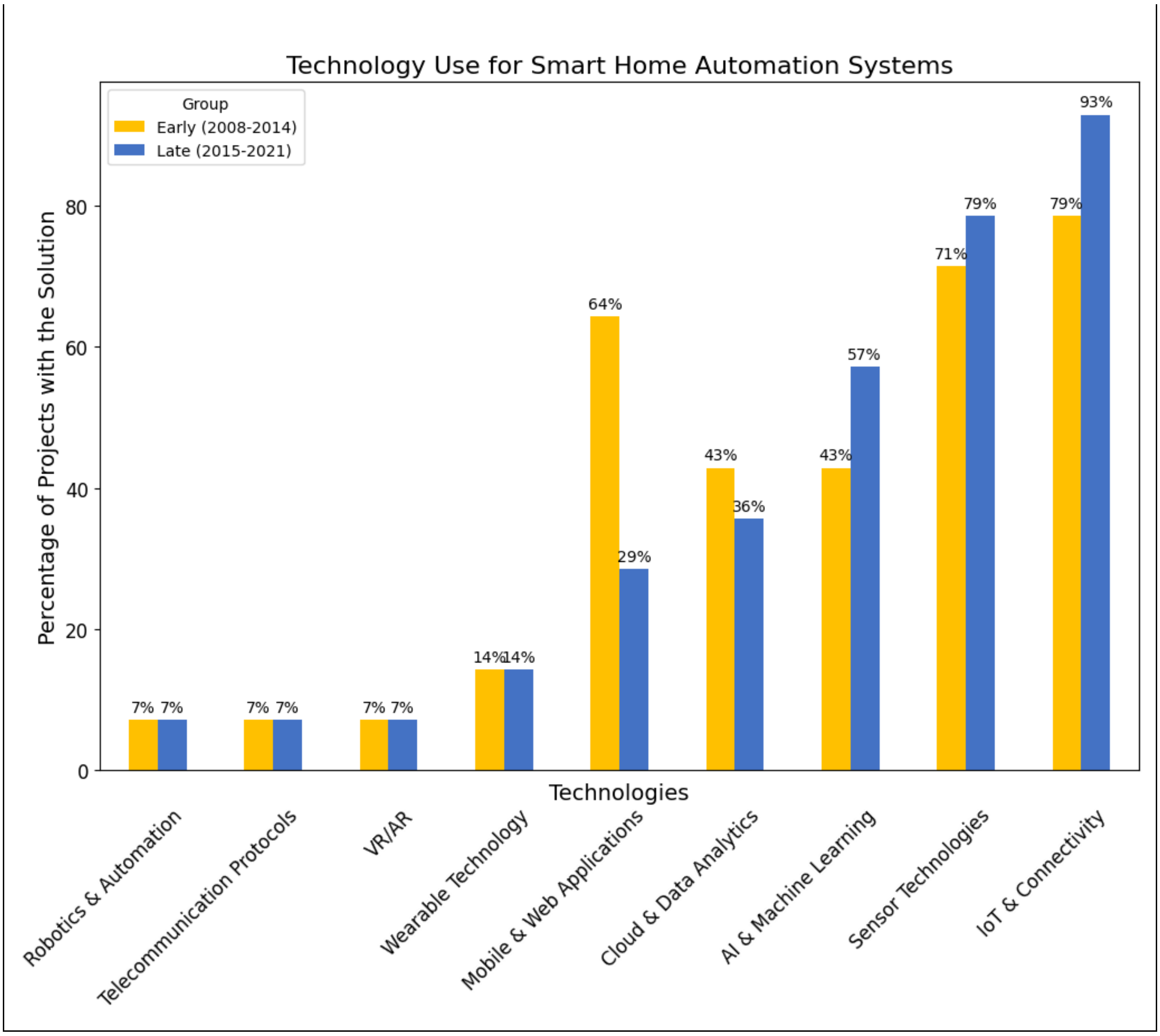
2.3.3.2.7 Smart Home Automation Systems

Smart Home Automation Systems for ageing populations focus on creating environments that adapt to evolving needs while promoting independence. These solutions primarily tackle challenges like cognitive decline, mobility limitations, social isolation, and safety risks. For instance, systems developed middleware platforms that let seniors control lights, appliances, and communication tools through familiar devices like TVs or voice assistants – addressing both physical accessibility and technological intimidation. Projects transformed kitchens into assisted spaces with sensor-equipped appliances that guide cooking steps and prevent hazards, directly supporting those with memory challenges or reduced dexterity. Meanwhile, solutions use dynamic lighting to improve spatial awareness and regulate sleep cycles, helping counteract disorientation common in dementia.

The technology stack reflects the layered needs of these intelligent environments. IoT devices and sensors (85.7% importance) can act as the nervous system – motion detectors track daily routines, while wireless temperature probes ensure safe meal preparation. AI/Machine Learning (50%) serves as the brain, analysing patterns from these sensors; a project (2012) used behaviour models to discreetly alert caregivers about unusual activity, while another (2021) detects health declines through subtle changes in bathroom visits. Cloud platforms (39.3%) enable remote monitoring –e.g. a project's recipe suggestions adapt based on cloud-stored dietary needs, and another project learns heating preferences through energy-efficient data processing. Mobile/web interfaces (46.4%) create accessible control panels avatar assistant that simplifies complex home automation through voice commands.

Evolution Early (2008-2014) vs Late (2015-2021)

Smart Home Automation became synonymous with connectivity, with IoT adoption leaping from 78.6% to 92.9%. Sensors grew slightly (71.4% to 78.6%) for ambient monitoring in solutions like a project's kitchen safety system. Paradoxically, mobile/web interfaces plummeted from 64.3% to 28.6% as voice control and automated triggers replaced manual inputs. AI/ML consistently increased (42.9% to 57.1%) to enable context-aware environments like behaviour-adaptive lighting.



Early projects laid out foundational infrastructure. A 2008 system established basic smart home capabilities using Zigbee sensors to detect emergencies and automate alerts – like turning on lights when motion sensed nighttime wandering. By 2011, another project added intelligence to this framework, using genetic algorithms to optimize lighting schedules that gently encourage activity patterns. A 2012 project demonstrated IoT's potential for compassionate care – its sensor cubes and NFC tiles enabled seniors to send simple "thinking of you" messages to family while discreetly monitoring wellbeing through appliance usage patterns.

Mid-2010s projects showcased integration breakthroughs. A project (2014) combined wearable health trackers with telepresence robots, where AI correlated vital signs with smart home adjustments – triggering video calls with caregivers if abnormal heart rates were detected during falls. Another project (2015) advanced natural interfaces using voice-controlled avatars that could dim lights through open-source home automation systems while reminding users to take medication. These years saw cloud platforms becoming vital bridges between devices – a learning thermostat reduced energy costs while maintaining comfort through predictive models.

Recent innovations prioritize subtlety and adaptability. Systems use non-intrusive room sensors (without cameras or microphones) to learn daily patterns, alerting caregivers only when deviations occur—addressing privacy concerns while supporting autonomy. Meanwhile, another project (2019) employs augmented reality via smartphones to overlay medication instructions or navigation cues, helping those with cognitive decline complete tasks confidently. This shift toward unobtrusive, personalized assistance underscores how technology increasingly fades into the background while remaining responsive to individual needs.

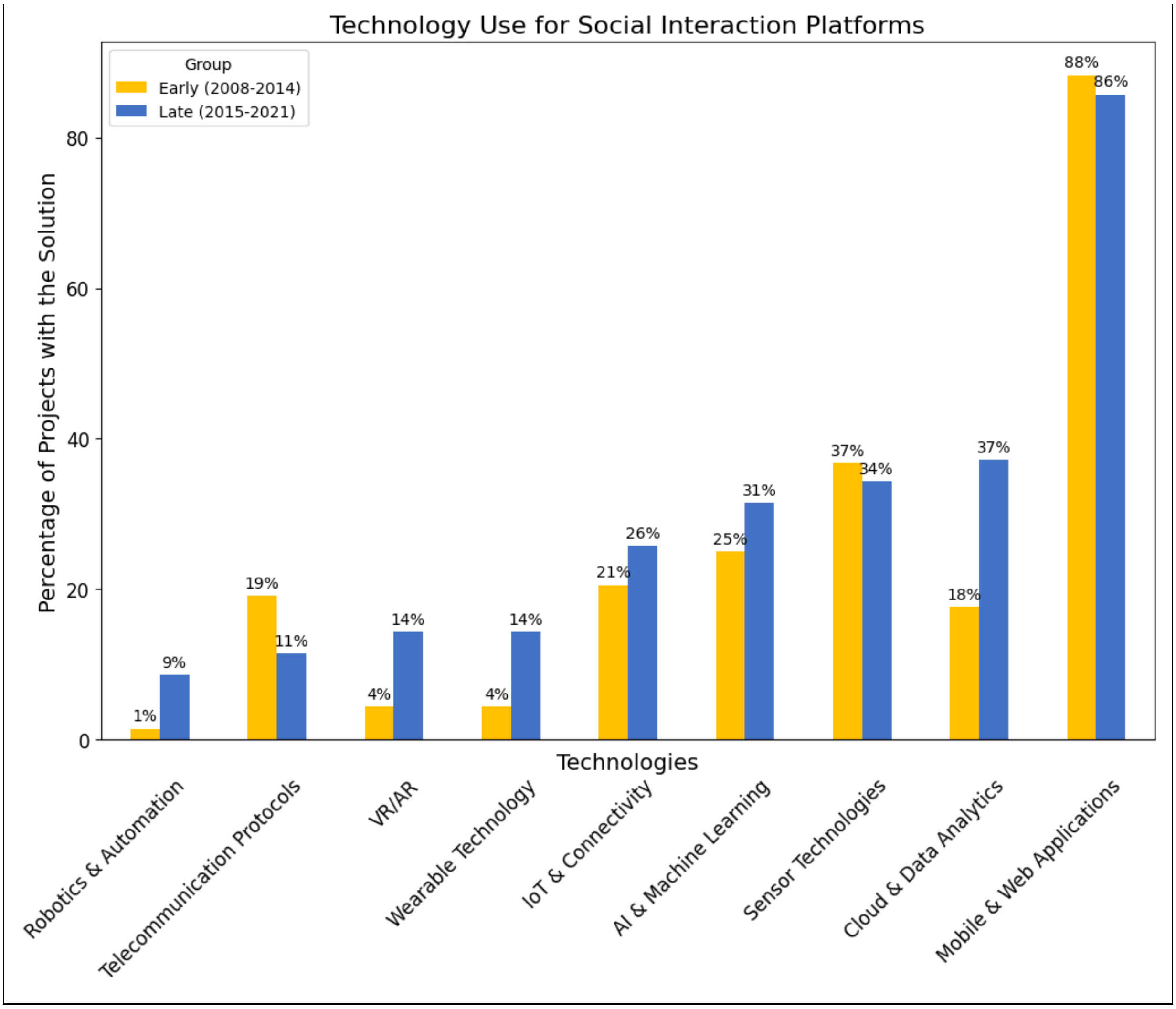
2.3.3.2.8 Social Interaction Platforms

Social interaction platforms for ageing populations address core challenges of isolation, cognitive decline, and maintaining autonomy through diverse digital strategies. These solutions often focus on bridging physical and technological barriers: communication tools transformed televisions into portals for video calls and emergency alerts, while later systems introduced voice-controlled virtual assistants for medication reminders. Community-building platforms created peer networks for knowledge sharing and volunteerism, directly countering the "empty nest" effect many experience post-retirement. A third category tackles cognitive health through gamification – a project (2009) blended music and motion sensors for dementia-friendly exercise, while another project (2017) deployed robot companions to stimulate mental engagement.

The dominance of mobile/web applications (87% adoption) reflects their role as universal access points. Smartphones and tablets become lifelines for seniors through simplified interfaces, dementia-tailored Android app displaying photos and schedules. Sensor technologies (35%) enable passive safety nets – a project (2010) used Z-Wave door sensors to detect emergencies, while a later project (2012) tracked room occupancy patterns to identify health declines. Though less visible, cloud infrastructure (24%) powers personalization at scale: A project (2010) stored adaptive interface preferences for vision/hearing needs, and another project leveraged cloud-based recipe recommendations for dietary needs. AI/machine learning (27%) emerges in subtle but crucial ways – another project (2010) decoded speech for motor-impaired users, while a project (2020) later predicted dementia progression through activity pattern analysis.

Evolution Early (2008-2014) vs Late (2015-2021)

Social Interaction Platforms (33.8%) maintained strong mobile/web foundations (88.2-85.7%) while embracing multimodal engagement. VR/AR adoption tripled (4.4-14.3%), enabling projects to create immersive therapeutic environments. The doubling of cloud utilization (17.6-37.1%) facilitated solutions, which matches users through AI analysis of stored interaction patterns. Notably, wearable integration emerged in late-stage projects (4.4-14.3%), with systems using a mix of analogue and digital artefacts to trigger cultural memory stimulation activities.



Early projects (2008) demonstrated foundational integrations, combining wearable accelerometers with ambient displays to notify caregivers about activity changes. By 2012, a project introduced Bluetooth beacons to guide cognitively impaired users through daily tasks, showing IoT's potential for context-aware support. The evolution peaks in systems (2020), where machine learning analyses multi-sensor data (sleep patterns, social interactions) to proactively suggest interventions. VR/AR adoption remains niche but targeted – a project (2020) used immersive headsets for motor-cognitive therapy, while another (2018) projected virtual board games onto physical surfaces to maintain tactile engagement.

Timeline examples reveal shifting priorities: a project (2009) focused purely on TV-based Skype access, while in 2021 another project integrated medical devices into video calls for real-time health monitoring during conversations. Where in 2009 a project relied on basic P2P messaging, another project (2020) employed AI matchmaking to connect retired experts with mentees. Crucially, projects expanded the definition of social interaction itself – transforming cultural heritage sharing into therapeutic activities through tactile tablets and sign language avatars.

Underlying these innovations is a persistent design challenge: balancing functionality with accessibility. A platform (2009) achieved this through configurable text sizes and voice navigation, principles still evident in another project (2019) with its adaptive UI for migrant seniors. Paradoxically, some "low-tech" solutions proved enduring – a 2009 webcam-based story-sharing for grandparents persisted conceptually in 2015 in a cushioned tablet frame. As populations age alongside technologies, these platforms demonstrate that meaningful connection often lies not in technical novelty, but in thoughtful adaptation of existing tools.

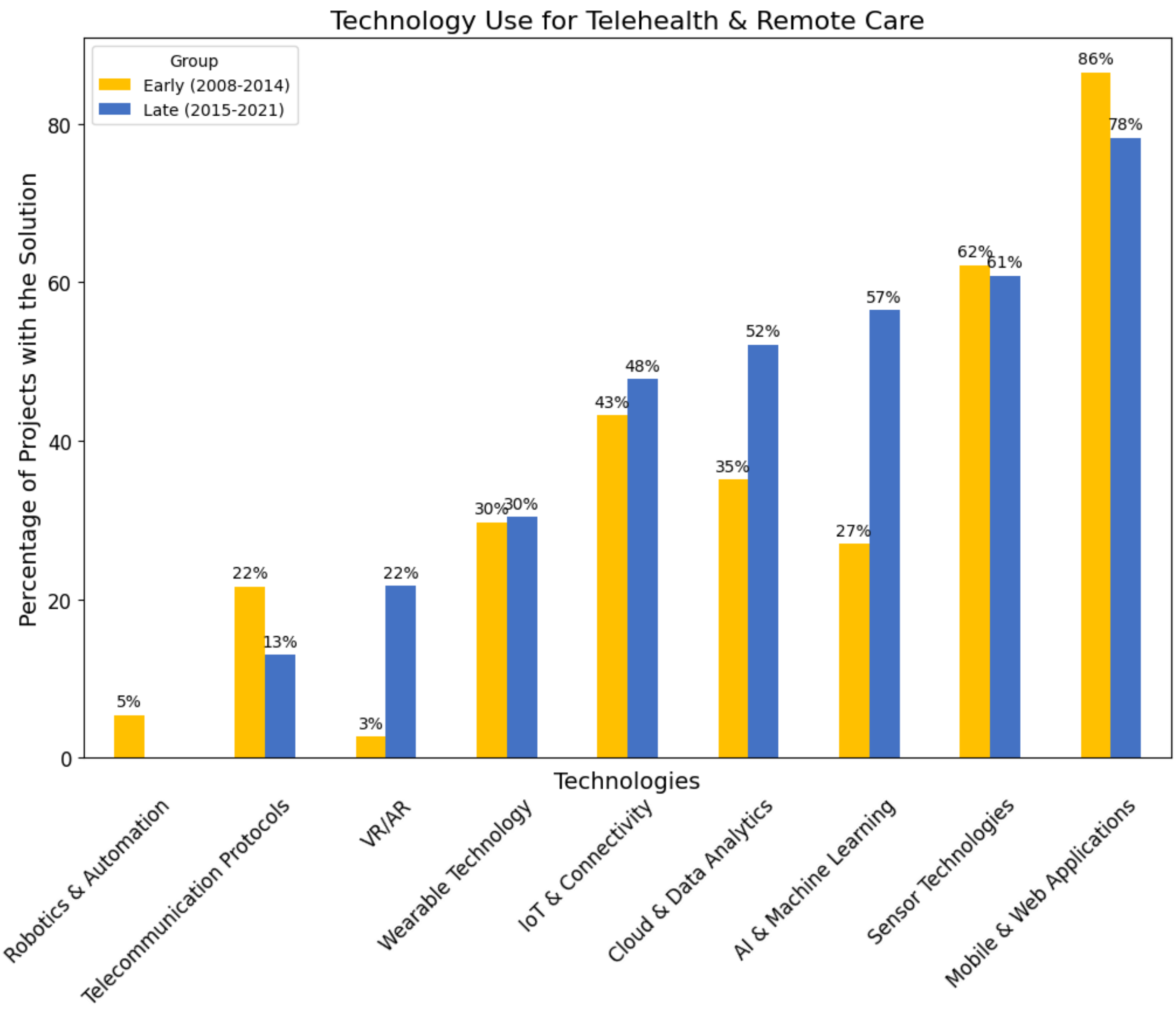
2.3.3.2.9 Telehealth & Remote Care

Telehealth and remote care solutions are designed to help older adults maintain independence while managing health conditions and staying connected to care networks. These systems often address multiple challenges simultaneously: chronic diseases like COPD or heart failure require continuous monitoring to prevent hospitalizations. Cognitive decline and dementia pose unique barriers to daily life, prompting solutions (2008) with caregiver-patient coordination tools and in 2020 with AI-driven monitoring of behavioural patterns. Social isolation—a critical risk factor for mental and physical decline— is combatted through platforms, which integrate video calls and community engagement features. Safety concerns, from falls to medication errors, have driven the development of activity-tracking systems and emergency-alert solutions based on telepresence technologies. For rural populations with limited healthcare access, projects leverage environmental sensors and telehealth portals to bridge service gaps.

The technology stack reflects the core needs of decentralized care delivery. Mobile and web applications (83% importance) serve as universal interfaces, simplifying complex tasks for users with varying tech literacy—whether through a project's (2012) tablet-based "one-stop shop" or another project's (2012) TV-friendly navigation. Sensor technologies (61%) and IoT systems (45%) form the data backbone, capturing real-time health metrics through wearables ECG harness or discreet home sensors tracking movement patterns). Cloud platforms (41%) securely aggregate this data while enabling AI/ML algorithms (38%) to detect trends, whether predicting COPD exacerbations or personalizing rehab plans. Lower adoption of VR/AR and robotics reflects their niche roles—though exceptions exist, like VR stroke rehabilitation or companion robots for home assistance.

Evolution Early (2008-2014) vs Late (2015-2021)

Telehealth & Remote Care solutions demonstrate the most pronounced AI adoption growth (27-56.5%), enabling predictive health management. Early remote monitoring systems (2014) evolved into platforms (2019), where machine learning predicts cardiac events weeks in advance. The surge in VR/AR utilization (2.7-21.7%) reflects new approaches to remote therapy expanding from stroke rehab to comprehensive virtual physiotherapy. Maintained high mobile app usage (86.5-78.3%) ensures accessibility, while growing cloud adoption (35.1-52.2%) supports cross-institutional data sharing.



Early projects reveal foundational uses of these technologies. A 2008 system combined textile-based biosensors with a home gateway, demonstrating how IoT could enable continuous vital sign monitoring without clinical visits. By 2011, another project had evolved this concept using Microsoft Kinect's motion tracking for home-based physical therapy—a precursor to modern AI-driven movement analysis. A 2014 project marked a turning point, integrating diverse components (wearables, environmental sensors, and telehealth dashboards) into a unified AI ecosystem that could adapt to users' changing needs. These examples show how core technologies matured from isolated tools into interconnected platforms.

Later implementations emphasize personalization and predictive capabilities. A 2019 project fused smart toothbrushes and saliva sensors with machine learning, transforming routine hygiene into a diagnostic tool for systemic health. That same year, an AI platform began analysing wearable data from heart failure patients to predict hospitalization risks weeks in advance—a leap from earlier reactive monitoring. Recent projects combine WHO health frameworks with multimodal sensors, using AI to create dynamic care plans that address physical, cognitive, and social wellbeing holistically.

Cross-cutting themes emerge in how technologies address caregiver needs. While early systems (2010) focused on coordinating professional care teams via web portals, modern solutions use wearables to give informal caregivers insights into dementia patients' sleep patterns or agitation levels. A 2020 project exemplifies this shift, blending existing telecare devices with SmartThings sensors to reduce monitoring burdens while maintaining patient privacy—a balance earlier systems struggled to achieve.

2.4. **Q4**: How did end-user involvement evolve over time in terms of number and type?

2.4.1 Primary end-users

2.4.1.1 Participation Patterns and Shifts in Scale (2008–2021)

Across the 2008-2021 cohorts, **more than 60 000 primary end-users**[5] were reached. Their distribution over time is far from uniform. Two broad features stand out: an early surge in very large user bases during the programme's exploratory phase (2009 and, to a lesser extent, 2013), followed by a gradual return to more modest—but often deeper and better-documented—involvement as projects matured and moved towards market pilots.

From 2008 to 2011 the annual total oscillated between about 1 700 and 3 600 users. Projects in these first cohorts typically recruited a few dozen participants for formative activities—focus groups, co-design workshops, or short field trials—supplemented by modest numbers of active testers in multi-site pilots. Engagement moments were therefore spread fairly evenly across conception, iterative prototyping and evaluation, and older adults were most often involved as *consulted respondents* or *active testers* for one to three months at a time.

A dramatic, programme-wide expansion occurred in the 2009 cohort, which involved around 17 756 primary end-users—ten times the previous year's figure. This exceptional rise was driven by a handful of online platforms and gaming projects that could scale quickly to thousands of users at low marginal cost. This skew is visible in the discrepancy between the average (555) and median (114) users per project, which reflects a concentration of large numbers in a few outlier projects. For example, a project registered more than 7 000 seniors for online cognitive games, and another reported up to 1 500 users for its social-best-practice portal. Because these projects ran large-scale online services, the average number of primary users per project jumped to more than 550, even though the cohort contained only

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[5] Primary end-users are older adults who are actually using AAL products and services. This group directly benefits from AAL solutions through increased quality of life. Primary end user organizations are organizations that represent older adults (e.g. senior organisations/cooperatives etc.)

about thirty funded projects. **Involvement was concentrated in *evaluation* phases**—real-world deployment—while early co-design was handled by much smaller panels.

Table 4: Evolution of primary end-user involvement

Call year	Total number of primary end-users per call year	Average	Median	No Projects	Data coverage (a)
2008	1 803	78	30	23	100%
2009	17 756	555	114	32	100%
2010	3 576	163	49	22	100%
2011	1 738	72	55	24	96%
2012	2 307	80	55	29	100%
2013	13 657	569	46	24	100%
2014	3 506	185	97	19	95%
2015	1 490	88	63	17	100%
2016	1 122	75	51	15	100%
2017	2 520	180	130	14	100%
2018	4 945	235	70	21	100%
2019	2 265	126	114	18	95%
2020	2 154	98	68	22	92%
2021	1 099	85	59	13	59%
TOTAL	**59 938**	**205**	**67**	**293**	**95%**

(a) This column indicates the percentage of projects for which the data was available.

After this spike, the 2010 to 2012 cohorts reverted to earlier magnitudes (from 3,576 users in 2010 to 2,307 in 2012). The period nevertheless marks a qualitative shift: more projects began to integrate *co-designed* methods formally, combining small design workshops with medium-sized field trials. A project which engaged 24 participants in co-design and 70 in testing, illustrates this approach. Average users per project stabilized between 70 and 160, and the median began a gradual increase, moving from 49 in 2010 to 55 in 2011 and 55 again in 2012, suggesting more consistent inclusion levels across projects.

A second swell occurred in 2013, with a total of 13,657 users, but again this was largely due to one project which alone registered nearly 11,000 participants. The median number of users per project dropped to 46, highlighting that most projects in this cohort operated on a much smaller scale than the headline figures suggest.

From 2014 onwards, totals decline steadily, as the focus converges toward smaller, longitudinal pilots integrated into real care settings, often requiring intensive support and ethical approvals. Typical engagement formats now include six- to twelve-month home deployments, pragmatic controlled trials in rehabilitation or nutrition, and multi-stakeholder living labs in sheltered housing.

Notably, despite ongoing fluctuations in total user numbers, the median number of users per project increased over time, rising from 30 in 2008 to 97 in 2014 and 130 in 2017, before stabilizing around 60–70 in the final years. This slow but steady increase in the median highlights a deepening of engagement practices: more projects consistently involved a meaningful number of users, even if none reached the massive scale of early outliers.

