Human-centered AI dilemmas in helping people with dementia

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Overview

- What is human-centred AI/AGI
- A(G)I in dementia/AD research
- A(G)I tools in dementia care
- HC-AI dilemmas

What is (human-centered) A(G)I

What is AI?

Standard model of AI

- Humans are intelligent to the extent that our actions can be expected to achieve our objectives
- Machines are intelligent to the extent that their actions can be expected to achieve their objectives

Human-compatible AI

- Machines are intelligent to the extent that their actions can be expected to help us achieving our objectives [S.Russell, 2018: AI25]

Scientific fields

- Engineering
- Computer science
- Cognitive science
- Probability theory
- Utility theory
- Causality research

Driving forces

- Moore's law
- Hardware
- Data
- Methods: theorem provers, goal-driven search, generative grammars, .. transformers

What is human-centred AI?

hcaim human centred artificial intelligence masters

Human-computer interaction

- Man-machine interfaces
- Man-machine hybrids
- Linguistic interfaces
- Sensorimotoric/brain-computer interfaces
- Augmented reality

Human-compatible AI

- Intelligence explosion
- Artificial general intelligence (AGI)
- Superintelligence
- Existential risk
- Value alignment
- Provably beneficial AI

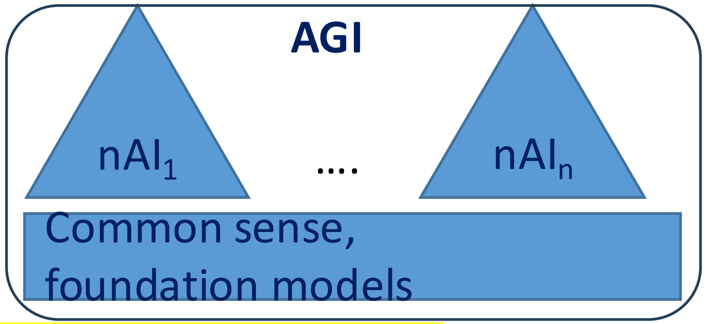
Human-centered AI (HCAIM)

- **Human rights (mental health,..)**
- **Democratic society (fake news, 1984,...)**
- **Trustworthy/Explainable AI**
- **Human-computer cooperation**
- **Collaborative workflows**
- **Auditing/approval (AI safety)**

Intelligence everywhere

- Smart wearable electronics
- Smart homes/cities
- Autonomous vehicles

Zoo of AIs



Narrow AI (nAI): expert-level performance in a given domain/task

Good old fashioned AI (GOFAI): expert-based systems using well-defined symbols and explainable rules

Deep learning: simultaneous learning of latent representations (features, ~symbols) and their usage

Artificial general intelligence (AGI): can learn to accomplish any intellectual task that humans can perform.

Foundation models: "trained on broad data that can be adapted to a wide range of downstream tasks"[1]

Human-level (machine) intelligence (HLMI): "unaided machines can accomplish every task better and more cheaply than human workers"[2]

Superintelligence: "machine intelligence that is **vastly better** than humans at all professions"[2]

Strong AI: emergence of mind-like properties (e.g., conscience) beyond mere simulations of **weak AIs.**

Explainable AI (XAI): AIs that can be understood by humans.

Trustworthy AI: AIs that can be expected to achieve **our** (human) objectives.

Human-centered AI (HCAI): human compatible AIs deferring to humans to respect human rights.

[1] Bommasani, Rishi, D. A. Hudson, E. Adeli, R. Altman, S. Arora, S. von Arx, M. S. Bernstein et al. "On the opportunities and risks of foundation models." *arXiv preprint arXiv:2108.07258* (2021).
[2] Katja Grace, Zach Stein-Perlman, Benjamin Weinstein-Raun, and John Salvatier, "2022 Expert Survey on Progress in AI." AI Impacts, 3 Aug. 2022

A chronology of artificial general intelligence (AGI)

Embodied agents?

Boston Dynamics

Generative Transformational Grammars[2]

Back-propagation[4,5]

IBM Watson[7] (Deep Question-Answering)

Transformers[9]

1936 | 1956 | 1959 | 1974 | 1984 | 2011 | 2014 | 2017 | 2023

Universal Turing Machine[1]

General Problem Solver[3]

CYC: Encyclopedic expert systems[6]

Deep reinforcement learning[8]

Large Language Models, Multimodal agents: GATO[10], GPT-4[11]

[1] Turing, Alan Mathison. "On computable numbers, with an application to the Entscheidungsproblem." J. of Math 58, no. 345-363 (1936): 5.