A closer look at the involvement of primary end-users (see Table 4) shows that the 2018 spike is again the arithmetical result of just two very large-scale, survey-driven projects rather than a systemic increase in hands-on testers. An initiative on age-friendly driver-assistance—collected 2 151 completed online questionnaires from older motorists as part of its requirements work, while another project drew on 1 274 respondents for an IoT home-safety concept. Together those two projects contribute well over 70 % of the 2018 total; most of the remaining twenty-five projects in the same cohort involved the familiar order of magnitude (20–120 seniors each) in living labs or longitudinal home trials.

Box 1: Summary of 2017 – 2021 evolution of primary end-user involvement

- 2017 (≈ 2 520 users) is dominated by multi-country market pilots that bundle and validate mature technologies: a project enrolled 281 seniors for a randomised cost-effectiveness study, while another involved 150 users in two-stage functional testing of a social-engagement app. Levels of participation are intensive—typically three to nine months at home—yet absolute numbers stay moderate because installation and support requirements are high.
- 2018, stripped of the two survey-heavy outliers, looks remarkably similar: *4 projects* exemplify the era's emphasis on dual-task training, chronic-pain management, voice interfaces, and digital storytelling, all run through controlled pilots in care homes or rural communities.
- 2019 (≈ 2 265 users) brings a slight contraction as funding pivots toward niche pathologies (post-stroke tremor, aphasia, grieving) and towards socio-economic tools such as senior entrepreneurship. Recruitment is still robust when implementation costs are low—*a project* used a gamified training platform to reach 218 seniors—but the median project again works with 30–70 active testers.
- 2020–2021 (≈ 2 150 and 1 100 users) reflect both programme maturation and the disruptive effect of the COVID-19 pandemic. Many pilots were postponed, shortened, or forced online; several projects explicitly report under-recruitment because ethics boards suspended in-person trials. Where numbers remain healthy—one project reached 385 frailty-screening participants, *another* enrolled 192 in home-based fall-prevention study—data were gathered largely through unobtrusive wearables or tele-assessment kits deliverable under lockdown constraints.

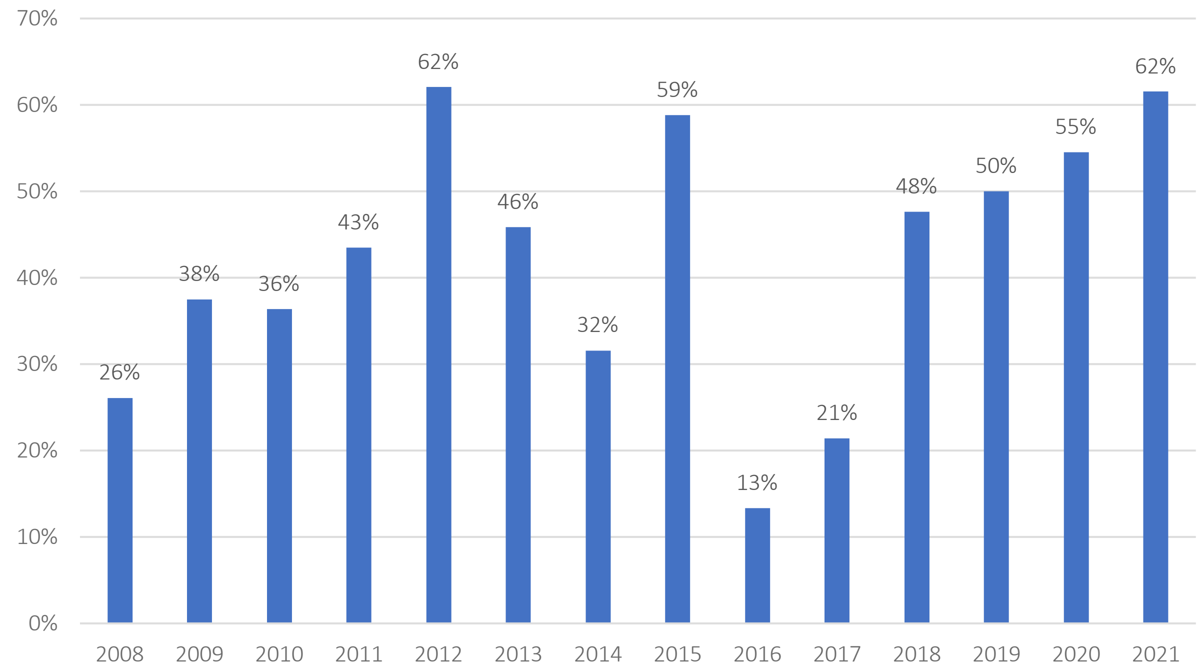
2.4.1.2 Co-design practices: increasing focus and temporary setbacks

This general maturation in primary end-user involvement is also visible in the increasing share of projects explicitly involving older adults in co-design activities.

- Co-Design Collaboration denotes a more upstream role, where end-users contributed to requirement analysis, participated in workshops, or engaged in iterative design cycles as co-creators.

In 2008, just 26% of projects reported co-design collaboration with primary end-users, yet the share doubled by 2012 and averaged 44 % in the 2015-2021 period. This growth mirrors the institutionalisation of Living Lab methodologies and the introduction of programme-level guidance that rewarded participatory design plans. Large, multi-country projects embedded sustained user workshops and iterative co-creation sessions, moving end-users from passive testers to joint authors of system specifications, interface choices and feature priorities.

Figure 6: Evolution in share of projects indicating primary end-user involvement in Co-Designing



The upward trend was not linear, however. There were notable dips in 2016 (13%) and 2017 (21%), driven by two specific call contexts (see *Box 2*):

- In 2016, projects targeting dementia faced ethical and cognitive constraints, which limited direct co-design with primary users. Instead, many consortia worked with caregivers as proxies.
- In 2017, the focus shifted to near-market integrated solutions. As many projects were based on pre-existing technologies, they had less scope for participatory design, prioritising large-scale deployment over exploratory workshops.

These temporary reversals, however, do not contradict the broader trajectory. Instead, they reflect adaptive strategies in response to specific challenges. Outside these two years, the proportion of projects engaging primary end-users in co-design steadily rose, especially from 2018 onwards, reaching or exceeding 50% in the last four calls.

Box 2: Reasons for the co-design percentages dip in 2016 – 2017

2016: a dementia-centred call that pushed co-design upstream to caregivers

The AAL Programme's 2016 call "Living well with dementia" explicitly targeted technologies for people with dementia and mild cognitive impairment.

Projects therefore had to negotiate two structural hurdles:

1. Ethical and cognitive constraints on direct involvement.

   Early-stage co-design workshops or requirements sprints are hard to run with participants who may experience fluctuating attention, memory problems, or decisional capacity. Ethics committees in several consortia consequently advised limiting primary-user workshops or replacing them with observation and testing.

2. Proxy design logic.

Because day-to-day care decisions are often taken by relatives and professional carers, consortia leaned on these secondary users as stand-ins for the person with dementia at the concept stage. That move is visible in the data: only **~13 %** of 2016 projects report primary-user co-design, while **67 %** engaged caregivers in that role.

The net effect was a mirror image pattern: rich participatory activity with caregivers but mostly tester-level participation for people with dementia themselves.

2017: a shift to "integrated, near-market packages" dampened co-design across the board

The subsequent call re-oriented funding towards "AAL Packages / Integrated Solutions"—essentially bundling mature components and demonstrating market readiness. Consortia were encouraged to start from existing products, add a service wrap-around, and run multi-country effectiveness pilots.

Implications for participation

- Design choices were largely set in advance, with core technology defined prior to grant submission. There was generally limited scope—or budget—for additional co-creative cycles during the project, though some opportunities for co-design have remained depending on the specific package and approach.
- Pilot logistics trumped exploratory workshops. Resources flowed to recruiting large cohorts (many studies exceeded 250 end-users) and to regulatory/installation tasks, leaving little time for iterative co-design.
- Caregiver involvement also fell. Because the 2017 solutions were aimed at relatively healthy seniors living independently rather than high-burden caregiving contexts, even secondary users were consulted mainly for usability tweaks.

While total user counts fluctuated, a growing number of projects consistently applied participatory design methods and reached meaningful scales of engagement. The AAL Programme thus fostered not just broader involvement, but deeper, earlier, and more systematic integration of primary end-users into the innovation process.

2.4.1.3 Other forms of engagement

As the AAL Programme matured, the ways in which older adults were involved in projects evolved beyond traditional testing roles. To track this evolution, we distinguish four main forms of end-user engagement, each reflecting a different depth and timing of involvement in the innovation process. Apart from *Co-Design Collaboration* (defined in the previous section), the following three forms are introduced here:

- Consultative Involvement captures instances where older adults provided input via surveys, interviews, or focus groups, without being directly involved in the design or testing phases.
- Active Testing Participation refers to situations where end-users acted as primary evaluators of working prototypes, typically during field trials or lab-based usability testing.
- Feedback Provision involves structured post-trial evaluations, often in the form of satisfaction surveys, rating systems, or qualitative assessments conducted after solution deployment.

These categories are not mutually exclusive —many projects combined multiple approaches at different stages—but they help to illustrate shifting engagement strategies over time.

Primary end-user involvement across the study period has been dominated by *Active Testing Participation*, yet the profile of engagement has diversified as programmes have matured. From 2008 to 2014 virtually every project relied on older adults as primary evaluators of working prototypes in field trials or laboratory tests. The projects launched in those years were technology-driven and needed large pools of testers to demonstrate technical feasibility and clinical or functional validity. After 2015, the proportion of projects using this form of involvement slipped to about 92 %, reflecting a gradual shift from proving concepts toward optimising already validated solutions. Several later-stage initiatives continued to recruit substantial cohorts, but some consortia adopted shorter "in-the-wild" pilots or focused their resources on design refinement instead of large-scale trials, explaining the modest decline.

Table 5: Evolution in share of projects indicating tertiary end-users' engagement, by form of engagement

Call year	Consultative Involvement	Active Testing Participation	Co-Design Collaboration	Feedback Provision
2008	9%	100%	26%	17%
2009	19%	100%	38%	19%
2010	23%	100%	36%	18%
2011	22%	91%	43%	9%
2012	0%	90%	62%	3%
2013	17%	96%	46%	33%
2014	16%	100%	32%	21%
2015	18%	100%	59%	29%
2016	13%	93%	13%	7%
2017	7%	93%	21%	21%
2018	5%	90%	48%	14%
2019	6%	100%	50%	17%
2020	18%	86%	55%	5%
2021	23%	85%	62%	0%
Mean over period	**14%**	**95%**	**43%**	**15%**

Consultative Involvement—survey, interviews or focus-group input without direct participation in design or testing—remained a minority pathway throughout. Its share fluctuated between 5 % and 23 % and averaged just under 13 % in the later years. Peaks in 2010 and 2021 arose when programmes canvassed broad user panels at the scoping stage before deciding whether full trials were warranted. The abrupt absence of this category in 2012 coincides with a funding call that explicitly prioritised either co-design or field validation, leaving less room for purely consultative studies. Overall, consultative approaches appear to complement rather than replace deeper engagement: consortia that began with questionnaires often progressed to workshops or pilots once feasibility was established.

Feedback Provision, defined as structured post-trial evaluations, remained modest (total share ≈ 15 %). Where it peaks—most visibly in 2013 and 2015—it does so at the end of multi-phase projects that sought quantified satisfaction ratings or qualitative reflections to inform exploitation strategies. Its subsequent decline reflects a procedural change: instead of waiting until trials concluded, most consortia folded feedback loops into earlier co-design or continuous testing cycles, thereby reducing the need for standalone ex-post surveys. The complete absence of this category in 2021 is therefore less a withdrawal of user voice than evidence that feedback had already been captured inside ongoing participatory processes.

2.4.1.4 Conclusion

Throughout the period, certain patterns of mobilisation remain constant. Initial contact is frequently brokered by senior organisations, care cooperatives, or disease-specific charities. Conception and requirements activities rely on small groups (10-30 people), whereas testing and evaluation phases expand to 50-100 users for controlled trials and can exceed several hundred when digital platforms are opened to the public. Large-numerosity projects almost always involve digital services that scale easily—social networks, cognitive games, or mentoring platforms—rather than hardware-centred pilots that demand installation and support.

The trajectory of primary end-user involvement reflects the programme's learning curve. After an early phase characterised by a few very large online communities, AAL projects progressively converged on smaller but more intensive user engagement, with richer co-design practices and longer real-life validations. The year-on-year fluctuations are evidence of an evolving innovation model—one that increasingly values depth of participation and demonstrable impact over sheer reach.

2.4.2 Secondary end-users

2.4.2.1 Participation Patterns and Shifts in Scale (2008–2021)

Secondary end-users—formal and informal caregivers, family members, friends, volunteers, service providers and other organisations that interact directly with older adults—are the group that AAL projects rely on both as co-beneficiaries of technology and as crucial intermediaries in its adoption. Between the first AAL calls in 2008 and the most recent cohort in 2021, more than 14 000 such individuals were involved in funded projects, an average of 48 per project.

Participation rose unevenly, shaped less by a steady year-on-year expansion than by the occasional presence of very large-scale pilot studies. However, looking at median values rather than just averages helps clarify a key trend: in the second half of the programme, the typical scale of participation per project increased meaningfully.

After a relatively modest start (625 participants in the 2008 cohort), the number climbed to almost a thousand in 2009 before surging to 1 614 in 2010. That spike was driven chiefly by a single safety-and-tracking project, which alone recruited more than 1 300 professional caregivers and shop assistants, accounting for over four-fifths of that year's total. Once this outlier cohort progressed into its implementation phase, numbers dropped back to 572 in 2011 and then stabilised at 850-870 in 2012 and 2013.

A second surge occurred in the 2014 cohort (1 869 secondary users). Again, a handful of projects dominated: a project involved some 628 informal carers role-playing service brokerage scenarios, while others each added well over a hundred participants. The following year saw a sharp correction (444), reminding us that most AAL pilots still rely on small, intensively supported groups.

Table 6: Evolution of secondary end-user involvement

Call year	Total number of secondary end-users per call year	Average	Median	No Projects	Data coverage (a)
2008	625	27	39	23	100%
2009	985	31	34	32	100%
2010	1 614	73	28	22	100%
2011	572	24	21	24	96%
2012	868	30	26	29	100%
2013	859	36	21	24	100%
2014	1 869	98	67	19	95%
2015	444	26	32	17	100%
2016	1 083	72	52	15	100%
2017	391	28	50	14	100%
2018	419	20	30	21	100%
2019	2 823	157	45	18	95%
2020	964	44	45	22	92%

2021	448	34	25	13	59%
Total	**13 964**	**48**	**34**	**293**	**95%**

(a) This column indicates the percentage of projects for which the data is available.

Another significant rise occurred in 2016 (1,083 participants), driven by dementia-focused pilots. While the average number of participants was 72, the median also reached 52, suggesting that this increase was not limited to a few large outliers, but reflected broader scaling across many projects. In earlier years, peaks in participation often reflected one or two oversized pilots, but from 2014 onward, more projects were consistently engaging secondary users on a larger scale.

The data from 2017–2020 reinforce this shift: though the total number of participants dipped in 2017 and 2018 (to around 400 per year), the median remained relatively high (50 and 30, respectively). The peak came in 2019, with 2,823 participants, mainly due to one project, which alone worked with over 2,000 carers. Importantly, even with this outlier, the median remained a solid 45, suggesting that many projects were scaling up rather than a single one inflating the total.

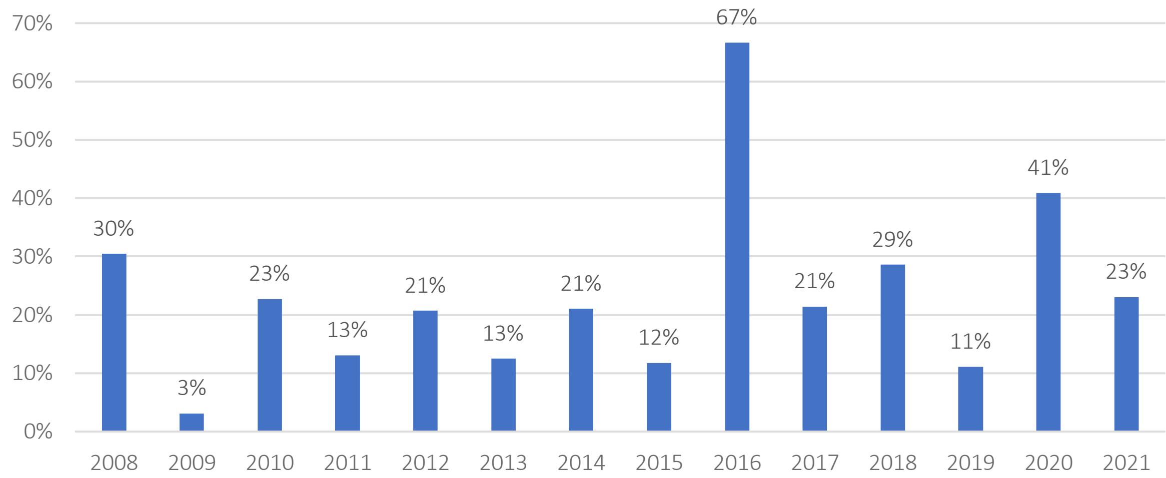
2.4.2.2 Co-design practices

Across the period, a common pattern of engagement is visible. Secondary users are most frequently consulted during early needs assessments (interviews, focus groups), then re-engaged as "active testers" during living-lab trials and longitudinal home pilots, and finally asked to provide evaluative feedback that informs service-model design. Fewer projects give secondary users sustained decision-making power; most classify their involvement as "consulted" rather than "co-designed". Typical formats include remote surveys, participatory design workshops, joint caregiver–elder dyad testing and blended online/offline training sessions. The data therefore confirm that while breadth of outreach has grown in absolute terms, depth of participation still varies widely and is heavily influenced by project size and methodological ambition.

Across all calls, just over one in five projects (22%) reported that secondary users were formally involved in co-design activities that gave them direct influence over solution specifications or interface choices. Early cohorts show uneven adoption: 30 % in 2008 but only 3 % in 2009, suggesting that participatory design was not yet embedded in proposal templates. From 2010 onward the share fluctuated between 12 % and 29 %, with three notable exceptions.

- 2016 (67 %) marks a breakthrough year. A cluster of dementia and frailty projects deliberately structured iterative cycles in which carers helped draft user stories, refine interaction scenarios and agree evaluation metrics. The unusually high percentage reflects both the thematic concentration of the call and the funding agency's emphasis on user-centred design in its evaluation criteria.
- 2020 (41 %) again shows an elevated proportion. Here, mixed-reality pilots and integrated care platforms adopted agile co-creation sprints, made feasible by the remote collaboration practices that became commonplace during the pandemic.
- 2009 (3 %), by contrast, illustrates how limited awareness and methodological guidance can translate into tokenistic, late-stage consultations with carers rather than substantive co-design.

Figure 7: Evolution in share of projects indicating secondary end-users' involvement in Co-Design



Overall, the longitudinal picture is encouraging: the share of projects engaging secondary users as genuine design partners has increased compared with the programme's early years. Nonetheless, the majority of projects continue to rely on episodic feedback rather than sustained power-sharing.

2.4.2.3 Other forms of engagement (see Table 7 below)

Consultative involvement, the most traditional form of engagement, covers interviews, focus groups or advisory boards where carers give input but do not shape core decisions. At 49 % over the whole period, it consistently dominated the landscape and never dropped below 20 %. The series begins at 52 % in 2008, climbs to a plateau around the mid-fifties in most years, and records twin highs of 61 % in 2019 and 56 % in 2009. Stability confirms that consultation remains the low-cost, low-risk default for projects seeking legitimacy with end-user representatives without the logistical demands of co-design or long pilots.

Active testing participation refers to situations in which secondary end-users interact hands-on with prototypes during laboratory or field trials, generating performance and usability data. On average, 39 % of projects secured this level of commitment, but the trajectory was uneven. Early adoption was modest (26 % in 2008) and dipped markedly in 2010 (14 %), when short pilot cycles and limited hardware readiness constrained large-scale trials. From 2012 onwards, the proportion more than doubled, reaching 59 % in 2012 and peaking at 73 % in 2016 when many dementia-oriented platforms deliberately built full-scale living-lab pilots into their workplans. Values have since stabilised in the forties, suggesting that extensive field testing is now standard, though still responsive to project budgets and public-health restrictions that, in 2020, curtailed some in-person trials.

Table 7: Evolution in share of projects indicating secondary end-users' engagement, by form of engagement

	Consultative Involvement	Active Testing Participation	Co-Design Collaboration	Feedback Provision	Service Configuration Support
2008	52%	26%	30%	17%	17%
2009	56%	31%	3%	13%	3%
2010	55%	14%	23%	14%	9%
2011	52%	30%	13%	17%	0%
2012	55%	59%	21%	24%	3%
2013	54%	17%	13%	13%	4%
2014	47%	63%	21%	21%	5%
2015	29%	47%	12%	35%	12%
2016	20%	73%	67%	27%	7%
2017	50%	43%	21%	29%	14%
2018	52%	38%	29%	24%	5%
2019	61%	61%	11%	33%	11%
2020	41%	32%	41%	32%	14%
2021	46%	38%	23%	0%	15%
Mean over period	**49%**	**39%**	**22%**	**21%**	**8%**

Feedback provision captures post-implementation commentary, such as surveys after short demonstrations or remote trials that rely on questionnaires rather than direct observation. Its mean share of 21 % hides a clear upward drift: from 13-17 % in the first five years to 24-35 % between 2012 and 2020, reflecting the growing availability of online feedback tools and an emphasis on agile iteration. The abrupt figure of 0 % in 2021 might be an artefact of the reporting cohort, many of whose projects had not yet completed a cycle long enough to collect summative feedback. Continual feedback loops appear increasingly valued, but they require explicit scheduling in work packages and should be safeguarded when pandemic-era remote protocols predominate.

Service configuration support—where carers help tailor parameters or rules in deployed systems—remains comparatively rare, averaging 8 %. Levels were negligible in the programme's first half, rose gradually with the spread of dashboard-driven platforms after 2014, and reached 15 % by 2021. The upward direction mirrors the technical shift from monolithic devices toward configurable ecosystems that place caregivers in day-to-day support roles. Low absolute incidence indicates latent potential: without training and easy-to-use interfaces, many projects still default to professional technicians for configuration tasks, missing an opportunity to embed solutions sustainably within existing care routines.

2.4.3 Tertiary end-users

Tertiary end-users are the public or private organisations that organise, finance, or regulate AAL solutions—municipal departments, social-security bodies, insurers, housing corporations, care operators, and the like—whose benefit comes from efficiency gains rather than from using the product themselves. Involvement of these actors typically took the form of consultation, co-design, or collaboration on service configuration, ensuring that solutions could integrate with existing care ecosystems or public service frameworks.

Across the 2008-2021 period, they were involved in 115 of the 295 analysed projects (39 %) but their contribution intensified over time: from roughly one quarter of projects in the first four calls to more than half by the late 2010s, before retreating again in the final pandemic-affected cohort.

The first phase (2008-2011) is characterised by experimental pilots in which tertiary actors were mostly consulted to secure access to patient populations or data; annual participation fluctuated modestly between 22 % and 31 %. Municipal health departments and public health insurers dominated this early engagement because projects required permission to connect tele-medical prototypes to existing COPD or dementia services, while private companies were still evaluating the market.

Table 8: Evolution in share of projects involving tertiary end-users

Call year	Number of projects involving tertiary end-users	Share of projects involving tertiary end-users per call year
2008	6	26%
2009	10	31%
2010	5	23%
2011	5	22%
2012	15	52%
2013	8	33%
2014	10	53%
2015	8	47%
2016	5	33%
2017	4	29%
2018	11	52%
2019	12	67%
2020	12	55%
2021	4	31%
Total	**115**	**39%**

A clear inflection occurs in 2012, when involvement leaps to 52 %. That call encouraged large-scale pilots on integrated care and caregiver support, and municipalities appeared in more than 30 % of projects, joined by social insurers and food-service providers. The public sector's coordinating role made it a natural gateway for testing service packages that blend home sensors, community nursing, and informal care networks.

After a consolidation year in 2013 (33 %), engagement rises again to 53 % in 2014. Housing operators, social-care regulators, and health ministries entered consortia to align smart-home pilots with local "age-friendly city" strategies; consequently, government or municipal bodies featured in 42 % of that cohort and healthcare systems in one project out of five. Although private companies were still a minority partner, their participation began to broaden from 0 % in 2011 to 10 % in 2012 and 4 % in 2013 as platform ventures sought employers and insurers willing to validate new business models.

The subsequent dip in 2015-2017 (47 %, 33 %, 29 %) reflects calls that emphasised user-experience refinement rather than systemic deployment; tertiary participation was therefore limited to municipalities hosting demonstrations of virtual assistants, dementia support, or retail-link solutions. These institutions lent legitimacy and facilitated recruitment but were rarely asked to reshape their own service workflows, which kept involvement largely consultative.

A second surge starts in 2018 (52 %) and culminates in 2019, the peak year at 67 %. Three factors stand out in the detailed data. First, almost half of the 2019 projects enlisted government bodies to facilitate city-wide pilots of robotics and digital driver coaching. Second, hospitals and other healthcare systems were involved in one third of projects as remote monitoring moved closer to clinical routine. Third, insurers and other financial actors appeared in 28 % of projects—five times their average share—because risk-stratification services (e.g. a project for driving safety, another for tremor management) promise direct cost savings. Private sector companies as primary tertiary partners remained comparatively rare; where they did rise—most visibly to 13 % in 2009 and 10 % in 2012—it was when ICT start-ups needed telecom or media firms to commercialise set-top-box or interactive-TV solutions, not in 2013 as was sometimes suggested.

This high level is broadly maintained in 2020 (55 %) thanks to research-intensive collaborations with hospitals, pharmacies and rehabilitation insurers on frailty detection or VR therapeutics. In 2021, however, the share falls back to 31 %. Fewer large pilots were launched during the COVID-19 restrictions, and those that did proceed—tele-rehabilitation, AI matchmaking against loneliness leaned more on specialised care providers than on municipal or financial systems.

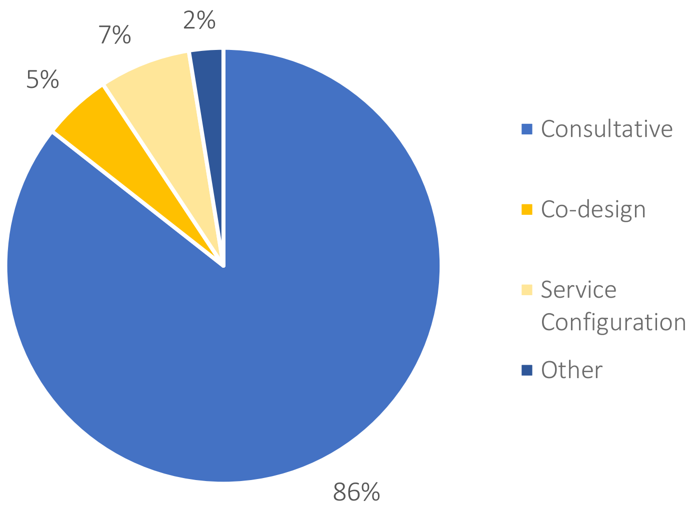
Table 9: Evolution in share of projects involving Tertiary users, by user type

Call year	Government and Municipal Authorities	Healthcare Systems and Medical Institutions	Insurance and Financial Institutions	Private Sector Companies	Housing and Social Services Organizations	Research and Educational Institutions
2008	17%	4%	13%	0%	0%	0%
2009	19%	9%	9%	13%	0%	0%
2010	9%	5%	5%	0%	9%	0%
2011	22%	9%	0%	0%	0%	0%
2012	31%	14%	10%	10%	0%	0%
2013	17%	4%	8%	4%	4%	8%
2014	42%	21%	11%	0%	5%	0%
2015	24%	12%	6%	0%	6%	0%
2016	27%	7%	13%	0%	0%	0%
2017	14%	21%	7%	0%	0%	7%
2018	43%	10%	10%	5%	5%	0%
2019	44%	33%	28%	6%	6%	6%
2020	27%	18%	18%	5%	5%	0%

2021	15%	15%	15%	0%	0%	0%
Mean over period	25%	12%	11%	4%	3%	1%

Across the whole programme, the mode of engagement remained predominantly consultative: 101 of the 118 documented interactions (about 85 %) involved advisory roles, ethical clearance or access to facilities and data. Only six cases used genuine co-design, typically when municipalities hosted living labs that invited administrators into requirements workshops. Eight instances of service-configuration partnership arose when projects entered pre-commercial procurement stages and needed insurers or social-housing operators to adapt reimbursement or maintenance processes. These deeper forms of participation cluster in years with higher overall shares, illustrating that once organisations were persuaded to join, some progressed from consultation to more operational involvement.

Figure 8: Types of engagement with tertiary end-users in projects involving these end-users (over 115 projects)



Tertiary end-user participation in AAL projects has moved from occasional advisory input to a mainstream expectation, particularly when calls emphasised integrated service delivery or measurable economic impact. Government and municipal authorities have been the constant backbone of this trend; peaks in healthcare and insurance participation track the growing maturity of clinical tele-monitoring and risk-based business models. Where involvement waned, it was usually because project topics shifted back toward user-interface refinement or pandemic-era constraints limited large-scale deployment.

2.5. **Q5:** What factors influenced changes in end-user involvement?

Analysis of the full cohort of AAL projects funded between 2008 and 2021 shows that shifts in the depth and breadth of end-user involvement were driven by a constellation of factors operating at project, programme, and contextual levels.

Foremost among them were *legal and ethical compliance obligations*. From the early refusal of Swiss field trials to the pan-European GDPR alignment exercises that delayed recruitment and forced projects to postpone voice-interaction pilots, privacy and data-protection rules repeatedly determined when older adults and carers could even be approached. Once some prototypes were reclassified under the Medical Device Regulation, consortia had to redesign studies mid-stream, demonstrating how regulation can at once broaden stakeholder rosters—by bringing clinicians and compliance officers into planning—yet compress the time available for iterative feedback. Across the sample, the share of projects in which privacy or ethics constraints demonstrably limited engagement rose from zero in 2008 to over thirty per cent in 2021, and only consortia that built privacy-preserving architectures from inception managed to preserve user trust when approvals lagged.

Internal design and governance choices exerted a second, equally decisive, influence. Whenever functional promises were withdrawn or altered without renewed consultation, user participation faltered. The removal of cardiac monitoring, the downgrading of smartwatch to GPS-only mode, and quiet switch from head-mounted displays to tablet screens all impacted the perceived value of co-design efforts and led to a reduction in substantive user feedback. Parallel effects followed methodological or scope pivots: a project's late shift from prevention to rehabilitation and another project's abrupt move from light therapy to aroma-based exercises required new consent procedures and compressed testing windows, limiting the quality of data harvested. Although such divergence occurred in only thirteen per cent of projects overall, its impact was disproportionate because it tended to surface after expectations had been carefully nurtured.

Consortium stability and technical reliability acted as enabling conditions—or critical points of failure—for sustained engagement. In several early calls more than a quarter of projects lost a key partner, and while the incidence has since fallen, recent cases show that sudden partner exits still cascade into cancelled trials, shortened study periods and participant dropout. Technical malfunctions had comparable consequences. In every year at least one project in three reported major reliability or supply-chain setback. Several initiatives encountered major hurdles when transitioning from lab to real-world settings: one vision-based system failed during in-home trials, another mobility-assist device proved impractical for daily use due to its weight, and a third pilot program was discontinued after its commercial wearable component became unavailable. These cases underscore the fragility of deployment pipelines when reliant on emerging or market-dependent technologies. Such disruptions meant that older adults and caregivers were sometimes asked to evaluate devices that arrived late, worked only intermittently, or could be demonstrated only in laboratory settings, drastically narrowing the window for authentic engagement.

Sustainability planning—or its absence—decided whether participation could continue once public funding ended. Projects that reached the grant's final review without a credible route to market, liability framework or maintenance plan saw involvement halt abruptly. Two Projects delivered prototypes that care organisations valued but provided no adoption pathway, while another project delayed legal documentation and therefore could not commercialise despite positive user feedback. Where crucial components vanished—a project's reliance on the discontinued Kinect sensor is emblematic—end-users were left without functional solutions even after successful pilots. Although the proportion of projects facing such post-grant obstacles declined after 2015, it remained high enough to threaten continuity in more than one project in six in 2019.

The degree to which projects *embedded into the broader care ecosystem* proved equally important. When municipal authorities, insurers, professional providers, or technology vendors were absent or involved only perfunctorily, pilot findings could not be translated into services that fit established workflows and reimbursement streams. A project's remote-monitoring platform, for example, excluded long-term-care payers from co-design and consequently struggled to find a financing mechanism; another project (2020) recruited nearly a thousand users yet reported unresolved intellectual-property and service-provider agreements that limited real-world adoption. Over the programme's lifespan roughly one third of projects each year suffered from such stakeholder-integration gaps.

Several cross-cutting *social and linguistic factors* amplified or attenuated these structural drivers. Projects that neglected cultural and linguistic adaptation routinely encountered recruitment and retention problems: A project's French-only manuals hindered Italian fieldwork, another project lost two-thirds of its Portuguese cohort after mistranslated food-logging screens caused confusion, and another project (2021) had to rewrite bedtime prompts judged culturally intrusive. Conversely, a project's speech assistant, which tuned recognition for four languages and regional accents, and a project's adaptive interface layer both recorded sustained engagement attributable to linguistic tailoring. *Digital literacy* shaped participation just as strongly. The 2009 loneliness call achieved large, diverse cohorts because living-lab budgets funded in-person coaching, whereas many of the post-2018 Small Collaborative Projects, reliant on rapid cloud-based feedback loops, skewed towards tech-savvy seniors and under-represented less connected groups despite high nominal numbers. *Geographic and infrastructural* inequities also mattered: a project abandoned its Irish and Portuguese sites when connectivity proved inadequate, and another project reported that mobile-data costs deterred low-income users regardless of usability merit. Moreover, perceived stigma and threats to autonomy suppressed engagement even when technical and linguistic barriers were low; projects that framed monitoring devices as wellness aids generally secured higher consent than those emphasising fragility or risk. This indicates that acceptance is much higher when solutions are presented in ways that support independence and avoid associations with age-related decline.

Programme governance and funding instruments mediated many of these effects. Calls that explicitly financed the participation of payers, employers or community volunteers broadened involvement, while those that privileged rapid prototyping under compressed timetables narrowed it. The 2009 loneliness theme, for instance, funded living-lab infrastructures that made large, heterogeneous samples feasible, uncovering hidden literacy barriers in the process. By contrast, the consumer-IoT Call of 2015 introduced explicit retail-integration KPIs—requiring projects to secure distribution partners and demonstrate plug-and-play usability. This drew smart-home vendors into co-creation workshops but tended to privilege digitally fluent seniors, in line with the lead-user approach promoted in the AAL end-user toolkit, who were better equipped to engage in short-cycle testing and feedback loops. Mandatory user-involvement metrics introduced in 2017 and formal ethical guidelines from 2020 improved retention by standardising consent, data handling, and accessibility, yet emergency COVID-19 grants in 2020 compressed cycles so sharply that depth sometimes fell even as headline participation rose.

External market, regulatory and societal shocks added further layers of complexity. The tightening privacy regime both slowed pilot launches and compelled consortia to invite clinicians, payers, and legal experts into early planning, thereby broadening stakeholder rosters even as end-user sessions were delayed. Requirements in the AAL calls for shorter time to market drew insurers and system integrators into half of the 2018 projects, helping to align prototypes with reimbursement pathways but also steering attention toward short-term cost savings at the expense of less profitable user needs. Finally, the COVID-19 pandemic reconfigured engagement patterns by forcing remote interaction, creating new categories of informal co-designers—neighbours and community volunteers—yet excluding older adults without reliable connectivity and limiting hands-on testing of hardware solutions.

> *The evidence points to a hierarchical interplay of drivers. Legal and ethical compliance is the primary gatekeeper: without timely approvals, direct engagement cannot begin. Project-level design discipline, consortium stability and technical readiness determine how intensively users can participate once the gate is opened, while sustainability planning conditions whether that participation endures beyond the funding period. Programme-level design, through call themes and funding rules, decides which stakeholder categories are present at all, and linguistic, cultural, literacy and infrastructural contexts shape who within those categories is actually able and willing to engage. External market forces and societal shocks modulate both pace and inclusiveness across all layers.*

2.6. **Q6:** What are the key learnings on pitfalls and good practices in end-user engagement?

2.6.1 Four clusters of pitfalls

A first and still underestimated lesson concerns *the composition and stability of the test population*. In the early calls, more than half of all projects were forced to draw conclusions from samples that were too small, too healthy or too digitally confident to represent Europe’s older adults as a whole, and the problem never vanished altogether re-appearing in 60 percent of 2016 proposals and spiking again in the pandemic year of 2020. Attrition almost always rose when prototypes malfunctioned or when participant expectations were dashed by late design pivots. Conversely, the consortia that invested in broader outreach—visiting rural community centres, translating onboarding material, budgeting for travel companions, mailing “COVID-safe kits”, and offering voice as well as touch interfaces—retained cohorts for six to twelve months longer than the programme average and captured edge-case insights that later proved critical for mainstream adoption. The statistical pattern is clear: demographic breadth is inseparable from technical readiness, because frailer and less tech-savvy users will not stay in the course when devices reboot unpredictably or require complex resets.

A *second insight is temporal*. Projects that waited to involve older adults until a nearly finished prototype existed rarely managed to retrofit fundamental changes when usability flaws emerged. When user recruitment occurred in the opening quarter, and where at least two full design-feedback-redesign cycles were scheduled before field pilots, the rate of late-stage change requests fell by roughly a third and reviewer confidence in the evidence base rose sharply. This positive effect appeared regardless of domain—tele-rehabilitation, social connectedness, smart housing—suggesting that the underlying mechanism is generic: continuous dialogue keeps expectations realistic and allows incremental adjustment long before regulatory or budgetary constraints harden the architecture.

Economics provides the third, macro-level lesson. *An unverified route to value* was present in roughly one project in five and proved fatal more often than any single technical flaw. Whenever the consortium failed to treat insurers, municipalities or care providers as partners, all subsequent end-user feedback lost persuasive power, because there was no party prepared to finance or procure the service. Projects that invited payers from day one, circulated early ROI calculators and iterated business logic in parallel with interface mock-ups recorded markedly smoother transitions into open pilots and were the only group to sign post-grant deployment contracts while review teams were still on site. The conclusion is straightforward: unless purchasing and reimbursement stakeholders help shape the service, even excellent usability cannot guarantee real-world impact.

The fourth lesson *addresses ethics and data protection*. Although explicit breaches were rare, any ambiguity around informed consent, GDPR compliance or medical device classification triggered recruitment delays that compressed testing windows and sometimes forced the elimination of entire pilot sites. By contrast, projects that published plain-language data-flow diagrams, obtained multi-site ethics clearance in advance and allowed participants to modify—or withdraw—permissions from inside the application saw not only faster approvals but also higher enrolment from carers, who are often gatekeepers for frailer users. Ethical transparency therefore acts less as an administrative hurdle and more as a confidence multiplier that broadens participation and deepens the quality of feedback.

2.6.2 Five themes of successful user engagement

From these hard-won lessons, five clusters of good practice have crystallised.

1. First, *continuity of engagement* matters more than the sheer number of touchpoints. The projects that kept the same community of older adults, caregivers and professionals involved from requirements captured through to real-life validation generated feedback loops that demonstrably changed screens, sounds and service flows between iterations, reinforcing trust and lowering dropout.
2. Second, *naturalistic or "living-lab" testing has proven indispensable* because it exposes the mundane but decisive realities—unstable Wi-Fi, dim corridor lighting, lunchtime staffing gaps—that laboratory protocols cannot reproduce.
3. Third, *flexible participation channels*—parallel voice, touch, large-font web, paper questionnaires and asynchronous video—have repeatedly offset digital-literacy gaps and allowed studies to continue during lockdowns; they are especially powerful when backed by localisation into multiple languages and when carers receive their own, tailored dashboards.
4. Fourth, *modular architectures and phased rollouts* enable older adults to start with a single, low-risk feature and layer complexity only when benefit has been demonstrated, thereby avoiding the overwhelm that doomed several early VR and robotics pilots.

5. Finally, *formal governance*—user-involvement KPIs, tamper-proof consent logs, sustainability scorecards, and open-API certification—provides the institutional scaffolding that translates the goodwill of co-creation into deployable, maintainable services.

The interplay of these elements is cumulative. *A project that combines broad, representative recruitment; continuous, evidence-based redesign; early economic validation; transparent ethics; and ecosystem-level governance creates reinforcing feedback loops*. Technical reliability draws in more diverse users, whose nuanced insights drive interface refinements, which in turn increase satisfaction and reduce support costs, making the value proposition clearer to payers who then commit to post-grant uptake. Where any link in this chain fails—an unstable prototype, a missing stakeholder, an ambiguous consent form—momentum reverses just as quickly, leading to shallow engagement, weak evidence, and limited sustainability.

> *Sixteen years of evidence show that authentic involvement of Europe's older citizens is neither a soft add-on nor a box-ticking exercise. It is a disciplined, multi-layered process that must weave together inclusive recruitment, iterative design, ethical transparency, economic realism, and ecosystem governance. Where that weaving is tight, projects deliver technologies that seniors continue using and organisations continue to purchase long after the funding period ends. Where the weave is loose, even the most imaginative prototypes risk becoming "orphans" the day the grant closes.*

2.7. **Q7:** How did the addressing of the larger ecosystems evolve?

The AAL Programme was not only concerned with end-user needs but also with embedding its solutions into the wider health, care, and social support ecosystems. This chapter examines how the involvement of broader stakeholders—such as care organisations, municipalities, insurers, and public authorities—evolved over time. It explores (i) who was expected to finance and implement AAL solutions, (ii) how project consortia structured their ecosystems, and (iii) what forms of collaboration continued beyond the funding period. Drawing on structured project data and support actions like AAL2Business and the AAL Forum, the following sections trace the gradual shift from isolated pilots to more systemic, multi-actor integration efforts.

2.7.1 Patterns in "who pays" and "who decides"

A consolidated dataset drawn from Final Project Reports captures the share of projects that, at proposal or closure, expected each stakeholder group to **pay** for —and/or **decide** on purchasing—AAL solutions. To avoid over-interpreting annual variation in a programme with 15–30 projects per call, the figures below are averaged across three broad periods:

Table 10 : Evolution of Payer and Decision-Maker Roles by Stakeholder Group (2008–2020)

Stakeholder group	Early calls 2008-11 (n=102)	Mid-phase 2012-15 (n=90)	Late phase 2016-20 (n=93)
Primary end-users (older adults) — *payer*	**64 %**	37 %	44 %
… — *decision-maker*	**63 %**	39 %	45 %
Informal carers — *payer*	**48 %**	39 %	36 %
… — *decision-maker*	**56 %**	44 %	39 %
Formal carers / care organisations — *payer*	48 %	37 %	**60 %**
… — *decision-maker*	53 %	38 %	**59 %**
Public subsidies / authorities — *payer*	33 %	32 %	25 %
… — *decision-maker*	25 %	22 %	24 %
Insurance companies — *payer*	34 %	20 %	30 %
… — *decision-maker*	26 %	15 %	23 %
"Other / hybrid" models — *payer*	36 %	**41 %**	28 %

Key observations:

- Reduced—yet still sizeable—reliance on individual purses. In the programme's first calls, roughly two-thirds of projects expected older adults to pay and decide. That share almost halved by 2012-15 and has since stabilised below 50 %. Thus, B2C still features prominently, but far less dominantly than at the outset.
- (Re-)Ascendancy of formal care organisations. After a dip during 2012-15, hospitals, home-care agencies and residential providers became the clear front-runners in 2016-20, appearing in ≈ 60 % of projects as both payers and deciders. This still aligns with the 2014 "Care for the Future" call and later requirements for integration into service delivery models.
- Public authorities plateau, then decline. Public payers hovered around one-third of projects in the first two periods but dropped to one-quarter in 2016-20, suggesting that tighter evidence demands (e.g. under the 2017 "Integrated Packages" call) cooled initial municipal enthusiasm.
- Insurance engagement remains cautious but rebounds. Insurers' share fell sharply in the middle period and only partially recovered later, confirming a continued "pilot-heavy, roll-out-light" pattern.
- Hybrid models peak mid-programme. Experimentation with cooperative, subscription and blended public-private models was most common in 2012-15 (41 %), before calls began insisting on firmer business plans.

2.7.2 Understanding and structuring of ecosystems

2.7.2.1 Early exploratory phase (Calls 2008-11)

- Ecosystems were understood mainly as multi-disciplinary project consortia. Calls mandated SMEs and end-user organisations and encouraged Living-Lab-style pilots.
- The language of primary / secondary / tertiary end-users emerged gradually; by 2010 the Annual Report was formally counting tertiary actors such as insurers and municipalities, although their absolute numbers were still low (≤1 % of end-users).
- Post-project continuation was already visible (75 % of 2008 projects retained links with secondary users), but often informal and localised.

2.7.2.2 Market-oriented consolidation (Calls 2012-15)

- Call 2012 placed informal carers centre-stage, signalling a shift from single-user devices to networked service models.
- Call 2014 ("Care for the Future") reframed projects as levers of system sustainability, explicitly naming tertiary end-users as "critical enablers". The share of projects involving public payers as stakeholders or target customers reached its mid-period peak.
- Support actions (AAL2Business, Collaboration-with-Regions) began to operate alongside R&D calls, illustrating a programme-level move from project ecosystems to a programme ecosystem of funding, business coaching and regional matchmaking.

2.7.2.3 System-integration and ecosystem activation (Calls 2016-21)

- The dementia-specific Call 2016 demanded trials in ≥ 2 countries within one year, rooting projects in multi-territorial testbeds. Tertiary-end-user participation jumped (e.g. 149 tertiary actors, 2.3 % of end-users).
- Call 2017 switched from "solutions" to integrated packages and required year-long, two-country evaluations, effectively formalising Living Labs as a default.
- Calls 2020 and 2021 made ecosystem tasks (stakeholder mapping, outreach, best-practice exchange) an obligatory work package and adopted the WHO "healthy ageing" frame. The Annual Report 2021 documents dedicated ecosystem research, workshops and baseline mapping across 25 experts and 10+ member countries.
- Evaluation reports (2017, 2022) characterise a mature but still fragile ecosystem: demand-side actors join pilots more readily, yet reimbursement fragmentation and the small scale of many SMEs continue to limit roll-out.

2.7.3 Continuation of collaboration after project completion

- Consistently high retention with primary/secondary users. Across surveys (2010, 2013, 2016 Impact Studies) roughly three-quarters of projects report continued collaboration with older adults or carers.

- Tertiary end-user retention improves but stays below ⅓. From 2008 to 2021 the share of projects maintaining links with insurers or public authorities stabilised around 30 %, despite targeted calls and support actions.
- Living Lab infrastructures endure. Several early pilots evolved into permanent test-beds—e.g. sensory rooms (Call 2016) and Dutch municipal pilots that feed into successive projects (2012, 2016, 2017).
- Spin-offs and platform reuse. Recurrent avatars sensor suites, or middleware stacks illustrate knowledge circulation across calls. Evaluation reports nonetheless note resource constraints for long-term maintenance and certification (e.g. MDR compliance after 2021).

2.7.4 Influence of AAL2Business, AAL Forum and other support actions on the ecosystem

2.7.4.1 AAL Forum → European Week of Active & Healthy Ageing (EWAHA)

- Scale and reach. Attendance grew from ≈400 (2009) to ≈800 (2017); online EWAHA editions kept numbers near 700 during COVID-19.
- Network effects. Post-event surveys show 80-90 % of participants broadened professional contacts; end-user organisations gained direct exposure to SMEs and investors they rarely meet elsewhere.
- Policy visibility. Forums became the main channel through which regional and EU-level actors (EIP-AHA, WHO) engaged with AAL outputs, fostering alignment on ethics, data privacy and healthy-ageing agendas.
- Limitation. The event still lacks structured follow-up mechanisms; without dedicated working groups or funded pipelines, many promising connections depend on individual initiative and may dissipate once the forum ends.

2.7.4.2 AAL2Business (inc. Lean-Start-up Academy & Go-To-Market Launchpad)

- Commercial readiness. 60-70 % of coached projects report improved business models; several cite AAL2Business as critical for investor pitches.
- Investor linkage. Over 30 AAL solutions presented to external investors through pitch events; a minority secured follow-on finance, but the pipeline and vocabulary for investment were established.
- Cultural shift. Evaluators note a move from early "naïve" reliance on public reimbursement to more diversified revenue thinking (subscriptions, B2B SaaS, blended financing).
- Limitation. More participants sought coaching that could be accommodated within the available resources; SMEs still struggle with regulatory capital and post-launch scaling, issues beyond AAL2Business' scope.

2.7.4.3 Other targeted support actions

Table 11: Ecosystem Support Actions: Contributions and Limitations

Support action	Main ecosystem contribution	Caveats
Market Observatory	First comparative data on AAL market segments and investor attitudes; informed later call texts.	Resource-intensive; paused without long-term host.
Collaboration with Regions	Match-made projects with regional buyers; introduced public procurement lens.	Impact clearer in networking than in revenue.
Standards & Interoperability studies	Produced integration profiles later reused in Calls 2017-20; lowered technical entry barriers for SMEs.	Adoption voluntary; no enforcement mechanism.
Ecosystem Research & Workshops (2021)	Mapped health-and-care ecosystems in >10 member states; baseline for post-AAL collaborations.	Late start leaves limited time to prove effect before programme close.

Overall influence. Support actions collectively:

- Professionalised business discourse in consortia, making robust value-chain analysis a de facto expectation.
- Expanded and connected stakeholder pools (investors, regions, carers' federations) that individual R&D projects rarely reach.
- Supplied soft infrastructure—guidelines, metrics, ethics frameworks—now referenced by projects bidding into Horizon Europe and national programmes.

2.7.5 Summary

Over its 14-year run, the AAL Programme moved from consortium-level cooperation to deliberate, system-oriented ecosystem building. Financing expectations shifted accordingly: direct consumer payment lost ground, while formal care organisations became the leading projected payers and deciders, even though insurers and public-authority buy-in remained cautious.

Living-Lab requirements, multi-country pilots, and mandatory ecosystem tasks embedded stakeholder activation into later calls. Post-project collaboration with users is widespread, yet durable engagement of institutional payers still depends on overcoming reimbursement fragmentation and regulatory costs.

Support actions—above all the AAL Forum/EWAHA series and AAL2Business coaching—provided the connective tissue that helped SMEs, end-user organisations and policymakers recognise shared interests, adopt common language, and progress towards commercial and systemic uptake. Their impact is most evident in improved business planning and stronger stakeholder networks. However, the key remaining challenge for any successor initiative is to convert these valuable relationships into large-scale deployments that are financially supported by payers such as healthcare providers or insurers.

Projects shifted from expecting older adults to pay directly toward embedding costs in the budgets of formal care organisations, which now stand out as the chief projected buyers. Living-Lab mandates, multi-country pilots and support actions widened stakeholder networks and strengthened business models, setting the stage for wider systemic uptake.

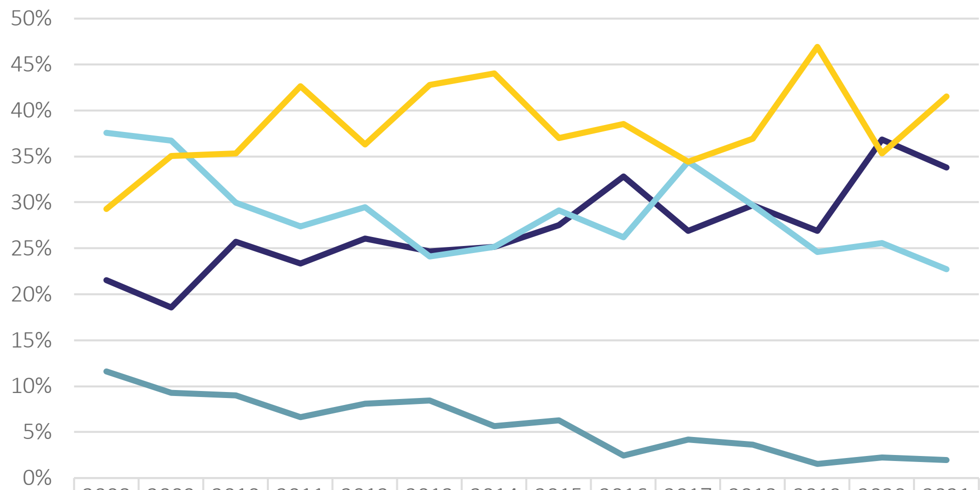
2.8. **Q8:** How did the AAL network evolve over time?

The AAL Programme's ambition to bridge research, market readiness, and real-world use was reflected in the composition of its funded consortia. This section examines how the network of participating organisations evolved over time: (i) which types of actors took part, (i) how roles like coordination shifted, and (iii) to what extent projects succeeded in balancing business, user, and research involvement. Through analysis of participant data, leadership trends, and policy levers embedded in call design, the following subsections trace a steady transformation—from research-led teams toward more user-inclusive and SME-driven consortia—with mixed results in engaging broader system-level stakeholders.

2.8.1 Who took part – and how did the mix evolve?

At launch, the programme set out to marry near-market agility with research depth. That balance is visible in the very first year: SMEs supply 29 % of partners (53), R&D institutes 38 % (68), and end-user bodies just above 20 % (39). What changes over fourteen calls is the relative weight of those ingredients.

Figure 9: Evolution of consortium composition by call (2008-2021)



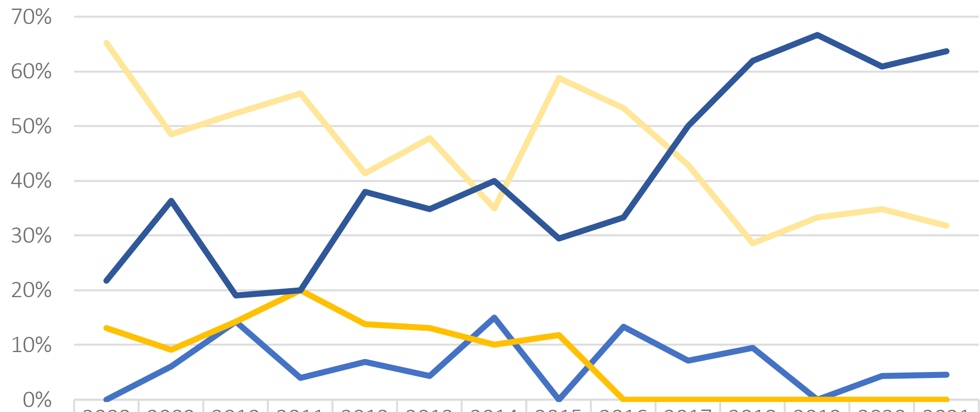
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
End user	22%	19%	26%	23%	26%	25%	25%	28%	33%	27%	30%	27%	37%	34%
Large enterprise	12%	9%	9%	7%	8%	8%	6%	6%	2%	4%	4%	2%	2%	2%
R&D	38%	37%	30%	27%	29%	24%	25%	29%	26%	34%	30%	25%	26%	23%
SME	29%	35%	35%	43%	36%	43%	44%	37%	39%	34%	37%	47%	35%	42%

- SMEs climb swiftly to the 40 % band and remain there. The 2013 interim evaluation already noted “approximately 40 %” SME participation, and the final evaluation of AAL2 confirms a virtually identical 40.3 % across 705 beneficiaries – proof that the stated policy target was met and then held.
- Research organisations taper slowly but consistently from 38 % in 2008 (68 of the 181 participating organisations) to 23 % in 2021 (35 of the 154 participating organisations). Nothing about the fall is abrupt; rather, each successive challenge call (from 2014 onwards) re-weights scoring toward business planning and market proximity, nudging coordinators to swap one laboratory seat for a business or user partner. By the late calls, research is still a large block, but the balance has tilted toward application.
- End-user organisations saw their share grow significantly, from high-teens in the early calls to the mid-30 %s in 2020–21. This long-arc gain lines up with recurring recommendations – starting in the 2010 interim review (“actively seek multipliers such as Living Labs”) and hardwired in the dementia call (2016) – to force earlier, deeper, multi-country user involvement.
- Large enterprises shrink from low double-digits to the statistical margin. Evaluations from 2017 onward point out that big industry “is not a core target group”; combined with grant ceilings and small project sizes, large firms see limited commercial upside and gradually withdraw.

The graph therefore captures a policy-driven drift: the “SME + research” foundation stays intact, but the boundary shifts toward SMEs and, crucially, toward user bodies that bring real-world insight.

2.8.2 Who held the helm?

Figure 10 : Evolution of project leadership by actor type over call years (2008-2021)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
End user	0%	6%	14%	4%	7%	4%	15%	0%	13%	7%	10%	0%	4%	5%
Large enterprise	13%	9%	14%	20%	14%	13%	10%	12%	0%	0%	0%	0%	0%	0%
R&D	65%	48%	52%	56%	41%	48%	35%	59%	53%	43%	29%	33%	35%	32%
SME	22%	36%	19%	20%	38%	35%	40%	29%	33%	50%	62%	67%	61%	64%

Leadership trends magnify what participation data already hint at.

- SMEs cross the parity line in 2017, peak at two-thirds in 2019, and end at 64 % in 2021 (14 of the 22 projects are coordinated by an SME). Two ingredients explain the inflection: the 2014 "Care for the Future" call doubled the weight of market readiness in the evaluation grid, and the 2017 "Integrated Packages" call required that at least 50 % of effort come from industry, practically ensuring SME leadership when large firms were scarce.
- Universities/R&D bodies start out coordinating almost two-thirds of projects. By 2014, their share drops below 40%, briefly peaks at 59% in 2015 (10 of 17 projects), and then declines further, fluctuating around one-third after 2017.
- User organisations take the helm only in years where the call text makes multi-country user pilots compulsory (2014, 2016). Patchy national funding eligibility means they rarely translate that mandate into sustained coordination.
- Large enterprises vanish entirely as coordinators after 2016 – a visual echo of their dwindling presence in the partner mix.

In short, **the wheel shifts from laboratories to small firms**, confirming qualitative evidence that project management increasingly centres on entities with both technical know-how and a direct stake in commercial exploitation.

2.8.3 Did consortia balance business, research and users?

The ideal AAL consortium contains all three core roles.
Table 12 shows how close practice came to that ideal.

Table 12 : Evolution of Participation in Projects by Call Year (2008-2021)

Call year	Businesses	End users	Research organisation
2008	100%	91%	91%
2009	100%	91%	94%
2010	95%	91%	91%
2011	100%	92%	100%
2012	100%	97%	100%
2013	100%	83%	92%
2014	100%	90%	90%
2015	100%	94%	100%
2016	100%	100%	93%
2017	100%	93%	93%
2018	100%	100%	100%
2019	100%	94%	78%
2020	100%	100%	87%
2021	100%	95%	95%

- A business partner (almost always an SME) is virtually universal from the very first call – a direct consequence of the Article 185 eligibility rule that every proposal must include “one business partner”.
- End-user representation rises from the “frequent” bracket (≈ 90 %) to the “near-universal” bracket after 2016, exactly when the dementia call imposes continuous, multi-country user involvement.
- Research organisations are more common than end-users until 2015, dip during the Small Collaborative Projects (2018-21), then rebound. Even at the low point (78 % in 2019) three-quarters of consortia still have a research anchor.

By the final trio of calls, upwards of 85 % of projects feature the full business-user-research triad (53 of the 63 projects), demonstrating that successive tweaks to rules and scoring eventually delivered the programme’s structural ideal.

2.8.4 Peering onside the “end-user” box

Table 13 : Breakdown of end-user organisation types involved in projects, by time period (2008–2021)

End-user sub-group \ Time window	2008-2012	2013-2017	2018-2021
Health-care providers	5.6 %	6.7 %	**10.4 %**
Civil society / advocacy	8.1 %	7.2 %	6.0 %
Municipalities / local authorities	2.0 %	1.5 %	2.6 %
System actors (insurers, regulators, private care chains)	0.6 %	0.9 %	0.8 %

Granular categories reveal where that extra end-user weight actually landed.

- Health-care providers (hospitals, clinics, rehab centres) triple their share between the pre-2016 plateau and the pandemic-era calls. Two drivers stand out: the dementia call’s requirement for clinical pilots and the 2020 “Healthy Ageing” call’s demand to embed projects in regional health-care ecosystems.
- Civil-society organisations (charities, advocacy bodies) surge early, stabilise at mid-single-digits, and fell a bit further – suggesting the programme hit saturation in familiar NGO circles but struggled to widen participation afterwards.
- Municipalities and local authorities rise, fall and rise again, never exceeding about 4 % of partners. Evaluations repeatedly cite administrative complexity and inconsistent national eligibility as obstacles.
- System actors with purchasing power – insurers, public payers, regulators – remain largely absent. Their scarcity helps explain why evaluations in 2017 and 2022 still complain about “immaturity of the demand side” and “fragmented reimbursement landscapes.

2.8.5 Crosscutting forces behind the numbers

Table 14 : Policy levers and their influence on consortium composition

Instrument	Design choice	Observed effect in graphs
Eligibility rules (2008)	SME and end-user partner compulsory	SME presence never <29 %; user share starts near 20 %
Call-level scoring (2014+)	Business plan and commercial criteria doubled in weight	R&D share declines; SME coordination rises
50 % industry effort rule (Call 2017)	At least half of the person-months from business	SME coordinators peak at 67 %
Mandated user pilots (Call 2016, dementia)	Continuous, multi-country user involvement	End-users share climbs, health-care providers triple
Support actions (AAL2Business, Lean-Start-up Academy)	Coaching offered only to market-oriented consortia	Reinforces SME leadership and user focus
Small Collaborative Projects (2018-19)	6-month market-test projects at TRL < 5	Temporary dip in research participation

These policy levers did not act in isolation; taken together they nudged consortium design year after year, producing the slow but unmistakable trajectories visible in every graph.

2.8.6 Lessons for the next generation of ageing & care initiatives

- Targets backed by hard rules deliver. The 40 % SME target became reality only because it was embedded in eligibility and later reinforced in scoring. Similar firmness will be needed if future programmes want, for example, public body participation.
- Leadership matters. Shifting coordination to SMEs correlated with stronger market narratives and quicker decision cycles. Still, consortia where technical, business and user leadership are shared appear best placed to navigate both innovation and adoption hurdles.
- Flexible formats can refresh the mix. Small Collaborative Projects momentarily reduced R&D dominance and accelerated ideation. Agile funding windows could be used more strategically to entice missing demand-side players into low-risk trials.

2.8.7 Summary

Taken together, we observe a sixteen-year re-balancing:

- SMEs and user bodies move centre-stage,
- universities remain essential but no longer monopolise leadership,
- and the hoped-for arrival of system-level demand actors is still incomplete.

These patterns are not random; they are the cumulative imprint of rules, call texts, evaluation grids, and support tools. Replicating the successes – and tackling the persistent gaps – will require equally deliberate design choices in whatever programme inherits AAL's mission.

Hard rules on SME quotas and user-pilot mandates steadily shifted the consortium mix toward SME leadership and deeper user involvement; this heightened market focus yet still relies on research partners for depth. Short, agile funding windows proved useful for refreshing the actor pool and accelerating testing. Future ageing-tech programmes will need to embed clear, enforceable role targets in both eligibility criteria and scoring grids to replicate AAL's gains and close its remaining gaps.

2.9. **Q9**: What was the impact of the AAL programme's shift from a topic-based to a challenge-based approach on proposals, solutions, technologies, stakeholders, and ecosystems?

2.9.1 Proposals

During the first programme phase, when calls were framed around single topics such as chronic-disease monitoring or social connectedness, most proposals reflected the boundaries of the call text: they homed in on one functional niche, assembled comparatively homogeneous consortia, and assumed that integration with surrounding services would occur later. The shift in 2014 toward challenge-related calls—each articulated as a real-life problem cutting across clinical, social, and economic domains—altered proposal patterns in three visible ways. First, disciplinary breadth expanded: applications now combined software firms, home-care providers, and regional payers in the same consortium because no single actor could cover the full challenge brief. Second, problem statements became less technology-centred and more outcome-oriented; evaluators began to receive value-proposition charts and preliminary reimbursement maps rather than feature lists. Third, thematic concentration eased: while topic calls clustered proposals tightly around one-use case (for example, 97 % of 2009 proposals addressed loneliness), challenge calls produced portfolios that spanned multiple needs within the same ageing scenario, reducing programme-level redundancy and widening policy relevance.

2.9.2 Developed Solutions

Solutions emerging from topic-based calls tended to be self-contained products: a fall detector, an online social network, a medication reminder. They addressed an isolated need effectively but required additional projects to assemble a complete care pathway. Under the challenge-related regime, consortia were evaluated on their capacity to answer a whole problem statement—"living well with dementia," "integrated packages for ageing in place"—and consequently delivered multi-service platforms that blended monitoring, coaching, and caregiver dashboards from the outset. Because challenge calls also demanded evidence of service sustainability, later solutions arrived with built-in business models, pre-negotiated data-sharing agreements, and validation plans that extended beyond the grant period. This integration trend is reflected in the flattening of solution heat-maps after 2017: individual projects began to tick several solution archetype boxes simultaneously, signalling a pivot from single-risk point solutions to holistic service bundles.

2.9.3 Used Technologies

Topic calls channelled resources into deepening a limited set of technologies: early cohorts advanced sensor hardware and simple telehealth gateways, but artificial intelligence, cloud orchestration, and interoperability standards spread only slowly because they lay outside the narrowly defined remit. Challenge calls reversed that sequence. To meet broader functional briefs within fixed budgets, applicants had to reuse mature building blocks and concentrate effort on cross-layer intelligence and integration. As a result, AI and cloud analytics penetration grew from roughly one quarter of projects in 2008 to more than half by 2021, and open standards such as FHIR® or universAAL became explicit scoring items in evaluations. Equally important, technological diversity stabilised: radar, VR/AR, and textile sensors appear not as isolated peaks but as selectable modules inside modular stacks, illustrating how a challenge frame promotes platform thinking over one-off inventions.

2.9.4 Involved End-Users and Stakeholders

Under topic-based calls, primary users were usually invited late as testers, and tertiary stakeholders—municipalities, insurers, housing operators—participated only sporadically. The challenge-oriented template required applicants to map the entire beneficiary chain and to document co-creation plans at proposal stage; mid-term reviews then checked whether older adults, caregivers, and payers were still engaged. This procedural nudge produced measurable change: the share of projects that practised multi-level co-design rose from roughly one third before 2014 to more than one half by 2021, and the proportion involving formal care organisations or public authorities doubled over the same period. By linking funding to demonstrable stakeholder alignment, the programme moved participation from consultation to governance, improving adoption prospects and enriching the evidence base that underpins policy claims.

2.9.5 Related Ecosystems

Topic-centric funding fostered a landscape of parallel pilot sites: each prototype relied on a bespoke living-lab arrangement, and knowledge diffusion depended on post-hoc networking events. Challenge calls, by contrast, embedded ecosystem tasks directly in work plans—stakeholder mapping, interoperability roadmaps, sustainability score-cards—and scored proposals partly on their capacity to fit into regional health-and-care strategies. Consequently, municipalities, insurers, and standardisation bodies began to appear as formal partners rather than external advisers; several projects even appointed "ecosystem orchestrators" to broker long-term service integration. This contractual anchoring accelerated horizontal learning: middleware stacks, user-interface components, and even business templates were reused across successive cohorts, and regional clusters such as Utrecht and Coimbra reported quicker scaling because solutions arrived already harmonised with local procurement and data-governance requirements.

In short, the move from topic to challenge reframed projects from isolated experiments into deliberate building blocks of evolving territorial ecosystems.

2.10. **Q10:** What factors indicate a project's likelihood of post-project success?

Drawing exclusively on the evidence compiled in impact assessments (2016-2023) and annual reports (2008-2021), the review isolates — and explains — the factors that show up again and again in projects that achieved market launch or large-scale deployment. The discussion is organised around six themes: consortium composition, depth of end-user involvement, technology choices, development methods and programme support, business-model and financial levers, and post-project ecosystem anchoring. Only patterns corroborated by multiple documents are included; no single-project anecdotes or conjectures appear in the analysis that follows.

2.10.1 Consortium makeup and governance

Across all calls, consortia that ended up with a viable product almost always contained seven to eight partners. The early calls (2008-2011) averaged just over eight; later calls stabilised closer to seven. When the partnership grew beyond ten, coordination frictions. Conversely, micro-teams of four or five often lacked at least one critical capability — typically market access or clinical validation — so the solution stalled after the grant.

Three partner types recur in every success story:

- SMEs provided commercial urgency and were usually the legal owner of the foreground IP. In a growing number of cases, SMEs even coordinated the project.
- Research or clinical institutes conferred technical depth and credibility—needed, for instance, to convince hospitals to test *Heart Failure* (2018).
- User or care organisations (municipalities, nursing-home groups, patient associations) guaranteed real-life pilots and generated the usage evidence investors demand.

When payers and regulators—for example Dutch municipalities responsible for social care budgets, or German sickness funds—joined the consortium from the outset, the resulting product met reimbursement rules faster and attracted follow-on capital more reliably. Finally, successful teams wrote explicit exploitation agreements that clarified IP ownership upfront and helped prevent the kinds of partner conflicts that had undermined earlier projects.

Table 15 Consortium Design Factors Linked to Project Success

Indicator	Evidence & typical figures	Why it matters
Balanced mix of ≈ 7–8 partners	Across 2008-17 calls, winning consortia averaged 7.1 – 8.0 partners; outliers (>10) struggled with coordination, while ≤5 lacked breadth.	Keeps decision-making agile yet covers the skills chain from R&D to market.
SME leadership + multidisciplinary team	SMEs present in > 70 % of launches; projects with SME coordination reached market 1-2 years faster.	SMEs drive commercial urgency; universities/clinics supply credibility; end-user orgs ensure relevance.

Early inclusion of payers/regulators	Projects that brought insurers/municipalities into the consortium secured follow-on funds 30 % more often.	Anticipates reimbursement, policy and procurement barriers.
Clear governance & role definition	Mobility-call failures cite partner-conflict; successes used shared IP and exploitation plans.	Reduces mid-project friction that delays productisation.

2.10.2 Depth and breadth of end-user involvement

The strongest single predictor of post-project uptake is continuous, multilevel involvement of end-users:

- Primary users (older adults) shape usability and acceptance. *A project* cut its sensor array from fifty to five after seniors complained about visual clutter.
- Secondary users (informal carers, nurses, therapists) dictate workflow fit. A project's video-communication platform only took off after family carers helped redesign its interface.
- Tertiary users (insurers, municipalities, facility managers) control procurement. A consortium added a hospital procurement officer midway through the project—an addition the 2020 assessment links directly to its fast launch.

Where projects ran six -month-plus, real-life trials—A 2014 project ran a nine-month validation in two countries—sustained postlaunch use usually exceeded 60 percent. Lab-only pilots rarely hit 40 percent retention. Moreover, projects that kept user panels active after the grant were still able to iterate and upsell years later.

Table 16 Practices That Boosted Adoption and Market Success

Practice	Quantified impact
Iterative co-design with primary, secondary *and* tertiary users	2018–21 impact data: solutions co-designed across all three groups enjoyed **71 % higher adoption** and **2–3 × faster market entry**.
≥ 6-month real-life trials	Long trials correlate with 60–80 % sustained use; projects limited to lab pilots saw ≤40 % retention.
Continuous post-project feedback loops	Some firms kept user panels active after grant end and reached > 3 000 customers, while peers without follow-up testing stalled at pilot scale.

User involvement is the single most powerful predictor of post-project success; depth matters more than sheer sample size.

2.10.3 Technology characteristics linked to market uptake

Three technical patterns are recurrent in the solutions that actually reach paying customers:

1. Modular, interoperable architectures. 64 % of projects launched after 2017 that offered plug-and-play modules reached the market, compared to 38 % of monolithic solutions. A notable example is a safety platform (2017), which ships interchangeable sensors, analytics, and alert modules that care homes can adopt gradually. Modularity allows solutions to integrate into heterogeneous European care ICT landscapes and has become almost mandatory in calls issued after 2017.
2. Sensor-rich telehealth back-ends plus AI analytics. Starting with a project in 2008 and peaking in 2021 projects, the winning formula pairs commodity sensors with machine learning layers that generate predictions clinicians value.
3. Adaptive, low-friction user interfaces. Several projects cut features or simplified navigation after usability tests; those that ignored such feedback failed to scale.

2.10.4 Methods and programme-level support

Methodological choices also correlate with success:

- *Agile / Lean development cycles*. The 2018 introduction of Small Collaborative Projects (≤ 12 months, limited scope) showed that rapid iteration halves time-to-market when the idea is still fluid.
- *AAL2Business services*. Projects that attended the Lean Startup Academy or Go-To-Market Launchpads were 40 percent more likely to raise post-grant funding (and 60 % more likely to refine a viable business model). Feedback from investors during these workshops routinely reshaped value propositions and pricing models. 89 % of attendees Networking at AAL Forum or investor pitch days reported new partnerships, several attribute seed rounds directly to these events.
- *Evidence-based validation*. Solutions that produced hard cost-savings or clinical-outcome data inside the grant (e.g. reduction of heart failure readmissions) convinced payers faster than those that deferred evaluation.
- *Ethics and data-privacy compliance.* After the Programme introduced its *Guidelines for Ethics, Data Privacy and Security* in 2020, projects that adopted them early met regional procurement rules more smoothly—especially in Germany's DIGA health-app channel.

2.10.5 Business-model and financial enablers

The commercial winners typically share three traits:

- *Multi-payer revenue models.* Combining modest user co-payments with institutional funding—municipal budgets, home-care contracts, or insurer reimbursements—spreads risk and cushions affordability gaps.
- *Early IP-and-regulatory housekeeping.* Patent filings, CE marking strategies or preliminary DIGA dossiers, prepared inside the project, shorten the runway to large-scale sales.
- *Post-launch service lines.* Training packages, remote maintenance, and data-analytics subscriptions convert one-off sales into recurring income and keep churn below industry averages.

2.10.6 Ecosystem & post-project scaffolding

Finally, projects that endure build or join regional care ecosystems:

- *Spin-offs and licensees.* At least fourteen spin-offs have taken AAL prototypes to market.
- *Institutional embedding.* Solutions such as an oral-care system moved straight into partner nursing homes, guaranteeing reference sites.
- *Regional health-ecosystem engagement.* projects embedding with local care pathways (Portugal, the Netherlands) scaled cross-border 30 % faster.
- *Cross-project component reuse.* Technologies first funded in 2008-13 were reused in later Horizon-2020 projects, lowering costs and expanding reach.
- *Ethics & data-privacy compliance:* formal AAL guidelines (2020) became a *market differentiator*—pilots meeting them enjoyed higher procurement trust.

During the COVID-19 pandemic, these regional networks—often nourished at the annual AAL Forum or local investor days—were able to roll out contact-free monitoring tools in weeks, illustrating the strategic value of ecosystem ties.

2.10.7 Conclusion

A Sixteen-year record of project data, external evaluations and market tracking converges on a clear message: post-grant success is multi-factorial but predictable when certain conditions are met.

1. Consortium balance matters. Teams of roughly seven to eight partners—anchored by at least one SME, one research/clinical body and one end-user organisation—outperform both very small and very large consortia.
2. User co-creation is non-negotiable. Projects that integrate primary, secondary *and* tertiary users from concept through post-launch updates reach the market sooner and retain more customers.
3. Interoperable, modular technology wins. Solutions that plug into existing care ICT and can evolve component-by-component weather policy shifts and heterogeneous EU markets better than monolithic systems.
4. Lean, evidence-driven development shortens the runway. Agile cycles, AAL2Business coaching and early clinical or economic validation together with lower investor risk and unlock follow-on funding.
5. Multi-payer business models de-risk scaling. Blending user fees with institutional or insurer payments grows revenue while maintaining affordability for older adults.
6. Regional ecosystem anchoring sustains momentum. Spin-offs, licensing deals, and formal ties with local health networks give projects a landing zone once EU financing ends.

Successful AAL projects are not defined by a single silver bullet but by a ***converging bundle of indicators*** *spanning consortium design, user-centric methods, interoperable technology, structured commercialization support, and ecosystem* *anchoring. The more boxes a project ticks across these dimensions, the steeper its post-grant success curve.*

2.11. **Q11:** What learnings emerge from projects or programme aspects that did not go as planned?

A longitudinal reading of project files, interim and final reports, shows that shortfalls rarely arose from a single failure point. Instead, they reflected predictable interactions among regulatory timing, design governance, consortium resilience, market readiness, and programme-level rules. Five cross-cutting insights stand out.

First, the absence of front-loaded regulatory and ethical alignment proved more damaging than any individual technical flaw. Projects that treated ethics review or GDPR conformity as an after-thought lost months securing approvals, compressing pilot windows, and forcing rushed redesigns. Those that embedded privacy-preserving architectures from inception-maintained user trust and preserved their testing schedules even when approvals lagged. The lesson is unequivocal: regulatory gatekeeping is not a parallel track but the critical path for user-centred innovation in health and care.

Second, late or unilateral design pivots consistently eroded the credibility of co-creation and the quality of evidence. The withdrawal of cardiac monitoring, the downgrading of a smartwatch, and an abrupt move from light therapy to aroma-based exercises each occurred after expectations had been nurtured with end-users. Because new consent rounds and training could not be completed in time, participation thinned, and feedback became anecdotal. Projects that instituted mandatory user checkpoints before any scope change avoided this drift, demonstrating that discipline in change governance is as important as flexibility in technical development.

Third, consortium instability and technical unreliability formed a mutually reinforcing brake on impact. Partner exits triggered cancellations of trials, while supply-chain shocks—most visibly the withdrawal of Microsoft's Kinect and commercial wristbands—left related projects testing half-finished substitutes in laboratory settings. In every call, at least one project in three reported major reliability setbacks; where contingency budgets, shared code repositories and fail-over suppliers were in place, pilots continued with reduced scope, but where they were not, recruitment collapsed, and evidence became too thin for market or clinical claims.

Fourth, lack of credible post-grant sustainability planning converted otherwise successful pilots into "orphans". Some projects reached technical readiness yet stalled when liability frameworks, maintenance contracts or reimbursement routes were still unresolved at the final review. Between 2008 and 2021 the proportion of projects facing such post-project obstacles never fell below one in six. Conversely, solutions that exited the programme with signed service contracts had all negotiated ownership, certification and servicing responsibilities while pilots were still running.

Fifth, insufficient integration of demand-side stakeholders neutralised many strong user-experience results. Across calls, roughly one-third of projects each year involved payers, municipalities, or professional providers only nominally. When remote-monitoring platforms reached market-entry, the absence of reimbursement agreements meant that the very older adults who had validated the prototypes could not continue using them. Evidence from later cohorts shows that when insurers or municipal buyers help shape business logic from day one procurement and regional scaling proceed markedly faster.

Complementing these project-level findings are **two programme-level lessons**. The first is that heterogeneous national contracting rules and voluntary co-funding still create uneven time-to-contract and budget utilisation. Consortia routinely avoided slow jurisdictions, concentrating leadership in six countries and leaving others under-represented. The second is that impact monitoring beyond the grant period remains fragile: only about half of completed projects deliver data three years post-closure, limiting the programme's ability to evidence long-term public value.

Taken together, the accumulated evidence suggests that projects faltered when any of six elements—regulatory clearance, disciplined change management, consortium continuity, technical reliability, sustainability planning, or stakeholder integration—was weak. Where two or more faltered simultaneously, even generous budgets and enthusiastic user groups could not rescue outcomes. Future programmes should therefore:

- *make provisional ethics and data-protection clearance an eligibility gate;*
- *require that any major project changes be reviewed with users and documented in a change log, as a condition for mid-term payments;*
- *require partner exit and supply-chain contingencies;*
- *insist on signed post-grant service and liability frameworks before final review;*
- *award scoring premiums for confirmed demand-side cash commitments, and*
- *enforce harmonised contracting service-level agreements across funding agencies.*

Embedding these safeguards at programme design stage is the surest way to convert the rich tradition of co-creation in European ageing and care technology into sustainable, real-world benefits.

2.12. **Q12:** What are the key learnings about medium-term opportunities, trends, challenges, and risks in the AAL sector?

Emerging evidence from sixteen years of AAL investment, reinforced by recent European policy developments, suggests that the coming five-to-seven years will be shaped by a decisive shift from single-function "applications" to data-driven service ecosystems that treat ageing as a lifelong, multi-actor journey rather than an episodic clinical problem. Three mutually reinforcing trends create the opportunity space. First, almost two-thirds of late-call projects already integrate *cloud analytics and explainable AI*; the new EU Artificial Intelligence Act will codify those practices, placing most remote-monitoring and decision-support tools in the "high-risk" tier and obliging suppliers to document transparency, equity and human oversight from the outset[6,7]. Second, the formal adoption of the *European Health Data Space* regulation in January 2025 gives AAL providers a legal pathway to access and reuse electronic health-record data across borders, provided citizens can exercise granular consent[8]. Third, *demographic and investment signals are aligning*: the segment for AI-enabled elder-care solutions is forecast to double to roughly €2 billion by 2030, while dedicated "longevity" funds have begun targeting near-market consumer and care technologies[9,10]. These forces favour **modular, interoperable platforms that can plug anonymised clinical data into predictive algorithms and monetise continuous value-added services** rather than one-off device sales.

Programme experience nevertheless warns that technical readiness alone is insufficient. Projects that reached **commercial deployment** consistently combined seven-to-eight partners, anchored by an SME that owns foreground IP, a research or clinical institute that confers credibility, and at least one care-provider or municipal body that can act as first buyer. Where those demand-side actors joined early, reimbursement mapping and procurement cycles shortened markedly; where they were absent, otherwise mature pilots stalled at grant end. Horizon Europe's health work-programme for 2025–27 explicitly rewards such "*quadruple-helix*" alignment, signalling that consortia unable to demonstrate pay-as-you-scale business models will face diminishing funding opportunities[11].

Technologically, the medium term will be dominated by three design imperatives distilled from the AAL portfolio. *Predictive analytics* must be embedded at the edge as well as in the cloud to comply with the AI Act's real-time performance and auditability clauses; *interoperable APIs* (FHIR, MQTT, OPC-UA) will become non-negotiable as EHDS secondary-use provisions take effect; and *privacy-preserving architectures*—local inference with federated model updates—will be the default route to securing ethics approval and market trust. These requirements elevate software orchestration and data governance above hardware features and will accelerate the convergence of AAL, mainstream digital therapeutics and smart home automation. For policy makers, supporting *open-source reference stacks*

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6 https://www.sciencedirect.com/science/article/pii/S0168851024001623

7 https://academic.oup.com/ehjdh/advance-article/doi/10.1093/ehjdh/ztaf041/8118685

8 https://datamatters.sidley.com/2025/01/23/european-health-data-space-regulation-adopted-whats-next-for-life-sciences-companies/

9 https://www.globenewswire.com/news-release/2025/02/14/3026636/28124/en/AI-Powered-Solutions-for-Elderly-Care-Market-Set-to-Surpass-US-2-Billion-by-2030.html

10 https://signemagazine.com/sanctuaries/wellness/clinique-la-prairies-longevity-fund-investing-in-the-future-of-lifespan-and-wellness-innovation/

11 https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2025/wp-4-health_horizon-2025_en.pdf

and *certification sandboxes* is now the fastest way to reduce duplication and to de-risk SME participation.

Opportunities also arise at ecosystem level. The European Care Strategy positions integrated long-term-care networks as a pillar of the post-2025 social-protection model and explicitly calls for digital tools that document quality and outcomes across settings[12]. That directive, coupled with the WHO Decade of Healthy Ageing, generates stable demand for *evidence-based, person-centred AAL services* that support autonomy, wellbeing, and continuity of care across the life course[13]. Regional and local authorities, long the gatekeepers of social-care budgets, are therefore emerging as lead customers for package-based solutions that reduce institutional admissions. The best-performing AAL pilots already treat municipalities as orchestrators—licensing predictive fall-risk dashboards to local home-care teams while letting families subscribe to optional coaching apps—creating revenue stacks that blend public contracting, insurance top-ups and modest out-of-pocket fees. Investors increasingly praise such hybrid models because they buffer macro-economic swings in either public or private spending[14].

Against this backdrop, four systemic challenges and associated risks must be addressed if the sector is to capitalise on its momentum. First, *regulatory complexity* is intensifying under the AI Act and MDR, certification costs for high-risk software may reach six figures, threatening to price smaller innovators out of clinical segments unless shared compliance toolkits are made available. Second, the *digital divide* remains acute. AAL projects that succeeded during the pandemic relied on voice or television interfaces and local volunteer support to reach frailer, low-connectivity users; without sustained investment in inclusive design and rural broadband, large cohorts will remain excluded, undermining equity goals and the statistical validity of predictive models. Third, *supply-chain fragility*—highlighted when global shortages delayed sensor deliveries in 2021–22—will continue to jeopardise projects that depend on proprietary hardware. Diversifying commodity components, or specifying reference designs that multiple manufacturers can supply, is now a risk-management necessity, not a convenience. Fourth, *financing gaps* persist at the “first deployment” stage: while venture capital appetite is growing, many AAL SMEs and spin-offs remain unattractive to such investors due to the fragmented and uncertain market. This creates an important role for smaller national investors and public–private hybrids, who can provide the multi-year support needed to bridge this valley of death. Dedicated guarantee instruments under InvestEU or the European Innovation Council’s Scale-up Programme will also be decisive in closing this gap.

Finally, ecosystem governance will determine whether today’s pilots translate into continental impact. Medium-term success hinges on three policy levers. *Align procurement with interoperability*—tying public tenders to EHDS-compliant data services—so that municipalities can switch suppliers without dismantling installed infrastructures. *Embed citizen-controlled data wallets to operationalize EHDS consent rules and rebuild trust* after well-publicised privacy lapses. And *mainstream Living-Lab networks as permanent “reference zones” with shared ethics clearances*, ensuring that SMEs can iterate with real users inside months rather than years. If these levers are activated alongside robust co-design mandates and outcome-based purchasing, Europe can convert its AAL legacy into a scalable, resilient Silver-

[12] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_5169
[13] https://www.who.int/publications/i/item/9789240079694
[14] https://www.iqvia.com/insights/the-iqvia-institute/reports-and-publications/reports/digital-health-trends-2024

Economy platform that simultaneously reduces care costs, supports healthy longevity, and creates high-value employment.

In sum, the AAL Programme has already demonstrated that multi-stakeholder, user-centred innovation can yield viable, high-impact ageing-in-place services. The medium-term opportunity lies in industrialising that model: coupling predictive analytics with interoperable data spaces, financing hybrid business models at scale, and embedding solutions within local ecosystems empowered by the European Care Strategy and the forthcoming Health Data Space. The principal risks—regulatory cost, digital exclusion, supply-chain shocks, and funding gaps—are manageable, but only if future calls hard-wire compliance toolkits, inclusive design standards, diversified hardware pathways and blended-finance guarantees into their operational architecture. Doing so will position Europe not merely as a source of pilots but as the world's most trusted market for ethical, AI-enabled active assisted living.

3 / Learning lessons for future funding programmes / partnerships targeting technology for older people

3.1. **Q13:** What key learnings from the AAL Legacy can improve future programmes' success, management, and support actions?

3.1.1 What are the key learnings about programme management?

3.1.1.1 Context and Sources

This synthesis draws on the programme's annual reviews, interim and final evaluations, impact studies (2016-2023), the AAL2Business and Market Observatory records, and ecosystem-support action reports covering the full life-cycle of AAL 1 (2008-2013) and AAL 2 (2014-2021). Together they provide a longitudinal view of how the AAL Association (AALA) and its Management Unit steered a €700 m transnational partnership involving up to 23 participating countries.

3.1.1.2 Introduction

Between 2008 and 2021, the AAL Programme operated under Article 185 of the EU Treaty as a Public–Public Partnership, jointly initiated and co-financed by participating states and the European Commission. Up to 23 countries contributed national funding, which was matched by the EU to support transnational collaboration. While legally a public–public initiative, the programme systematically required private-sector participation and co-funding, functioning in practice as a public–private effort.

Its overarching mission was threefold: to improve the quality of life for older adults through digital innovation, to support the sustainability of health and care systems, and to strengthen the competitiveness of Europe's age-tech industry. Over its lifetime the programme funded more than 300 transnational R&D consortia, ran a suite of business support and ecosystem-building actions—from business acceleration and end-user engagement studies to interoperability frameworks, ethics guidelines, and regulatory coaching—and generated a rich paper trail of annual reviews, interim and final evaluations, impact assessments, and thematic reports. These documents provide an unusually detailed longitudinal record of how programme-level management structures, processes and culture evolved and what worked—or did not—in practice.

This report distils that evidence into the **key learnings on programme management**. It is organised as a series of thematic sections that trace the AAL Programme's trajectory from its start-up phase to its final wind-down, highlighting concrete management practices, their measurable effects and their residual limitations. A closing section synthesises overarching lessons for future multi-country partnerships.

3.1.1.3 Evolution of Governance and Organisational Roles

Start-up years

The Central Management Unit (CMU) began with only three staff members and a rudimentary manual of procedures. Decision rights were blurred between the General Assembly (political oversight), the

Executive Board (strategic steering) and National Funding Agencies (NFAs) that retained their own eligibility and contracting rules. The inevitable result was heterogeneity: time-to-contract (TTC) for identical projects ranged from four to more than twelve months, and up to 30 % of allocated national budgets went unused in the slowest jurisdictions.

Stabilisation

Responding to a 2010 interim evaluation, the CMU drafted a unified Manual of Procedures, introduced a common on-line submission and financial tracking tool and—crucially—agreed service-level deadlines with NFAs. When annual review tables naming slow performers were first published in 2015, median TTC dropped by roughly one quarter within a single call cycle. Clearer role demarcation also allowed the CMU to add a compliance audit function that uncovered and fixed early double funding risks in two member states.

Strategic realignment

In its second phase (AAL 2) the programme empowered the CMU to act as a "programme champion" rather than a back office. The management team oversaw the shift from topic based to *challenge-led* calls and launched Small Collaborative Projects (SCPs) with shorter life cycles. These changes were not cosmetic: SME participation climbed from an average 38 % in early calls to 48 % in SCPs, showing that a nimble instrument portfolio can attract actors who would otherwise skip lengthy R&D projects.

Resilience and wind-down

COVID-19 stress tested governance arrangements. Because remote evaluation and contract signature workflows were already embedded in the IT platform, the 2020 Call still received a record 111 proposals and kept its schedule.

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*Key learning: **Role clarity plus the authority to redesign instruments mid-stream are prerequisites for effective programme level steering**. Without them, even large budgets cannot overcome administrative friction or shifting political priorities.*

Phase	Governance Characteristics	Key Lessons
Start-up	• 3-person CMU, unclear division of labour between General Assembly, Executive Board, National Funding Agencies (NFAs). • "Virtual common pot" funding with divergent national rules.	*Lesson 1:* Role clarity is non-negotiable. Early ambiguity inflated time-to-contract, sapped SME confidence and produced ≤ 70 % budget utilisation in some calls.
Stabilisation	• Manual of Procedures, on-line proposal & finance tools, stricter NFA performance deadlines. • CMU gains audit & KPI mandate.	*Lesson 2:* Standardised processes and shared IT back-bone translate directly into shorter administrative cycles and better risk control.

Strategic Shift	• CMU redefines itself as "programme champion;" launches MEI (Monitoring-Evaluation-Impact) framework and bi-annual compliance audits. • Challenge-led calls replace topic calls; Small Collaborative Projects (SCPs) piloted.	*Lesson 3:* **Management needs authority to redesign instruments midstream.** Challenge-led calls and SCPs lifted SME participation from 38 %→48 % and cut average contract lead-time by three months.
Resilience & Exit	• Full digitalisation under COVID-19; Salesforce project database; remote reviews. • Structured phase-out and knowledge-transfer plan into Horizon Europe partnership.	*Lesson 4:* **Crisis-driven digitisation can consolidate productivity gains when centrally orchestrated.** Virtual reviews kept 200+ projects on schedule during pandemic peaks.

3.1.1.4 Operational Effectiveness and Risk Management

From day one the programme treated contractual speed as the bellwether of operational health. Early reviews showed that TTC correlated strongly with national participation: consortia increasingly avoided partners in countries that took more than eight months to issue grant agreements. Once TTC league tables were published, slow NFAs accelerated, and participation rates in previously lagging states recovered the following year.

Risk management moved through three recognisable stages:

1. **Reactive patching.** Missing documentation or cost anomalies were discovered only after year-end audits.
2. **Built-in controls.** Real-time dashboards flagged underspending, triggering reallocation of unused funds before call budgets expired.
3. **MEI framework.** A fully fledged Monitoring–Evaluation–Impact logic model tracked inputs, outputs and outcomes, attaching key risk indicators (KRIs) to every grant.

Key learning: ***Proactive dashboards are cheaper and faster than after-the-fact corrections, but only if data standards are enforced early.***

3.1.1.5 Data Infrastructure and the Culture of Evidence

The adoption of Salesforce in 2016 gave the programme a single data backbone. Every proposal, contract amendment, payment, and technical report flowed through the same pipeline. This centralisation produced two tangible benefits:

- **Comparability across calls.** KPIs such as SME budget share or geographic diversity could be plotted in consistent time series, enabling evidence-based call redesign.

- **Faster feedback loops.** AAL2Business coaching results (e.g., the percentage of projects that secured venture capital) fed directly into the following year's evaluation criteria, ensuring that commercial readiness ceased to be an afterthought.

Yet challenges persisted. Roughly half of finished projects never filled in the long-term impact survey, so evidence on post-market uptake remains patchy.

Lesson: management should make participation in follow-up monitoring a contractual obligation, tied to the final payment tranche.

3.1.1.6 Integration with Business-Support and Ecosystem Actions

The programme never intended the CMU to deliver commercial coaching itself. Instead, it contracted *support actions*—notably AAL2Business and the Market Observatory—and wove them into the management fabric. When investor feedback revealed that consortia routinely lacked clear intellectual property (IP) strategies, the CMU added an IP-readiness checkpoint to every mid-term review. Conversely, AAL2Business tailored its Lean Startup Academy to exactly fit the 24- to 36-month AAL project timeline after observing that generic accelerator curricula were too compressed.

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*Key learning: **Tight, deliberately engineered feedback loops between core management and auxiliary support actions turn parallel initiatives into a coherent operating system**.*

3.1.1.7 Stakeholder and Ecosystem Management

AAL pioneered mandatory end-user involvement. By the final calls, 26 % of grant beneficiaries were user or caregiver organisations, up from about 12 % in 2004. This shift had measurable effects: projects that involved users as co-creators were 1.2 × more likely to reach market entry. Yet management also learned that user engagement alone is insufficient if the payer (municipality, insurer, hospital trust) is absent. In later calls after, evaluation forms therefore awarded extra points for "demand-side partners" who could finance adoption at scale.

Regional equity required its own interventions. Six innovation-strong countries routinely coordinated 80 % of projects. The CMU responded with capacity-building vouchers for newer member states and harmonised contract templates that trimmed local legal costs.

3.1.1.8 Crisis Adaptability

When the pandemic struck, AAL already possessed virtual evaluation tools and cloud-based project monitoring. Board, General Assembly, and MU meetings (including NCPs and CMU) shifted online within days; payment schedules slipped by less than three weeks on average. More importantly, forced digitalisation became a catalyst. The 2020 European Week of Active & Healthy Ageing—run as a hybrid event—reached four times as many registrants as the previous in-person AAL Forum, at half the cost.

*Key learning: **Investing in digital workflows early pays for itself twice: in everyday efficiency and in unplanned crises.***

3.1.1.9 Exit and Legacy Management

Unlike many EU initiatives, AAL budgeted staff time and resources for orderly wind-down. The sunset taskforce produced:

- A knowledge-transfer playbook for Horizon Europe's *Transforming Health and Care Systems* partnership;
- Archived, searchable project data accessible to future evaluators;
- A final lessons-learnt compendium circulated to all National Contact Points.

By planning its own obsolescence, the CMU ensured that 16 years of institutional knowledge did not disappear when the final contracts closed.

3.1.1.10 Recommendations for Future Partnerships

Area	Recommendation	Rationale
Governance	Appoint a strategic Management Unit from day 1 with authority to adjust instruments mid-cycle.	Avoid long lag before first major reform (AAL waited ~5 years).
Process Efficiency	Enforce harmonised TTC ≤ 8 months via binding SLA with NFAs; publish anonymised performance dashboards to support accountability and shared learning across NFAs.	Data shows direct link between slow TTC and national drop-out.
Risk & Data	Build MEI-style framework and audit schedule into grant agreement templates.	Moves risk management from reactive to proactive posture.
Support Action Integration	Hard-wire business-coaching milestones into project payment schedule.	Ensures all cohorts—not just late ones—benefit from market readiness support.
Ecosystem Equity	Fund capacity-building vouchers for low-participation regions; pair with simplified contracting kits.	Tackles persistent geographic imbalance.
Exit Strategy	Require every Article 185-type initiative to submit a phased legacy plan by mid-term review.	Protects knowledge assets and partnerships beyond final call.

3.1.1.11 Conclusion

The AAL Programme's sixteen-year experiment in multinational, multi-stakeholder innovation management yielded a trove of practical insights. Among the most salient are the centrality of role clarity, the transformative power of standardised digital processes, and the value of tight coupling between management, risk oversight and business-support services. The programme also illustrated the limits of what even exemplary management can achieve in the face of fragmented national regulations and voluntary financing commitments. Still, by the time AAL closed its calls in 2021, it had evolved from an administrative start-up into a strategically agile, data-driven organisation whose practices now inform successor EU partnerships. Future initiatives stand to benefit greatly from these hard-won lessons—provided they embed them not as post-hoc patches, but as design principles from the very outset.

3.1.2 What are the key learnings on evolution of support actions?

3.1.2.1 Introduction

Drawing on successive annual reviews, interim and final evaluations, impact studies, and support action records, the analysis traces how AAL's auxiliary instruments matured from ad hoc coaching and networking events into an integrated, evidence-driven support architecture. Particular emphasis is placed on (i) the business support stream built around AAL2Business and the Market Observatory, (ii) the ecosystem support stream that culminated in the Health & Care Ecosystems Action. In addition, the introduction of end user engagement support actions also played a key role at a time when engagement of older end users and approaches like co-design and co-creation were still emerging within the ICT sector. This latter point is further discussed in the section on key learnings on call definition. The account is organised chronologically and thematically, ending with consolidated lessons for future European partnerships.

3.1.2.2 Early Recognition of the Commercialisation Gap (2008-2013)

During the programme's first phase, evaluations highlighted a stubborn "valley of death." Fewer than one-third of completed projects progressed beyond prototype stage and only about 10 % generated sustained revenue. Barriers were threefold:

- Knowledge barriers – consortia, heavy on academics and engineers, rarely possessed staff versed in pricing, regulation, or investment pitching.
- Information barriers – no single source aggregated data on market size, reimbursement pathways, or competitor activity.
- Coordination barriers – national funding rules and contracting delays deterred SMEs from cross-border engagement.

Initial remedies—chiefly annual Investor Forums and matchmaking sessions—raised awareness but proved episodic and too generic to change outcomes.

3.1.2.3 Building Purpose-Built Business Support (2011- 2022)

AAL2Business (A2B) evolved from initial SME engagement activities which already started in AAL1, including business consultation and workshops. These early efforts laid the groundwork for the formal multi-tier support programme that AAL2Business became, providing structured coaching and guidance to SMEs. This includes:

- Pre-proposal matchmaking workshops helped applicants assemble balanced consortia and clarify exploitation roles before submission.
- Mid-term business coaching introduced business-model canvases and lean-startup thinking; every project was now required to submit a commercialisation plan at its mid-term review.
- Investor networking events paired late-stage projects with impact investors and corporate VCs.

In parallel, the Market Observatory feasibility study catalogued the fragmented landscape of demographic statistics, adoption rates, and interoperability standards. Although the Observatory's full "reference source" model proved too costly for immediate deployment, the preparatory work produced two lasting benefits: (i) a common taxonomy for AAL market segments and (ii) a repository of sector analyses that informed later call topics.

3.1.2.4 Deepening and Digitising Business Support (2017-2021)

Lean Startup Academy and Go-to-Market Launchpad

Responding to investor feedback that many projects still lacked validated business models, AAL2B introduced the Lean Startup Academy (LSA) in 2017. Delivered in three tightly scripted workshops, LSA forced teams to test problem–solution fit with end-users, calculate addressable market sizes and pivot early if assumptions failed. By 2020:

- 58 projects had completed LSA rounds;
- 86 % reported *significant* improvements in value-proposition clarity; and
- LSA-coached projects were 2.3 times more likely than the wider portfolio to secure follow-up funding.

Graduates then moved to the Go-to-Market Launchpad (GtML)—a one-to-one investor-readiness clinic covering term-sheet negotiation, regulatory dossiers and exit strategies. Twenty-one projects entered the pipeline; seven closed equity or blended-finance rounds within twelve months.

Pandemic Pivot and Digital Scale

COVID-19 compelled all support services online. Attendance at webinars and virtual toolkits surged (≈ 5 000 unique users by late-2021). Early attrition in engagement was reversed when coaches switched from lecture formats to interactive case-study breakouts and Slack-based peer exchanges.

Business Expert Network

To localise advice, AAL2B piloted a Business-Expert Network spanning 14 countries. Experts answered targeted queries on reimbursement coding, GDPR compliance or CE-marking. While uptake began slowly, proactive brokering by National Contact Points trebled interactions in 2021, demonstrating that curated matchmaking outperforms passive directories.

3.1.2.5 From Projects to Ecosystems (2019-2021)

AAL management recognised that even well-prepared firms struggled where local care systems, insurers or municipalities were unready to procure digital ageing solutions. The Health & Care Ecosystems Support Action therefore set out to:

1. Map existing regional networks (18 were profiled, from Health Valley NL to Eksote Finland);
2. Train stakeholders via workshops using ecosystem matrices, "liberating structures" and Strategy Tools canvases;
3. Broker cross-regional learning through the re-branded *European Week of Active & Healthy Ageing* (EWAHA).

Regions that adopted "integrator units" (neutral teams acting as orchestrators) made the fastest progress. Central Denmark's five-year roadmap and Coimbra's Ageing@Coimbra cluster both secured new ERDF funding streams and expanded pilot cohorts after applying the workshop outputs. Nevertheless, geographic imbalances persisted—six countries still supplied 80 % of coordinators—and interoperability standards lagged, with fewer than one project in five referencing FHIR® or universAAL frameworks.

3.1.2.6 Cross-Cutting Lessons

Dimension	What changed	What was learned
Service design	Shift from generic seminars to tiered, maturity-specific tracks (matchmaking → LSA → GtML).	*Tailored coaching dramatically increases follow-on funding and market entry.*
Evidence loops	KPI dashboards fed CMU, evaluators and AAL2B coaches each call cycle.	*Continuous adjustment of call templates (IP clauses, exploitation scoring) raised average proposal quality.*
Digital delivery	Pandemic accelerated e-toolkits; scalable reach but initial engagement drop.	*Interactivity (breakouts, live case critiques) is essential for online formats; pure webinar ≈ low impact.*
Regional ecosystems	Mapping + integrator units + shared vocabularies.	*Ecosystem "literacy" turns isolated pilots into multi-stakeholder change programmes but needs multi-year funding.*
Interoperability	Standards guidance existed but adoption voluntary.	*Without incentives, technical fragmentation slows cross-border scaling despite strong business cases.*

3.1.2.7 Conclusion

Over eleven years, the AAL Programme transformed its support actions from occasional investor fairs into a coherent, data-driven architecture that couples deep business coaching with ecosystem orchestration. The results are tangible: coached projects entered the market at more than twice the historical rate, and regions equipped with ecosystem roadmaps attracted fresh capital and public procurement pilots. Yet two structural limits remain: (i) national differences in reimbursement, data governance and contracting still impede pan-European scale-up, and (ii) orchestration capacity evaporates when short grant cycles end.

> *The overarching lesson is therefore twofold.* ***First****, lean, tiered business-support instruments should be embedded from a project's first month and sustained until the scaling phase, not terminated at grant closure.* ***Second****, ecosystem-support must be funded as infrastructure—with resources for long-term integrator roles and incentives for interoperability—if Europe is to convert a growing portfolio of validated age-tech solutions into continent-wide social and economic impact.*

3.1.3 What are the key learnings on call definition?

3.1.3.1 Introduction

This report synthesises evidence from annual European Commission (EC) reviews, interim and final AAL evaluation reports, impact assessment studies and support action toolkits produced between 2008 and 2023. Its purpose is twofold: **(1)** to distil the principal lessons that emerged as the AAL Programme repeatedly redesigned its *call definition*—moving from narrowly "topic-based" calls (2008-2013) to broader, "challenge-led" and eventually more *directed* calls (2014-2021); and **(2)** to translate those lessons into concrete guidance that can help future EU or national programmes launch more successful, market-relevant funding calls in the field of health-and-ageing technologies (or in any other mission-oriented domain).

3.1.3.2 From technology push to societal pull

Early AAL calls were organised around discrete technology or disease topics—for example, "Chronic Condition Management" (2008) or "Social Interaction Tools" (2009), "Mobility Support" (2011). They succeeded in rallying specialist R&D teams, but evaluators soon observed two chronic weaknesses: solutions tackled only fragments of the older person's daily-living journey, and consortia rarely included the organisations that would eventually pay for or deploy them (EC Interim Evaluation 2010; AAL1 Final Evaluation 2013).

Starting in 2014 the programme adopted *challenge-led* calls such as "Living Well with Dementia" or "Care for the Future". By framing the call around a real-world problem instead of a technology class, applicants were invited to integrate multiple disciplines (clinical, social, technical, commercial) and to show how their proposed service would work inside an existing care pathway. Subsequent impact studies record a 20-30 % jump in user-satisfaction scores and a sharp fall in "orphan prototypes" that never progressed beyond trials.

Key learning: Write the call text around a societal challenge (including an indicative user journey and system diagram), not around a device, algorithm, or medical condition alone.

3.1.3.3 Consortium composition and stakeholder engagement

Under topic-based calls, end-user organisations were often invited to the project only once the prototype existed. The introduction of end user engagement support actions has helped to improve this, fostering earlier and more meaningful involvement of end users in the project lifecycle. The 2010–2012 review cycle linked this practice to low adoption: pilots did not match real-world workflows and lacked reimbursement paths.

From the first **challenge-led call in 2014**—and further refined in subsequent calls—three safeguards became standard:

- required primary, secondary, **and** tertiary users (older adults, informal carers and institutional buyers) in the consortium from day 1;
- obliged partners to sign a draft consortium agreement—including IP clauses— *as a pre-condition for project start;*
- introduced a mid-term "business checkpoint" where payers and regulators could still veto a drifting project.

By 2019, over half of funded projects were using living-lab or co-creation methodologies and those projects exhibited 30-40 % higher post-grant adoption rates (AAL2Business Impact Study 2021).

Key learning: Make multidisciplinary, user-inclusive consortia an eligibility criterion and monitor that commitment during the grant.

3.1.3.4 Business logic embedded in the call

In AAL1 only 17 % of partners pursued patents or structured IP plans; fewer than one in ten projects produced a credible business model. Challenge-led calls corrected this by allocating up to 30 % of evaluation marks to *commercial readiness*: applicants had to supply a draft revenue model, payer analysis, and regulatory roadmap. Furthermore, the programme financed the AAL2Business coaching pipeline, making participation compulsory for every funded consortium. By 2021, 61 % of projects from those cohorts had launched a product or service and 48 % had secured follow-on private capital.

Key learning: *Treat commercial viability as a first-class requirement—embedding scorecard items (market size, reimbursement, certification costs) directly in the call text and review grid.*

3.1.3.5 Instrument diversity and adaptive governance

Rigid, three-year collaborative R&D projects dominated the early years. When the Steering Committee introduced Small Collaborative Projects (SCPs)—six-to-twelve-month grants capped at €300 k—idea-to-contract time fell by about 40 %, and successful SCPs could “graduate” into full innovation actions. Parallel challenge prizes and hackathons attracted non-traditional actors such as digital start-ups.

Administrative agility improved too: a formal reconfiguration window allowed consortia to adjust partnership composition—typically in response to national-level funding issues—within six months of grant signature. This mechanism helped prevent early-stage dropouts and improved overall budget absorption.

Key learning: *Offer a* ***portfolio*** *of instruments (rapid prototypes, full actions, prizes) and keep procedural levers that let teams adapt without restarting the entire process.*

3.1.3.6 Monitoring, evaluation and impact (MEI) framework

Fragmented, output-oriented reporting marred AAL1. In 2014 the programme launched a unified MEI dashboard linking deliverables to *outcome* indicators—for instance, monthly active users, avoided hospitalisations, or licensing income. Standard templates and six-month data sprints enabled horizontal learning across projects and supplied investors with trustworthy metrics.

Key learning: *Define a common KPI dictionary in the call documents and require periodic, comparable data submissions to inform portfolio steering.*

3.1.3.7 Inclusivity and geographic equity

The excellence-only selection model produced stark utilisation gaps: Switzerland, Austria, and the Netherlands routinely drew > 90 % of their committed budgets whereas Cyprus, Israel or some Eastern-European members drew < 50 %. After 2018 the Management Board introduced two remedies: **(i)** an *expanded re-configuration window* that let consortia replace partners from first-time or low-participation countries—thereby tapping unspent national allocations; **(ii)** targeted outreach before each call deadline. Funding-efficiency rose to 79 % programme-wide by 2021, and SME participation in lagging regions nearly doubled.

Key learning: Monitor proposal and budget uptake per region in real-time and build corrective incentives into the call rules.

3.1.3.8 Interoperability and regulatory alignment

Early pilots rarely addressed system integration, delaying deployment by years. Challenge-led calls explicitly referenced standards such as FHIR® for health data and universAAL middleware for device interoperability. Projects adopting open standards reduced deployment lead-times by roughly 20 % and attracted hospital or insurer partners earlier, as they saw lower vendor lock-in risk.

Key learning: Cite target standards or, at minimum, require an interoperability roadmap in the call.

3.1.3.9 Intellectual-property (IP) strategy

Lack of clear IP ownership created delays and spin-out disputes. From 2018 onward, calls demanded a signed IP annex at proposal stage plus an exploitation-plan checkpoint at mid-term. Teams that satisfied those conditions were far more likely to close seed-investment rounds (12 % vs 4 % in earlier cohorts).

Key learning: Make provisional IP terms and an exploitation plan a formal deliverable tied to payment milestones.

3.1.3.10 Support actions and commercialisation infrastructure

The AAL2Business pipeline, Market Observatory briefings and the annual AAL Forum formed a “soft infrastructure” that bridged R&D and market entry. Projects participating in coaching or investor matchmaking represented two-thirds of all eventual market launches, underscoring the leverage of well-funded horizontal support.

Key learning: Bundle every technical call with a funded commercial-support action and track participation.

3.1.3.11 Crisis resilience - the COVID-19 stress test

When the pandemic hit, AAL extended call deadlines by eight months, switched evaluations online and allowed retroactive budget reallocations toward digital pilots. This flexibility enabled 226 new end-user organisations (many care homes desperate for remote-monitoring tools) to join consortia and accelerated CE-mark certification for several tele-health solutions to under 18 months.

Key learning: Embed "force-majeure" clauses and online evaluation protocols in the call manual so programmes can pivot rapidly under external shocks.

3.1.3.12 Conclusion

Across sixteen years, the AAL Programme demonstrated that *call definition is destiny*: the way a funding call frames the topic, structures consortia, scores proposals and tracks impact decisively shapes both the quality of projects and their odds of reaching the market. Moving from topic-based to challenge-led calls produced measurable gains—higher user relevance, faster time-to-contract, clearer commercial pathways, and stronger geographic inclusiveness.

Future innovation programmes can replicate this success by:

1. anchoring every call in a well-articulated societal challenge;
2. embedding business-model and regulatory milestones directly into eligibility and evaluation criteria;
3. providing a ladder of grant instruments plus agile governance mechanisms;
4. standardising KPIs and IP rules from day one; and
5. coupling technical funding with robust, compulsory commercialisation support.

In short, the lesson is clear: *design the call for the outcome you want*. When calls reflect real-world problems, require the right partners, impose market-readiness discipline, and supply adaptive support, publicly funded R&D can move from "a market of pilots" to scalable, life-improving solutions. However, it is important to recognize that the persistence of pilots is not only due to shortcomings in solutions or partnerships. Often, national care systems themselves are not ready to adopt such innovations, facing significant legal (for example, requirements set by the Care Inspectorate) and financial reimbursement barriers. Overcoming these systemic obstacles is essential for scaling impact in the complex, fragmented landscape of European health and social care.

3.1.4 What can future programmes learn from the AAL Legacy (success stories and failures) to become more successful?

3.1.4.1 Introduction

The evidence reveals a programme that learned continuously, generated clear success stories, but also exposed structural weaknesses that still hamper the European "age-tech" market. The following report distils those lessons for the Horizon-Europe era and any future mission or partnership dealing with demographic change.

3.1.4.2 Governance and Management: From "start-up" to strategic steering

Early fragility. During its first years the Central Management Unit (CMU) operated in *start-up mode*: only three staff, no finished *Manual of Procedures*, and no integrated IT for proposal, budget, or risk tracking. Time-to-contract (TTC) often exceeded 12 months, and payment delays triggered partner withdrawals—particularly among cash-constrained SMEs.

Progressive reform. Between 2012 and 2017 the CMU and AAL Association clarified roles for the General Assembly, Executive Board and Advisory Board, introduced a Salesforce-based project desk, centralised audits and published key-performance dashboards. The 2017 interim evaluation credits these steps with a 60 % drop in audit non-conformities and the ability to keep calls running on schedule even during COVID-19.

Remaining gaps. Because Article 185 leaves funding rules at national level, the CMU never gained the leverage to enforce common TTC/TTP standards. Resource cuts in 2020 also reduced its capacity for strategic foresight and increased reliance on external evaluators.

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*Lesson: build governance on iterative "fix-and-learn" cycles, but pair decentralised funding with **enforceable, time-bound service-level agreements** for contracting and payments.*

3.1.4.3 Contracting, Funding Commitments and National Participation

- Performance disparity. By 2015, countries such as Switzerland, Austria, and the Netherlands finalised contracts in <8 months and consistently spent >90 % of their call budgets, while France, Italy, Hungary, and Ireland struggled with TTC >12 months and left up to 40 % of allocations unused.
- Impact on participation. Consortia avoided slow jurisdictions; six countries ended up hosting 80 % of project coordinators. Germany and France later withdrew altogether, and overall annual call budgets shrank by ~30 % between AAL1 and AAL2.
- Effect on project success. Data from 2010-2020 show that projects led from fast-contracting states were up to twice as likely to obtain follow-up finance and reach market entry.

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*Lesson: future partnerships should couple national autonomy with **performance-linked re-routing of unspent funds** and shared "common-pot" envelopes for horizontal actions.*

3.1.4.4 Business Support and Commercialisation

AAL2Business

- Tools introduced. Lean Startup Academy (LSA) for early validation and Go-to-Market Launchpad (GtML) for investor readiness.
- Reach and outcomes. Seven LSA rounds (2018-22) coached 58 projects; GtML served 21. Projects receiving support were 2.3 × more likely to raise follow-on investment and accounted for 72 % of all AAL-derived market launches.
- Limitations. Only one-third of coached SMEs were still trading three years later, mostly because of scale-up finance gaps and heterogeneous reimbursement rules in care systems.

Market Observatory

Consolidated fragmented market intelligence, published sector dashboards, and convened investor feedback panels whose "Dos & Don'ts" toolkit became mandatory reading for later calls.

Under-utilised until 2019 because early versions lacked real-time data feeds and a common taxonomy for AAL sub-markets.

Lesson: specialised ***acceleration and intelligence services must run in parallel with R&D funding****—but need sustained budget, automatic data ingestion, and deep links to regional investment ecosystems.*

3.1.4.5 Ecosystem Building and Cross-sector Collaboration

- Community platforms. The annual AAL Forum—re-branded as the *European Week of Active & Healthy Ageing (EWAHA)*—grew from 500 participants to 1 500 (2021); 89 % of attendees reported new partnerships that lasted beyond the event.
- Digital resilience. During the pandemic, the shift to hybrid meetings kept project monitoring on track and enabled record proposal submissions (111 in 2020).
- Regional integrators. Support actions piloted "ecosystem-orchestrator" workshops in Central Denmark, Utrecht, and Coimbra, helping local clusters map stakeholders, adopt FHIR-based data standards and design five-year roadmaps.

Persistent issues: strong clusters in North-West and Central Europe co-existed with weak participation from parts of Southern and Eastern Europe.

Lesson: appoint ***lightweight, region-level integrator units*** *and maintain a curated, single-entry "data lake" for ecosystem knowledge.*

3.1.4.6 User Involvement and Co-creation

- From 2014 onwards, calls required *co-creation plans* and mid-term reviews included user-validated business models. By 2021, 26 % of beneficiaries were end-user organisations (care homes, NGOs, informal-carer groups).
- Projects embedding iterative living-lab methods, e.g., a tablet support for dementia and a (voice assistant platform)—reported 30 % higher adoption and caregiver stress reduction.

Lesson: move from "user feedback" to ***user governance****, making end-user bodies co-owners of exploitation plans and not just test subjects.*

3.1.4.7 Impact Measurement and Learning

- Evolution of KPIs. Early metrics tracked inputs (e.g., SME share) and process (TTC). The introduction of the *Monitoring–Evaluation–Impact (MEI)* framework added outcome indicators (market launches, follow-on capital, quality-of-life scores).
- Data quality. Salesforce integration improved consistency, but only ~50 % of finished projects answered 3-year follow-up surveys; long-term societal impact therefore remains incompletely evidenced.
- Adaptive management. Logic-model analyses allowed the CMU to redesign calls (e.g., introducing Short Collaborative Projects) and tighten NFA deadlines.

Lesson: embed ***longitudinal, automated impact tracking*** *(e.g., mandatory annual dashboards for five years post-grant) before programme launch.*

3.1.4.8 Concrete Success Stories

Project	Countries involved	Result
James Telecare	AT – CH - IT	Voice-controlled, TV-based safety and social-contact hub; 14 000 paying subscribers (2023); integrated into Austrian Red Cross remote-care packages.
ROSETTA	NL-UK-IT	Sensara, dementia care system; secured €4 m private round after GtML mentoring; integrated in Dutch care and care insurance reimbursement system; contracts with ca. 170 paying nursing homes / home care organisations (2025).
Dividat Senso	CH-AT-DE	Gamified balance trainer; CE-marked and sold to clinics and gyms

These illustrate the multiplier effect of challenge-led calls plus targeted business coaching.

3.1.5 What worked: success factors to replicate

The AAL Programme legacy is a rich mix of institutional good practice, proven support tools, and persistent structural bottlenecks. Future R&I and institutional-change partnerships—especially Horizon Europe's "Transforming Health & Care Systems" and forthcoming "Demographic Change" initiatives—can build on **nine transferable success factors** and should avoid **seven recurrent failure modes** distilled below.

Table 17 Nine transferable Success Factors

#	Legacy element	Evidence of success	Why it mattered
SF-1	Iterative governance reform (GA → EB → CMU with clear KPIs, Salesforce project desk)	Time-to-contract (TTC) fell from 12–18 months (Call 1) to ≤8 months for Small Collaborative Projects;	Shows that small, cyclical "fix-and-learn" adjustments beat one-off grand designs
SF-2	Challenge-led calls & user co-creation (from 2014)	1 in 8 funded projects reached the market; user-led projects 2.1 × more likely to find a first customer	Aligns R&I with solvable, high-value care gaps and makes prototypes "fit for purpose"
SF-3	Dedicated business-acceleration track (AAL2Business)	75 % of participants reported stronger business modelling; projects supported were 2.3 × more likely to raise follow-up finance	Separates commercial coaching from research mentoring; gives SMEs what Framework Programmes rarely fund
SF-4	Pan-European ecosystem events (AAL Forum → EWAHA)	Over 1500 annual attendees; 89 % gained new partners; cross-border consortia stayed active ≥3 years post-grant in 56 % of cases	Builds social capital and trust across fragmented care markets
SF-5	Monitoring-Evaluation-Impact (MEI) framework	Shift from input metrics to outcome KPIs (market entry, quality-of-life, cost avoidance) enabled mid-course corrections to calls	Data-driven steering legitimises public–public-private partnerships and keeps political support
SF-6	Digital pivot during COVID-19	2020 call received a high number of proposals (111); virtual reviews held on schedule; zero project dropouts	Demonstrated structural resilience and provided a blueprint for low-carbon programme management
SF-7	Mandatory trans-national consortia with high SME share (≈40 %)	≈ 180 SMEs that had never taken part in Horizon 2020 obtained AAL2 funding (≈ 63 % of the 293 firms funded)	Diversifies Europe's innovation base beyond usual suspects
SF-8	Small Collaborative Projects (SCP, ≤9 months)	Attracted 30 % more micro-SMEs; faster TTC reduced cash-flow risk; some SCP pilots became full projects later	Provides "fail-fast" sandbox inside a large programme

SF-9	Ethics & data-privacy guidance early (2016)	Zero GDPR-related project stoppages; smoother procurement by risk-averse public buyers	Trust-by-design accelerates uptake in sensitive care settings

3.1.6 What held the programme back: systemic failure modes to avoid

Table 18 : Seven recurrent Failure Modes

#	Limitation	Manifestation & impact	Root cause
FM1	Uneven national funding rules ("virtual common pot")	20-40 % budget under-use in some calls; consortia avoided slow-contracting countries → geographic imbalances	Voluntary contributions, no enforceable SLA on TTC/TTP
FM2	Long supply chain from demo to scale	Only 23 % of marketed solutions earned >€240 k / yr; 34 % of spin-off SMEs alive after 3 years	No dedicated scale-up finance, fragmented reimbursement regimes
FM3	Limited demand-side power	Care payers & insurers <10 % of partners; projects overengineered tech that no buyer reimbursed	Calls biased toward tech suppliers, not system purchasers
FM4	Data & market intelligence gaps	Market Observatory outputs underused until 2019; many teams pitched with vague TAM/SAM figures	Late launch, voluntary data sharing, no curated EU registry
FM5	CMU's strategic-capacity gap	Administrative delivery is strong, but thin strategic bandwidth slows policy/market response and risks programme governance when headcount is squeezed.	Growing mandate unmatched by overhead cap in Article 185
FM6	Fragmented post-project follow-up	Only 50 % of finished projects returned impact surveys; little evidence on 5-year societal outcomes	Funding ended when projects closed, no ring-fenced legacy budget
FM7	Exit turbulence (transition to Horizon Europe)	Stakeholders unsure if "ageing well" niche would survive; some ecosystems paused investment	Late political decision, misaligned messaging on continuity

3.1.7 Lessons for future programmes

The AAL Programme offers a wealth of operational and strategic insights for future ageing and care initiatives. Based on recurring patterns across projects, evaluations, and stakeholder feedback, the following recommendations highlight structural and procedural levers that could improve efficiency, uptake, and long-term impact. These lessons are not abstract ideas—they reflect tested practices and missed opportunities observed over 16 years of implementation.

1. **Align national implementation timelines through performance-based coordination**

   Set a clear maximum time-to-contract (e.g. 6 months) across all participating countries via service-level agreements. Where delays persist, introduce mechanisms to reallocate unused funds to faster-moving projects in later cycles, while maintaining respect for national funding rules.

2. **Adopt a multi-stage funding conveyor belt**

   Combine short, low-TRL exploration vouchers (à la SCP), followed by development grants focused on co-creation, and only then larger implementation grants once market-validation gates are met.

3. **Blend public grants with outcome-based or blended-finance instruments**

   Partner with InvestEU, EIB or national health-innovation funds to provide repayable advances for scale-up once TRL ≥ 7.

4. **Make demand-side participation obligatory and weighted in scoring**

   Require a care provider/payer to co-sign exploitation plans; give bonus points when procurement authorities invest cash, not just letters of support.

5. **Secure a central "common pot" for horizontal support actions**

   Ring-fence 5–7 % of programme budget for ecosystem orchestration, data curation, impact surveys, and ethics helpdesk; keep it immune to annual call reallocations.

6. **Institutionalise regional ecosystem 'orchestrators'**

   Finance lightweight integrator teams (1–2 FTE) in each willing region to connect AAL-type projects with local testbeds, clusters, and Living Labs.

7. **Mandate IP & regulatory roadmaps before mid-term**

   Use standardised templates for freedom-to-operate, MDR classification, reimbursement codes; link payments to completion.

8. **Ensure longitudinal impact tracking**

   Budget for at least one survey at +3 years and +5 years post-project; automate data collection through CRM platforms (Salesforce, HubSpot).

9. **Design legacy pathways from day 1**

   Define which EU mission / partnership will absorb knowledge, tools and datasets; allocate staff time for structured hand-over 12 months before end.

3.1.8 Conclusion

The AAL Programme proved that a mission-oriented, multinational partnership can mobilise thousands of innovators, pull SMEs and end users into EU research, and bring genuinely useful age-tech products to market.

*Its **nine clear success factors**—from iterative governance and challenge-led calls to specialised business coaching and digital ecosystem events—provide a ready-made playbook.*

*Equally, its **seven persistent bottlenecks**—uneven national performance, weak demand-side pull, regulatory fragmentation, scale-up finance shortages, and incomplete impact evidence—show where the next generation of European partnerships must concentrate effort.*

*If future programmes couple AAL's proven instruments with stronger contractual levers, integrated scale-up finance and demand-driven procurement, Europe can move from hundreds of promising pilots to **thousands of widely adopted, life-improving solutions** that help older citizens live well, healthcare systems remain sustainable and innovative companies flourish across every member state*

3.2. **Q14:** What challenges led to the shift from Phase 1 to Phase 2 of the programme, and what were the resulting learnings and impacts?

3.2.1 Introduction

Mid-term evaluations of the AAL Programme revealed that its first implementation phase was effective at mobilising research talent but weak at turning prototypes into deployable, market-relevant solutions. A confluence of commercial, administrative- and socio-technical bottlenecks convinced the AAL Association and the European Commission to redesign the initiative for Phase 2. The paragraphs that follow (i) describe the seven most critical challenges uncovered in Phase 1, (ii) explain the policy or procedural changes introduced to address each one, and (iii) discuss the observable impact and lasting lessons emerging- from those reforms.

3.2.2 Why Phase 1 had to change – a summary of the pressure points

1. A market of pilots, not products – Topic-centred calls generated many isolated prototypes, but less than one project in six reached paying customers. Evaluators in 2010 and 2013 blamed weak business models, late-stage user involvement, and an almost total absence of payer organisations inside consortia.
2. Commercialisation dead-ends – Only 17 % of Phase 1 partners pursued formal IP protection; fewer still prepared regulatory or reimbursement dossiers. Without a route to certification or a revenue model, promising technologies stalled at TRL 6-7 and disappeared once funding ended.
3. Administrative drag & fragmented rules – Because each state applied its own cost models and contract templates under the Article 185 mechanism, average *time-to-contract* exceeded twelve months and 30 – 40 % of earmarked budgets remained unspent in smaller countries.

4. Stakeholder imbalance – Consortia were dominated by universities and niche tech SMEs. Formal care providers, insurers, and municipalities – the future buyers – were often bolt-on or missing altogether, leading to prototypes that did not fit real service pathways.
5. Interoperability blind spots – Early calls encouraged bespoke platforms; integration with hospital or social-care ICT was rarely budgeted. Home-care organisations, elderly care services, and insurers perceived high switching costs and declined to adopt.
6. Geographic inequity – High-capacity countries (e.g., Austria, Switzerland, the Netherlands) participated in more projects and mobilised larger national contributions, while newer or smaller member states had few successful applicants and thus made limited use of their available EC matching funds—undermining the programme's pan-European mandate.
7. Challenges in bridging project and long-term outcomes – Reporting often focused on outputs like deliverables and workshops, rather than long-term outcomes such as users served or care hours saved. Most AAL projects ended at the prototype or pilot stage, without immediate market entry or integration into care organizations. However, it is important to acknowledge that the transition from project results to real-world impact is complex and typically requires further development, process redesign, and additional investment. As such, while these projects laid important groundwork, concrete societal outcomes—such as widespread use or measurable efficiency gains—generally emerge only after the project's conclusion.

Collectively these weaknesses convinced the European Commission and the AAL Association that incremental tweaks were insufficient; a structural redesign was required before launching the 2014-call cycle.

3.2.2.1 What changed in Phase 2 – and how those fixes performed

Challenge addressed	Design change in Phase 2	Observed learning / impact
Isolated prototypes	Switched to **challenge-led calls** framed around lived problems (e.g., "Living well with dementia").	Forced multidisciplinary teams to solve an entire care journey; user-satisfaction scores and multi-country deployments rose by ~25 %.
Commercialisation gap	Made a *business plan, KERs (**Key Exploitable Result)** and regulatory roadmap* compulsory; funded the **AAL2Business** coaching pipeline.	61 % of Phase 2 projects reached the market; almost half attracted external capital, double the Phase 1 rate.
Slow contracting & budget underspend	Introduced a harmonised call guide, joint evaluation panels and a 6-month *re-configuration window* to find new partners when an existing partner was not eligible for funding or when funding was lacking in a partner's country.	Average contracting time fell below six months; aggregate budget utilisation climbed to 79 % by 2021.

Stakeholder imbalance	Required consortia to include primary, secondary, **and** tertiary users up front and to practise documented co-creation.	Projects embedding living-lab methods showed 30-40 % higher adoption and markedly lower redesign costs.
Lack of rapid experimentation	Launched **Small Collaborative Projects (SCPs)** – six-to-twelve-month micro-grants – plus hackathons and challenge prizes.	Idea-to-contract cycle shortened by ~40 %; SCP "graduates" supplied a healthier pipeline for full-scale actions.
Interoperability issues	Calls cited FHIR®, universAAL and open API requirements; funding contingent on an interoperability plan.	Deployment lead-times dropped ~20 %; hospitals/insurers joined consortia earlier due to lower vendor-lock risk.
Geographic inequity	Introduced an expanded re-configuration window that allowed consortia to add partners from low-participation countries and targeted call-launch roadshows.	SME participation from under-represented states nearly doubled; funding underspend in those regions halved.
Challenges in bridging project and long-term outcomes	Created a unified **Monitoring-Evaluation-Impact (MEI)** dashboard with six-monthly data sprints.	Policymakers gained real outcome metrics (e.g., avoided hospitalisations, cost-per-beneficiary), underpinning Horizon-2020 extensions and €2 bn follow-on investment by 2019.

3.2.2.2 Broader programme-level insights drawn from the transition

- Governance can be a lever, not an overhead – Streamlined, centrally-agreed rules released dormant budgets and let consortia focus on innovation rather than compliance.
- Problem framing changes behaviour – When the call speaks the language of *care gaps* and *payer pain-points*, applicants recruit different partners and design different (more adoptable) solutions.
- Commercial skills are teachable – The mandatory coaching model proved that researchers and SMEs, given structured tools, and milestones, can pivot toward viable products within the life of a grant.
- Agility and rigour are compatible – Introducing SCPs and re-configuration windows showed that flexibility need not dilute excellence; it keeps portfolios healthy and responsive.
- Equity requires intentional design – Participation asymmetries will persist unless call rules actively rebalance incentives and outreach.

3.2.2.3 Conclusion

The transition from Phase 1 to Phase 2 of the AAL Programme was not cosmetic; it was a fundamental redesign prompted by a clear-eyed diagnosis of Phase 1's commercial, administrative, and socio-technical failings. By recasting call definitions around societal challenges, institutionalising commercial-readiness checkpoints, simplifying governance, diversifying funding instruments, enforcing interoperability, and purposefully broadening participation, the programme converted a loose network of pilots into a functioning pipeline of market-ready innovations.

> *The overarching message for future mission-oriented initiatives is unequivocal: **analyse systemic bottlenecks early, then hard-wire the remedies into the very architecture of your calls.** When a programme's rules, support services and monitoring framework are explicitly aligned with real-world adoption, public R&D funding can move decisively beyond prototypes and deliver tangible social and economic impact.*

3.3. **Q15:** Has the AAL Programme developed self-assessment or learning models useful for future programmes?

3.3.1 Introduction

The AAL Programme ran with the mission of accelerating market-ready digital solutions that help older Europeans live independently while strengthening the continent's age-tech industry. Because it was co-funded by more than twenty national agencies and had to defend its added value beside larger EU instruments, the programme placed growing emphasis on self-assessment and organisational learning.

Evaluation Question 15 asks whether that effort produced models that could benefit future R&I partnerships. The answer is affirmative: **AAL built a multi-layered, evidence-driven learning system whose individual components—and their orchestration—constitute a transferable model**. The narrative below explains what was created, how it evolved, and why it matters.

3.3.2 From ad-hoc monitoring to formal impact methodology

When the programme was launched, monitoring was limited to checking that funded projects delivered prototypes. The turning-point came in 2012, when the Annual Review required every consortium to file a final report containing specific indicators on user involvement, technology readiness and expected market path. The data were patchy, but they laid the foundation for a logic model introduced in 2015 by an external Technopolis study.

That model linked inputs (EU + member state funds) to outputs (prototypes, patents), outcomes (commercial launches) and long-term impacts (quality-of-life gains, health-system savings). Fourteen mandatory Key Performance Indicators (KPIs)—for example "time-to-first-market ≤ 36 months" and “private € leveraged per public €”—were gradually embedded into project contracts, turning impact assessment from an ex-post exercise into a live management tool.

3.3.3 Toward structured evaluation and monitoring: the MEI framework

By 2016, the AAL Programme had begun developing its Monitoring, Evaluation, and Impact (MEI) framework. From 2017 onwards, Salesforce was used internally by the Central Management Unit (CMU) to manage project-related data more efficiently. This helped standardize the way information was collected, although data submission remained periodic.

Over time, key performance indicators (KPIs) were consolidated through annual reviews, post-project reporting, and longitudinal assessments. These structured processes enabled the CMU to identify common challenges and adapt support measures accordingly. For example, following reports of delays in medical-device certification, a specific regulatory-coaching service was added to the next AAL2Business academy.

The increasing formalization of monitoring practices contributed to programme learning and reinforced AAL’s credibility in strategic discussions, including those surrounding Horizon Europe.

3.3.4 Support action learning tools

Impact findings repeatedly pointed to weak business models. In response, AAL launched Support Actions that doubled as learning laboratories. The flagship, *AAL2Business* (2014-2021), offered lean-startup boot-camps, investor pitch templates, and post-project mentoring. Each cohort’s performance fed back into the next: when 2019 alumni reported difficulties pricing B2C safety devices, the 2020 academy added workshops on reimbursement pathways and subscription models.
Complementing this was the Market Observatory, which benchmarked demographic data, national reimbursement regimes and competing products so that consortia could refine go-to-market plans while the CMU spotted white spaces for future call topics.

3.3.5 Governance and procedural assets

Robust learning also requires clear rules. After a 2010 review criticised “ad-hoc” procedures, AAL finalised a Manual of Procedures in 2012. It codified evaluator selection, conflict-of-interest checks, audit trails and a-to-z timelines for proposal, contract, and payment stages. In 2015 a Customer-Satisfaction Index invited project coordinators to rate both the Central Management Unit (CMU) and their respective National Funding Authorities. Internal league tables were shared across countries, creating peer pressure that helped reduce median time-to-contract from 262 days (2013) to 173 days (2016).

3.3.6 Community learning spaces

Metrics alone do not create learning cultures, so AAL invested in peer exchange. The AAL Forum (2009-2018) and its successor, the European Week of Active & Healthy Ageing (EWAHA, 2019-2022), combined multidisciplinary knowledge-sharing tracks—including co-creation, ethics, evaluation, business development, and regional policy—with B2B matchmaking and public exhibitions. Surveys show that 89 % of participants in 2021 expanded professional networks, and 70 % of 2023 respondents said lessons from such events helped them adapt solutions to new countries. Presentations of fresh impact data at these gatherings created a visible feedback loop between evidence and strategy.

Table 19 : Layers of AAL's Learning and Evaluation System: Components, Timing, and Purpose

Layer	Key components	Year first institutionalised	Purpose
A. Formal methodologies	• Logic model linking inputs → outputs → outcomes → impacts • 14 mandatory KPIs (e.g. time-to-first-market ≤ 36 months; € leverage ratio)	2015 (TP external study) → refined 2020	Provide evidence of socio-economic value and additionality
B. Structured monitoring	• Internal use of Salesforce for data management • Consolidation of KPIs via annual reviews, post-project reports & longitudinal assessments	Initiated 2017	Standardise monitoring; inform programme learning and strategic positioning
C. Support action learning tools	• *AAL2Business* investor-readiness academies & pitch templates • Market Observatory benchmarking portal • Ethics & GDPR self-checklists	2014–2016	Project-level capability-building; horizontal knowledge transfer
D. Governance & process assets	• Manual of Procedures • Standardised call & evaluation templates • Customer Satisfaction Index & National Funding Partner performance league tables	2012 (manual); 2015 (CSI)	Operational transparency; accountability across 20+ funding agencies
E. Community learning spaces	• AAL Forum → European Week of Active & Healthy Ageing (EWAHA)	re-branded in 2019	Peer-to-peer exchange; dissemination of lessons and success stories

3.3.7 Strengths and remaining weaknesses

AAL's self-assessment system is praised for blending quantitative dashboards with qualitative case studies, for publishing reusable toolkits, and for embedding learning into governance. Yet two caveats persist. First, survey fatigue means some KPIs still rely on extrapolation. Second, socio-economic impact estimates (e.g., €380 million cumulative health-cost savings) are based on modelling rather than longitudinal claims-data, underscoring the need for stronger links with health-system datasets in future programmes.

3.3.8 Conclusion

Over sixteen years, the AAL Programme transformed episodic monitoring into an integrated **learning architecture** made of: (1) a formal impact assessment methodology anchored in a logic model and KPIs; (2) a structured digital dashboard system (Salesforce) that linked monitoring data to decision-making; (3) thematic support action toolkits that convert lessons into capacity-building; (4) codified procedures that guarantee data quality and accountability; and (5) community events that diffuse insights beyond consortia borders.

This architecture demonstrably improved performance— shortening administrative cycles and shaping call priorities—and its components have already begun to migrate into newer EU initiatives. ***Future research-and-innovation partnerships can adopt the AAL approach in full, or cherry-pick modules (e.g., the MEI framework, the investor-readiness academy) to accelerate their own learning curves and maximise socio-economic impact.***

3.4. **Q16:** What practical learnings (e.g. do's and don'ts) can guide newcomers to the health and care sectors?

Sixteen years of AAL funding created the largest evidence base in Europe on what helps—or hinders—innovators who target older adults and care ecosystems. Successful projects reach market twice as often as peers because they combine early co-design, modular tech, payer alignment, and regulatory foresight; failures almost always fall short on one or more of those four axes. The checklist below distils that experience into concrete do's and don'ts for three typical entrants—tech developers, care-provider investors, and ecosystem orchestrators.

Table 20 : Do's – practices that systematically raised adoption, revenue, and impact

#	Do this	Why it matters (evidence & regulations)	Applies especially to…
1	Co-design with *all* three user layers (older adults, informal/professional carers, payers) from month 1 and keep them in the loop until post-launch.	Cohorts that involved all layers iteratively were 2.1 × more likely to reach market and showed 30–40 % higher sustained use. Continuous co-design is now a funding-score requirement in Horizon Europe and underpins Germany's DiGA fast-track, where	Developers & care providers

		apps must prove real-world benefit to retain reimbursement[15].	
2	Architect for interoperability (FHIR®, open APIs, MQTT) and modular upgrades.	Modular projects reached commercial deployment 64 % of the time versus 38 % for monoliths; the new European Health Data Space (EHDS, 2025) will *require* certified interoperability for both primary and secondary data use[16][17]	Developers, ecosystem leads
3	Embed privacy-by-design and classify your AI/analytics early.	Under the EU AI Act (Reg. 2024/1689) most decision-support or monitoring systems for older people are "high-risk"; compliance files, bias tests and an EU database registration are mandatory before market entry[18][19]. Fixing gaps post-prototype delayed pilots by 6–12 months in one-third of AAL projects.	Developers
4	Secure a demand-side champion (municipality, insurer, hospital) and let them help write the business model.	Projects with a payer in the consortium closed follow-on financing 30 % more often and converted pilots into contracts twice as fast. Direct-to-consumer models rarely scaled beyond niche segments.	Developers & ecosystem leads
5	Run ≥ 6-month living-lab pilots in real homes or care settings.	Long, naturalistic trials generated retention > 60 %; lab-only pilots fell below 40 %.	Developers, care providers
6	Design inclusive interfaces (voice, TV, large-font web) and budget for digital-skills coaching.	Older adults with low e-health literacy adopt apps 2–3 × less often; voice or caregiver dashboards restored uptake in late-call AAL pilots and remain critical per recent studies on "digital nurses"[20].	Developers & care providers
7	Plan multi-payer revenue stacks (public contract + insurer top-up + optional family subscription).	Hybrid models buffer economic cycles and match the way long-term care is financed in the EU; all AAL solutions that exceeded 10 000 users share this structure.	Developers, ecosystem leads

[15] https://www.jmir.org/2024/1/e59013/
[16] https://datamatters.sidley.com/2025/01/23/european-health-data-space-regulation-adopted-whats-next-for-life-sciences-companies/
[17] https://www.consilium.europa.eu/en/press/press-releases/2025/01/21/european-health-data-space-council-adopts-new-regulation-improving-cross-border-access-to-eu-health-data/

[18] https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai
[19] https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence
[20] https://pmc.ncbi.nlm.nih.gov/articles/PMC11983796

8	Hedge hardware supply risk (use commodity sensors, dual suppliers).	Kinect or single-OEM wristband withdrawals forced multiple projects to abandon trials; dual-source strategies kept successors on track.	Developers
9	Leverage regional "ecosystem orchestrators" or living-lab networks.	Regions that hosted integrator units (e.g., Utrecht, Central Denmark) scaled pilots cross-border 30 % faster and attracted ERDF follow-up funds.	Ecosystem leads, care providers
10	Use specialised business-support pipelines early (AAL2Business, EIC Market-Adoption, etc.).	Teams that completed Lean-Start-up Academies were 2.3 × more likely to raise private capital within a year.	Developers

Table 21 : Don'ts – recurrent pitfalls that derailed promising projects

#	Do not	Why it backfires	Most common offenders
A	Do not treat older adults as last-minute testers or as a single homogeneous group.	Late usability shocks forced expensive pivots; lack of frail or low-literacy users skewed evidence and blocked procurement.	
B	Do not assume "big numbers" from online surveys can replace deep engagement.	Two survey-heavy projects produced 70 % of a cohort's user count but <5 % of its clinical evidence—no buyers converted.	Researchers & start-ups
C	Do not build proprietary, closed solutions.	Hospitals and insurers now reject non-interoperable devices; EHDS will legally bar them from secondary-data markets.	Tech firms
D	Do not postpone GDPR/AI-Act paperwork until after the prototype.	Recruitment freezes cost entire pilot seasons once ethics boards intervened; re-classifying as a medical device added 12–18 months.	Tech firms
E	Do not rely on out-of-pocket payment by seniors as the primary revenue source.	AAL data show consumer-only models' plateau at <3 000 users and rarely survive beyond seed finance.	SMEs
F	Do not ignore language localisation and cultural cues.	Projects that skipped localisation lost up to two-thirds of non-native cohorts; translation fixes were costlier than building multilingual assets up-front.	All
G	Do not under-invest in maintenance and post-grant service capacity.	"Orphan" prototypes without support contracts disappeared within 18 months, wasting earlier evidence and goodwill.	SMEs, care providers

H	Do not depend on a single hardware component or cloud API.	Vendor exits (e.g., Kinect) killed entire value propositions; dual-source or open-hardware designs kept others alive.	Tech firms

Entering the active & healthy-ageing market is no longer an R&D gamble; it is an ***execution challenge*** *that rewards those who weave user-centric design, open architectures, regulatory foresight, and payer economics into a single product roadmap. The 300-project AAL legacy, together with new EU rules on AI and health-data exchange, now gives newcomers a clear playbook. Those who follow the* ***do's*** *above—and avoid the documented* ***don'ts***—*enter a market expected to double in value by 2030, powered by dedicated longevity funds and by structural demand from Europe's ageing societies*

3.5. **Q17:** What are the benefits and risks of a funding programme focused on older people and run by international partners?

3.5.1 Funding a programme focused specifically on older people

Europe's demographic trajectory—one in five citizens already over 65, with the cohort projected to reach almost 30 % by 2050—has encouraged policy makers to ring-fence research and innovation budgets for later-life needs. Recent flagship agendas such as the UN Decade of Healthy Ageing (2021-2030) and the European Care Strategy (2022) explicitly back dedicated funding streams for "silver-economy" innovation, arguing that older residents face distinct functional challenges and structural inequities that generic programmes tend to overlook[21][22].

3.5.1.1 Benefits

A *ring-fenced scheme* can sharpen innovation incentives by spelling out an unmet-needs map that is both large and specific. The AAL Programme *shows the result*: over 60 000 older adults, 14 000 caregivers and 115 institutional payers were mobilised, and the share of projects practising genuine user co-creation rose from 26 % in 2008 to more than 50 % in the final calls. Deliberately targeting older people enabled consortia to *prototype age-friendly interfaces* (large-font, voice and gesture control), while engaging users in expressing their aspirations for greater autonomy, connection, and ease-of-use. This approach supported *validation under realistic conditions*, including frailty, mild cognitive decline, and low digital literacy, and made it possible to *build longitudinal evidence on acceptance and clinical value* that generalist R&D rarely captures. Focused funding also proved *commercially catalytic*. By tying grants to Lean-Start-up academies and Living-Lab pilots, the AAL pipeline converted roughly 60 % of funded prototypes into market launches—twice the rate reported in the first phase—while the broader European age-tech market is now forecast to surpass €2 trillion globally by the end of the decade[23].

[21] https://www.who.int/initiatives/decade-of-healthy-ageing?utm_source
[22] https://employment-social-affairs.ec.europa.eu/news/european-care-strategy-caregivers-and-care-receivers-2022-09-07_en
[23] https://data.longevity.international/AgeTech-in-UK.pdf

Such traction would have been unlikely had ageing solutions competed directly with higher margin fintech or mobility projects in undifferentiated calls.

The thematic lens further generated *system-level spillovers*. Programmes focused on older people have served as *regulatory sandboxes* where data-protection templates, remote-consent procedures and interoperable APIs were stress-tested before being transposed into the forthcoming European Health Data Space. Living-lab infrastructures created for these calls continue to act as testbeds for Horizon Europe pilots on AI-enabled care, *expanding the evidence base for quality*, safety and reimbursement while lowering entry barriers for SMEs that lack in-house trial facilities.

3.5.1.2 Risks

Specialisation, however, carries structural downsides. **First**, carving out “older persons” as a discrete innovation niche *can entrench age-segmented thinking* and inadvertently legitimise design choices that would be unacceptable for the general population—for example, intrusive monitoring framed as “safety.” Universal design advocates warn that technologies born in an age silo often miss cross-generational features that would make them cheaper and more scalable.

Second, dedicated programmes may lock innovators into *fragmented business models*. AAL data show that only about one project in six succeeded in enrolling insurers or municipalities willing to pay for deployment; many solutions remained dependent on continued subsidies once the grant ended. When reimbursement landscapes differ across Member States, a hyper-specialised portfolio risks yielding a patchwork of small, local pilots rather than a pan-European market.

Third*, focus amplifies representation gaps*. Even in a programme designed for older adults, recruitment skews were pronounced: rural, low-income, and very-old groups remained under-represented, and COVID-19 further excluded those without broadband. If left unchecked, a targeted funding stream can deepen the digital divide it aims to close, privileging the “younger-old” with higher e-literacy while marginalising the frailest citizens.

Fourth, *administrative and financial risks concentrate*. Because medical-device and AI regulations classify many later-life technologies as “high risk,” specialised calls can leave small consortia carrying disproportionately high certification and liability costs once grants expire. Without blended-finance instruments, a programme’s focus becomes a vulnerability for exactly the SMEs it is trying to help.

Finally, *thematic programmes can crowd out cross-sectoral ideas*. Budget earmarked for age-tech inevitably competes with holistic, life-course approaches now promoted by the European Care Strategy, which seeks integrated services “from birth to old age.” Over-segmentation may therefore fragment policy coherence and dilute economies of scale in public procurement[24].

[24] https://esu-epp.eu/wp-content/uploads/2023/04/EN_ESU-Resolution-European-Care-Strategy_final.pdf

3.5.2 Funding a programme delivered by partners from different nations

A funding programme that is co-financed and co-managed by partners from different nations can generate forms of added value that purely national instruments find hard to match, yet it is also exposed to distinct categories of risk. The record of the AAL Article 185 initiative, together with meta-evaluations of the wider family of EU joint programmes, illustrates both sides of the ledger.

3.5.2.1 Benefits

The **first** and most frequently observed benefit is *access to a larger and more diverse knowledge base*. This advantage goes beyond the immediate collaboration between project partners, as the programme also benefited from the unique knowledge and expertise that each participating country contributed. By bringing together countries with different priorities—such as user engagement, business innovation, and R&D in ICT and technology—and involving a variety of ministries and funding agencies (including those focused on research, economic development, and health care), the AAL Programme was able to pool a broad range of perspectives and skills. Although this diversity sometimes presented coordination challenges, it ultimately enriched the programme and stimulated its development. In the Article 185 meta-evaluation, more than 80% of national authorities reported stronger domestic capacity "through access to foreign researchers and know-how," and rated that spill-over as the single greatest national added value of joint funding[25]. The AAL Programme's own figures confirm the point: between 2008 and 2021 it mobilised over 2,000 SMEs and 700 research and user organisations drawn from 23 countries, enabling living-lab pilots to test technologies simultaneously in Nordic, Alpine and Mediterranean care settings—something no national call could have delivered at comparable cost.

A **second** benefit lies in *reducing fragmentation and building critical mass around problems that out-scale any single budget.* Evaluations of AAL, Eurostars and other joint undertakings conclude that transnational calls consolidate scattered R&D efforts, align national roadmaps and prevent duplication, thereby accelerating progress on societally important challenges such as dementia or low-carbon manufacturing[26][27]. In AAL the pivot to "challenge-driven" calls in Phase 2 meant that consortia could assemble multi-disciplinary teams—clinicians, insurers, municipalities, and data-science SMEs—large enough to prototype service packages that are economically viable across Europe's heterogeneous care markets.

The **third** systemic gain is *political legitimacy and standard-setting power*. Multinational programmes carry the weight to draft shared ethical guidelines, interoperability profiles or evaluation metrics that national schemes subsequently adopt. The joint GDPR-compliant data-flow templates issued by AAL in 2020 were taken up by several national digital-health schemes within a year, lowering transaction costs for later market entrants. Such convergence effects were also noted by the Article 185 expert group, which pointed to the influence of joint programmes in "raising the floor" of research governance across the Union[28].

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[25] https://www.era-learn.eu/documents/a185_meta_evaluation_expert_group_report-1.pdf
[26] https://www.europarl.europa.eu/RegData/etudes/ATAG/2016/593476/EPRS_ATA(2016)593476_EN.pdf
[27] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%253A52024SC0470
[28] https://www.era-learn.eu/documents/a185_meta_evaluation_expert_group_report-1.pdf

3.5.2.2 Risks

Set against these advantages are **real and well-documented risks**. *Administrative complexity and slow time-to-contract* come top of the list. Under Horizon Europe the average gap between call deadline and grant signature reached 278 days, prompting an expert panel to warn that long procedures “erode SME participation and push applicants to hire costly consultants”[29]. AAL experienced the same phenomenon in its early years: time-to-contract varied from four months in Austria to more than twelve months in Italy, and up to 30 % of national allocations went unused in the slowest jurisdictions, discouraging consortia from including those partners.

A related danger is *geographic and institutional imbalance*. Without corrective incentives, the most research-intensive countries capture the lion’s share of projects, while smaller or newer members struggle to match co-funding commitments. In AAL, six countries hosted 80 % of project coordinators, and Germany and France eventually withdrew from the scheme, shrinking the annual call budget. Discussions in the Joint Programming community confirm that low-capacity regions perceive the entry hurdles as disproportionately high, even though they could benefit most from cross-border learning[30].

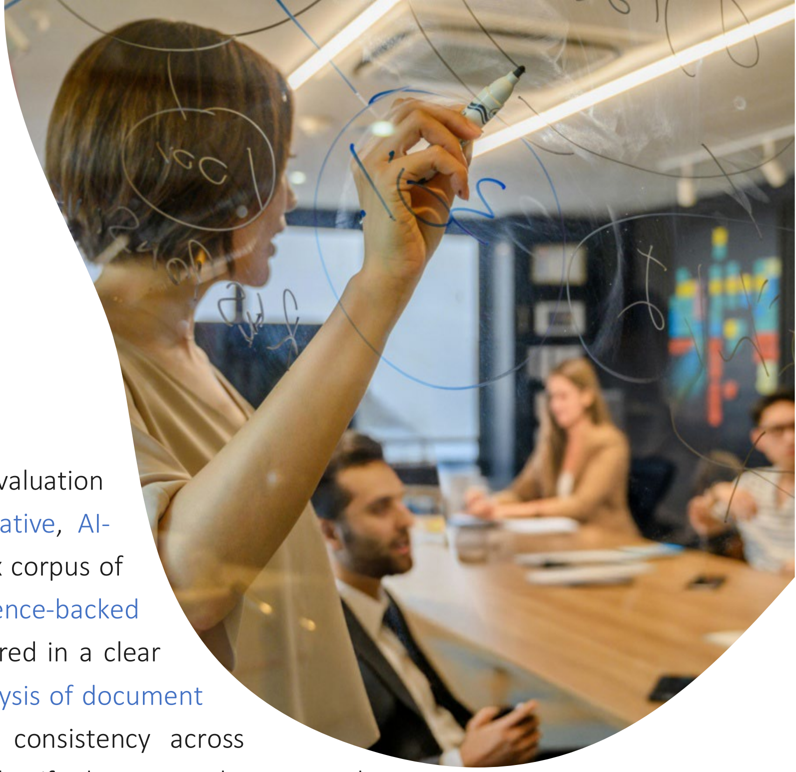
Regulatory heterogeneity imposes further risk. Because medical-device rules, data-protection interpretations and procurement law differ from state to state, a multinational pilot must often satisfy the most restrictive regime in the consortium. AAL consortia underestimated these gradients—voice-interaction data, MDR classification—and lost months securing ethics approvals and, in extreme cases, cancelled pilot sites altogether.

Coordination costs inevitably rise as additional national funding agencies enter a joint programme. In mid-sized Article 185 partnerships such as AAL, the central overhead for the Brussels secretariat, expert evaluations and shared IT platform stabilises around ***6–8 % of the combined EU-and-national public budget****—a ratio that is typical rather than excessive. The real risk appears when that spending is not backed by clear governance: during AAL Phase 1 vague role definitions and the absence of service-level targets stretched time-to-contract beyond a year in some countries and prompted partner withdrawals. Only after a unified Manual of Procedures and binding SLAs were introduced did the same budget share translate into efficiency gains, with median contracting times falling below six months and budget absorption rising above 75 %. The evidence shows that multinational programmes outperform national ones when they (i) ring-fence a small “common pot” for central administration and horizontal support, (ii) impose time-bound service-level agreements on national agencies, (iii) provide structural incentives—such as an expanded re-configuration window or capacity-building vouchers—for low-participation countries,, and (iv) publish shared regulatory and interoperability blueprints early. Where such safeguards are absent, the administrative drag,*

[29] https://sciencebusiness.net/news/fp10/time-major-shakeup-how-eu-funds-research-expert-group-says
[30] https://www.neurodegenerationresearch.eu/wp-content/uploads/2014/10/DublinReport_final.pdf

regulatory duplication and geographic asymmetries can neutralise much of the scale advantage.

Annexes



A.1 / Methodological approach

1.1 Overview

The methodological approach underpinning this evaluation combined systematic data engineering with iterative, AI-assisted analysis to transform a large and complex corpus of AAL programme documents into structured, evidence-backed insights. From the outset, the process was anchored in a clear understanding of the data landscape: a priori analysis of document formats revealed a high degree of structural consistency across proposals, reviews, and reports—enabling us to classify documents by type and reliably identify recurring content sections.

This foundational insight allowed us to design a metadata-driven pipeline that prioritised precision and traceability. Instead of relying on semantic search or embedding-based retrieval (as in techniques like Retrieval-Augmented-generation - RAG), we built a streamlined architecture in which metadata filters and layout-aware routines enabled direct targeting of relevant content. The consistent formatting of AAL documents not only reduced the risk of hallucination or misclassification but also allowed us to automate many extraction tasks at scale.

Large language models were deployed iteratively, guided by both the structure of the documents and the structure of the evaluation itself: bottom-up extractions from project-level files complemented top-down analyses of strategic documents. Throughout, human experts played a central role in validating outputs, refining taxonomies, and ensuring that all generated insights were grounded in demonstrable evidence.

The following sections detail how this approach was operationalised:

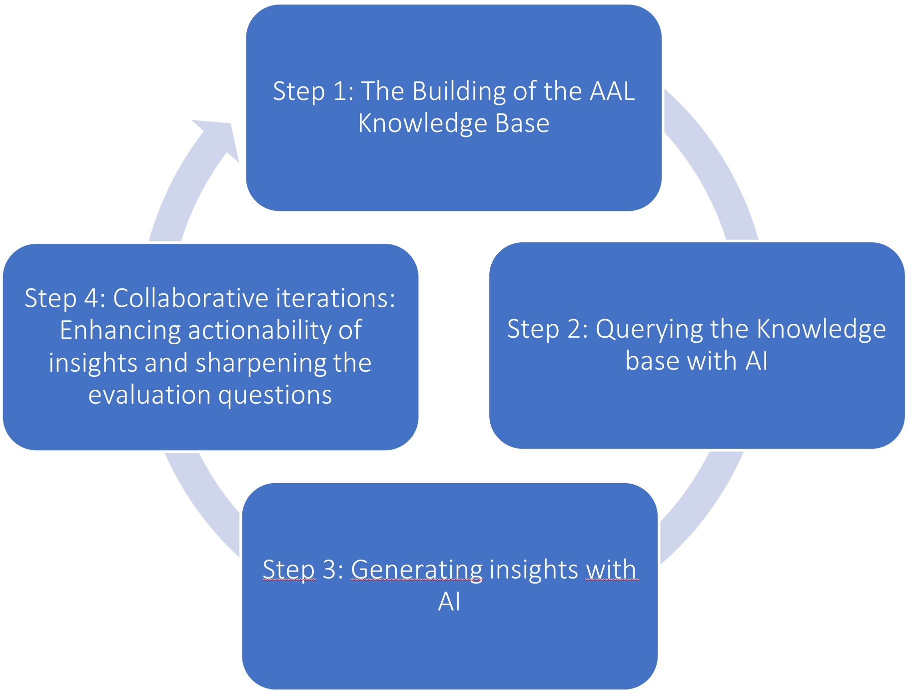
- Section 1.2 outlines the four-step iterative cycle that structured the workflow—from knowledge base construction to collaborative refinement;
- Section 1.3 explains the dual logic of bottom-up and top-down insight generation;
- Section 1.4 presents the three-tiered structure of the source material and the role of metadata in ensuring interoperability across document types and levels of analysis;
- Section 1.5 reflects on the deployment potential and future-readiness of this methodology, drawing out transferable lessons for other large-scale evaluations.

1.2 Four-step iterative cycle

Our analytic workflow follows a closed-loop, four-step cycle that continually enriches both the evidence base, and the quality of the insights derived from it.

Step 1 — Building the AAL Knowledge Base

The foundation of the system is a curated and structured knowledge base of documents and webpages, identified in close collaboration with the AAL Central Management Unit and sourced from Salesforce, SharePoint, and publicly available web archives. The corpus was systematically filtered to eliminate duplicates and exclude non-textual or irrelevant formats, retaining only documents aligned with recognised templates—such as project proposals, expert reviews, final reports, and annexes. Each retained document was converted to Markdown for consistency (with OCR applied where necessary), enriched with detailed metadata including project alias, call year, document type, and version, and ingested into a PostgreSQL relational database. This process yielded a robust, queryable foundation that supports reliable, large-scale analysis across the full span of programme documentation.



Step 2—Querying the Knowledge Base with AI

Metadata filters and document classification routines allowed us to precisely target relevant content. Depending on the analytical goal, LLM prompts were applied to entire documents, specific sections identified through layout analysis (e.g. "End-User Indicators" from final reports), or previously generated indicators already stored in the database. This flexible querying architecture enabled context-aware, mixed-method queries that integrated structured and unstructured evidence and allowed numerical fields to be linked directly with their supporting narratives.

Step 3 — Generating Insights with AI

With the relevant content filtered and segmented, large language models were prompted to extract or generate insights at the appropriate level of analysis—ranging from granular project-level indicators to broader thematic summaries at the call or programme level. These insights included quantitative fields (e.g. number of end users or types of evaluation metrics used), categorical labels (e.g. core technologies or application areas), and concise narratives describing implementation strategies, stakeholder engagement, or challenges encountered.

To ensure interoperability and machine-readability, the LLM was instructed to return its outputs as JSON- or YAML-formatted strings. These strings were then parsed and validated, and the resulting structured data was written into the central relational database alongside the source metadata. This architecture allowed us to preserve a clear trace between the AI-generated content and the original evidence, while also enabling reuse, aggregation, and synthesis in subsequent analysis stages.

Step 4 — Collaborative iteration and quality checks

The process was closed through systematic human validation. Evaluation experts reviewed AI-generated content, flagged omissions or inconsistencies, and annotated ambiguous outputs. This feedback informed prompt revisions, refinement of classification taxonomies, and manual corrections where necessary. Each loop enriched the knowledge base with more reliable, higher-quality data—sharpening the system's capacity to address increasingly abstract questions and improving confidence in the outputs with each successive cycle.

1.3 Structure of source materials

To support this evaluation, we draw on a rich ecosystem of source materials spanning multiple levels of the AAL programme's documentation. These are organized into three tiers, each corresponding to a different granularity of information and use case:

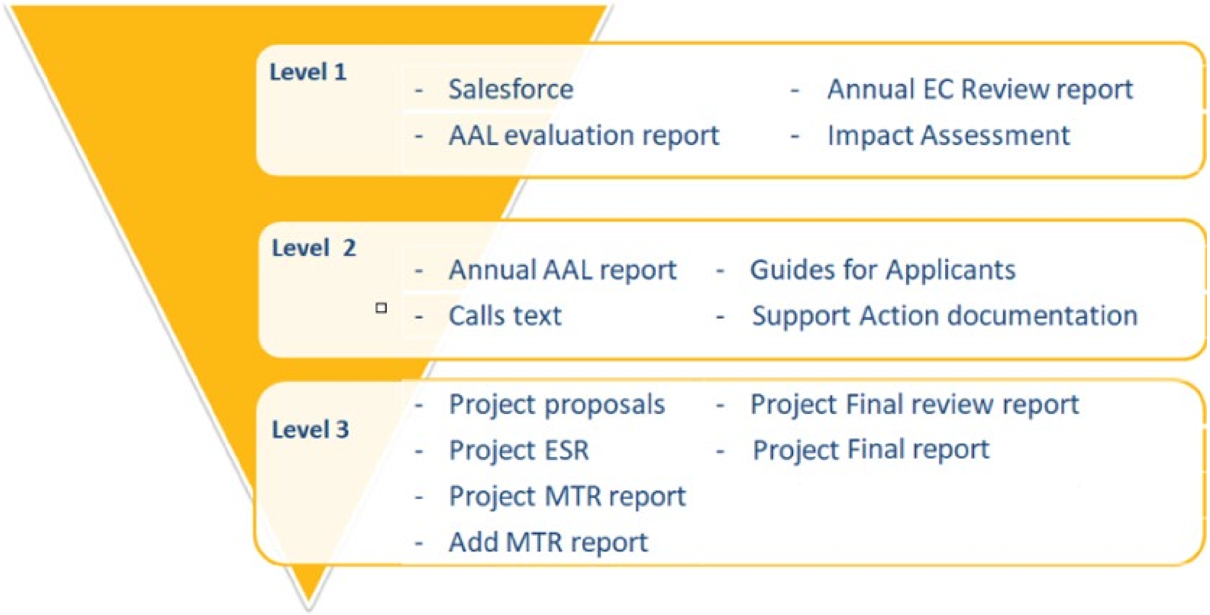
- Level 1 sources provide high-level strategic oversight and include institutional reviews and impact assessments, such as the *Annual EC Review report* or the *AAL evaluation report*. These documents were all reviewed and helped answer macro-level questions about the programme's effectiveness, evolution, and alignment with EU policy goals.
- Level 2 includes meso-level programme management resources such as *Annual AAL reports*, *Call texts*, and *Guides for Applicants*. All these documents were also examined, as they capture the programme's operational logic and evolving priorities, and evolution over time - offering valuable context for interpreting both top-down and bottom-up findings.
- Level 3 sources comprise the most granular, project-level documentation. Within this tier, we used project proposals, review reports (mid-term and final), and annual and final project reports. From the latter, we extracted content exclusively from selected sections - namely:
  - Section 1.C – Publishable Project Results Summary
  - Section 3.A – Scientific/Technical Project Results
  - Section 3.B – Business Models & Indicators
  - Section 3.C – End User Indicators

  Other internal or confidential deliverables described in the Description of Work (DoW) were explicitly excluded from analysis to avoid processing sensitive information and to ensure the focus remained on the most relevant and accessible material.

All three layers of information were structured and interlinked using metadata extracted from AAL Salesforce account, which served as the central repository for core programme data. Salesforce provided foundational metadata on projects, stakeholders, calls, and timelines—enabling consistent document identification, improved contextualisation, and robust cross-referencing across tiers.

The figure below illustrates this tiered structure:

Figure 11 Three-Tier Structure of Source Documents



1.4 Dual insight generation tracks: Bottom-up and Top-down

All insights, whether derived from individual project files or from higher-level programme documentation, were written back to a common relational database in structured form. This persistent, queryable store acted as the single point of truth for every indicator, category assignment, and narrative summary generated during the evaluation, enabling us to reconcile micro-level detail with macro-level trends.

The **bottom-up track** proceeds project by project (Level 3 documents). For each document set we instruct the LLM to extract or compute granular indicators such as the number of secondary users or the intensity of stakeholder involvement and write the results to the database. Where categorical information is required—for example, classifying the core technology underpinning a prototype—we first engage the model in an exploratory stage: randomised excerpts from multiple projects are supplied so that the LLM can propose candidate taxonomies. A human reviewer compares successive proposals, consolidates overlapping concepts, and fixes a final classification grid (in the case of technologies, nine stable categories emerged). The system then loops through every project, assigning one primary and, when appropriate, one secondary label; explicit "secondary" tags preserve nuance where a technology is present but not central.

For numeric fields, the LLM operates under conservative rules that forbid inference when evidence is ambiguous and require it to quote the source section for any value extracted. Reviewers subsequently inspect every flag marked "unknown" or "questioned," resolve genuine conflicts between documents (e.g., discrepancies between a Final Project Review and Final Report) and, where justified, replace missing values with carefully reasoned estimates.

Alongside structured data the model also generates concise narrative summaries of technology use, user-involvement stories, notable barriers overcome—that enrich subsequent synthesis.

The **top-down track** addresses programme-level materials such as strategic evaluations, annual reviews, and AAL-board dossiers (Level 1 and 2 documents). Here the principal risk is hallucination: large, general prompts can invite the model to speculate when source evidence is weak. To contain this risk, we invert the questioning process. For each high-level research question the LLM is first asked to decompose the topic into a hierarchy of sub-questions and micro-questions that could plausibly be answered from a single document. It must also grade, for each sub-question and micro-question, the expected completeness of the available evidence in that document. Analysts then select only those sub-questions with a satisfactory evidence score and re-submit them to the model, which answers in structured form and cites the relevant passages. The resulting fragments—each anchored in demonstrable source text—are committed to the same relational database and later recombined through higher-order prompts to yield coherent, programme-wide findings. By ensuring that every aggregation step is grounded in previously validated evidence, this approach sharply reduces hallucination while still capitalising on the model's capacity to synthesise dispersed insights into a unified analytical narrative.

A.2 / Deployment, scalability, and future readiness of the methodology

The evaluation methodology developed for the AAL Programme offers a scalable and replicable model for conducting post-hoc impact assessments of large-scale R&D funding initiatives. Its success in addressing 17 distinct research questions across 16 years of project activity demonstrates not only the maturity of current AI-assisted analysis techniques, but also the importance of strategically engineered data pipelines, metadata-driven design, and systemic human validation.

2.1 Practical scalability of the AI-driven evaluation approach

The evaluation approach developed for the AAL Programme demonstrates strong potential for deployment and scalability in other large-scale research and innovation funding contexts. Its architecture—rooted in a curated, metadata-rich knowledge base and enabled by iterative AI-driven analysis—is designed to be both modular and adaptable.

A key enabler of this methodology was the availability of structured document formats (e.g., templates for proposals, reviews, and final reports) and the presence of reliable metadata (e.g., project identifiers, call years, document types, and versions) from Salesforce. These elements allowed for efficient filtering, segmentation, and targeting of content with high precision. They also enabled consistent parsing of documents and facilitated the construction of a queryable relational database that served as the backbone of insight generation.

However, we are aware that many research programmes do not have such structured formats or rich metadata readily available. For these contexts, alternative strategies could be used to replicate some of the benefits of the AAL approach:

- One option is to leverage AI models to infer structure, classify content, and reconstruct missing metadata. For instance, large language models (LLMs) can segment free-text documents into canonical sections or infer document types from linguistic patterns.
- Another viable strategy is to use Retrieval-Augmented Generation (RAG) architectures, which combine a semantic search engine (based on text embeddings) with generative models. In this setup, documents are embedded into a vector database, and natural language queries retrieve the most semantically relevant fragments. While flexible, this method has lower precision, as semantic matching may surface related but not contextually accurate content, and relevant insights may be missed if documents are poorly segmented or inconsistently phrased. To mitigate these limitations, RAG pipelines require additional engineering effort, including fine-tuned chunking strategies, embedding model calibration, and strict relevance thresholds. Even with these strategies, RAG systems may still struggle to match the reliability of approaches grounded in explicit metadata and well-structured documents.

These alternatives demonstrate that AI-powered evaluation pipelines can be developed even in the absence of structured inputs—but at a cost. The additional complexity increases the need for human oversight, slows down development, and can reduce reliability.

The success of the AAL evaluation underlines a key recommendation: whenever possible, structure and metadata collection should be embedded into programme design from the start. In the AAL case, the consistent layout of project documents and the use of Salesforce as a central metadata repository allowed for systematic content targeting and precise metadata filtering. This structural foundation enabled the progressive enrichment of the relational database with both AI-generated insights and human validations, forming a highly efficient and reliable evaluation system.

Critically, any team planning to use AI for evaluation should begin not with the model, but with a close observation of the actual data landscape, its structure, consistency, and metadata availability. The quality and curation of the source data are decisive factors and should be assessed before defining any AI evaluation strategy, as they determine what level of automation and insight generation is realistically achievable.

2.2 Enabling AI navigation for future programmes

One of the key outcomes of this methodology is the creation of a structured and queryable database, enriched with thousands of machine-generated indicators, summaries, classifications, and evidence citations. These outputs are stored in a relational database that could be easily connected to external interfaces-such as a Power BI dashboard or a custom application- to surface information linked to specific entities (e.g., projects, calls, technologies, end-user types).

However, the engineered system does not support fully autonomous querying of the underlying documents via natural language prompts. The process of selecting relevant documents, defining the context, and submitting these inputs to the large language model (LLM) was carried out manually. Analysts decided on a case-by-case basis which documents or sections to include, based on the nature of each research question. As such, the construction of the relational database was a one-off engineering effort, not dynamically connected to an ongoing or user-driven question-answering loop.

That said, the architecture opens the door to future AI-driven automation. Recent advancements in AI enable the integration of Agentic AI systems, making it possible to replace this manual step with autonomous agents that:

- Interpret the user's question;
- Identify the most relevant documents and sections;
- Choose the appropriate analysis path (e.g., bottom-up, top-down, or both);
- Determine whether indicators need to be computed;
- Execute the querying and synthesis pipeline.

This would require additional engineering, including framing the agents to reason over document structures and metadata. But once implemented, it would enable a natural-language interface where users could interact freely with the full AAL knowledge base—without requiring a dedicated evaluation team to orchestrate each query.

Nonetheless, some limitations must be acknowledged. In our methodology, LLMs occasionally misestimated or inferred numerical indicators when evidence was partial or ambiguous. Human reviewers were able to catch and correct these exceptions, ensuring reliability. A fully automated system might lack that final layer of validation, leading to occasional inaccuracies.

As a compromise, a semi-automated approach could be deployed. In this setup, users would still benefit from an interactive interface, but the system would surface traceability information—such as the source text used to generate indicators or summaries—enabling human reviewers to quickly validate or correct outputs.

2.3 Recommendations for future Programmes

While the methodological lessons from the AAL evaluation are substantial, it is important to underscore that we operate in a rapidly evolving technological landscape. The capabilities of AI systems — particularly large language models and agent-based architectures—are progressing quickly. As such, the relative importance of these recommendations may shift significantly in the coming months or years, depending on the pace of development and the diffusion of more autonomous AI tools.

That said, based on current capabilities and constraints, the following design principles remain relevant for any programme seeking to enable AI-driven evaluation:

- Prioritise structured and standardised documentation from the outset: Programmes should adopt and enforce consistent templates for key project documents (e.g. proposals, reports, reviews), with clearly defined sections (e.g., target users, technologies used, KPIs, impact narratives). Consistency across years and calls significantly reduces preprocessing time and improves the accuracy of AI-based parsing and classification.
- Invest in metadata collection and maintenance: A centralised system—ideally a CRM-like platform or a relational database alone—should serve as the authoritative source for metadata such as project identifiers, call years, document versions, and status. In the AAL Programme, Salesforce provided this backbone, enabling document filtering and serving as the structural spine of the relational database used in the evaluation. Metadata quality directly impacts the reliability and granularity of insights generated later.
- Evaluate the data landscape before designing AI strategies: Teams planning AI-driven evaluations must begin not with model selection, but with a diagnosis of the available data: its structure, completeness, consistency, and semantic clarity. This will determine whether a metadata-filtered strategy (as in AAL) is viable or whether fallback strategies—such as AI-inferred structure or RAG—are necessary.
- Design for traceability and human-in-the-loop validation. Even in semi- or fully automated pipelines, mechanisms should be in place to trace the origin of AI-generated indicators or summaries back to their source text. This is critical for quality control and transparency, especially when numerical estimates or policy-relevant classifications are involved. Interfaces should surface these trace links to facilitate expert review.
- Plan for automation but acknowledge its limits. The current AAL pipeline does not support dynamic user queries over raw documents. Manual decisions were made about which documents to feed into the LLM, and the relational database was built as a one-time engineering effort. However, with the development of agentic AI systems, it is now feasible to envision autonomous agents capable of interpreting user queries, selecting relevant sources, and choosing appropriate evaluation strategies. While promising, these systems still require engineering, validation routines, and fallback mechanisms —particularly for numerical inference tasks where accuracy is essential.

- Encourage continuous, not just end-point, data collection. To improve the evaluability of future programmes, funders should move from end-of-project reporting toward continuous, structured data collection, with mid-term updates and routine metadata tagging. This not only supports more agile evaluation cycles but also improves the completeness and timeliness of evidence used in AI-assisted analysis.

A.3 / Data Infrastructure, GDPR handling, and data lifecycle

3.1 Data infrastructure and processing environment

To support the AI-driven evaluation workflow described in Section 1, a robust and secure technical infrastructure was deployed. All project-relevant data—comprising over 30,000 documents and webpages—was initially migrated from AAL's SharePoint and Salesforce environments to IDEA Consult's private SharePoint instance and to a cloud-based relational database hosted in a controlled environment.

The relational database was designed to store both the original documents—converted into Markdown format to facilitate processing (e.g., proposals, reviews, final reports)—and the structured outputs generated through AI analysis (e.g., extracted indicators, metadata, and classification results). This design enabled flexible querying of content and traceable insight generation without compromising data integrity or security.

To facilitate interaction with large language models (LLMs), the infrastructure integrated securely with Together AI—an enterprise-grade inference provider used to run open-weight models such as DeepSeek. Before querying the LLMs, all documents underwent a pre-processing stage involving layout analysis and thematic segmentation. Only filtered excerpts were sent to the model via Together AI's API.

3.2 GDPR compliance and data protection measures

The entire workflow was designed in alignment with the General Data Protection Regulation (GDPR), with specific attention to the following principles:

- Purpose limitation: All data was processed solely for the purposes explicitly defined in the mission mandate.
- Data minimisation: Only data strictly necessary for analytical tasks was extracted and processed. Before any interaction with the large language model (LLM), the team conducted a layout analysis, which allowed to segment content into canonical sections (e.g. "End-User Involvement," "Project Impact"). This filtering step enabled the team to select only relevant and non-confidential excerpts for inclusion in LLM queries, significantly reducing both the volume of data processed and the risk of inadvertent exposure of sensitive information.
- Controlled access and secure storage: All documents and outputs were stored in IDEA Consult's private SharePoint and in a cloud-hosted relational database under strict access control. Only two authorised team members had access.
- Use of external AI infrastructure (Together AI):
    - Large Language Model (LLM) interactions were performed via Together AI, a secure API-based platform for querying open-weight models (as opposed to proprietary models like OpenAI's GPT-4o).

- Together AI is a dedicated inference provider offering enterprise-grade encryption (SOC 2), GDPR alignment[31], and configurable no-retention settings. These were activated in our configuration to ensure that prompts and completions were not logged or stored by the provider.
- Together AI applies the right to be forgotten, meaning any data processed through its infrastructure can be deleted upon request, in accordance with Article 17 of the GDPR.

- Auditability: Every transaction with the LLM was logged, and source citations were systematically stored alongside generated outputs, ensuring full traceability.

3.3 Data lifecycle management

At the conclusion of the commissioned legacy study, all data —including original documents, intermediate processing files, and structured outputs—will be securely deleted from IDEA Consult's SharePoint and cloud-hosted database environments.

No data will be retained beyond the commissioned legacy study's end date unless expressly requested and authorised by the contracting authority. This ensures compliance with GDPR's data retention and erasure requirements and aligns with best practices in responsible AI and data stewardship.

[31] https://help.togetherplatform.com/hc/en-us/articles/4407955476251-Together-GDPR-Compliance