[2] Chomsky, Noam. "Three models for the description of language." IRE Transactions on information theory 2, no. 3 (1956): 113-124.

[3] Newell, Allen, John C. Shaw, and Herbert A. Simon. "Report on a general problem solving program." In IFIP congress, vol. 256, p. 64. 1959.

[4] Werbos, Paul. "Beyond regression: New tools for prediction and analysis in the behavior science." PhD thesis, Harvard University (1974).

[5] Rumelhart, David E., Geoffrey E. Hinton, and Ronald J. Williams. "Learning representations by back-propagating errors." nature 323, no. 6088 (1986): 533-536.

[6] Lenat, D. B., M. Prakash, M. Shepherd. "CYC: Using common sense knowledge to overcome brittleness and knowledge acquisition bottlenecks." AI magazine 6, no. 4 (1985): 65-65.

[7] Ferrucci, David, Anthony Levas, Sugato Bagchi, David Gondek, and Erik T. Mueller. "Watson: beyond jeopardy!." Artificial Intelligence 199 (2013): 93-105.

[8] Silver, David, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot et al. "A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play." Science 362, no. 6419 (2018): 1140-1144.

[9] Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Łukasz Kaiser, and Illia Polosukhin. "Attention is all you need." Advances in neural information processing systems 30 (2017).

[10] Reed, Scott, K. Zolna, E. Parisotto, S. G. Colmenarejo, A. Novikov, G. Barth-Maron, M. Gimenez et al. "**A generalist agent**." arXiv preprint arXiv:2205.06175 (2022).

[11] Bubeck, Sébastien, Varun Chandrasekaran, Ronen Eldan, Johannes Gehrke, Eric Horvitz, Ece Kamar, Peter Lee et al. "**Sparks of artificial general intelligence: Early experiments with gpt-4**." arXiv preprint arXiv:2303.12712 (2023).

LLM scaling laws for space, time, and data

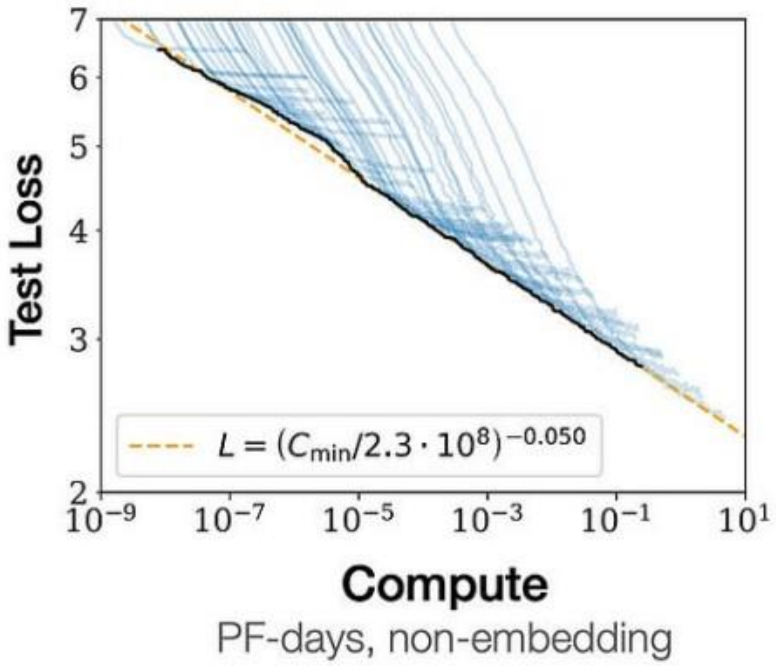


Figure 1 Language modeling performance improves smoothly as we increase the model size, datasetset size, and amount of compute[2] used for training. For optimal performance all three factors must be scaled up in tandem. Empirical performance has a power-law relationship with each individual factor when not bottlenecked by the other two.

Kaplan, Jared, et al. "Scaling laws for neural language models." *arXiv preprint arXiv:2001.08361* (2020).

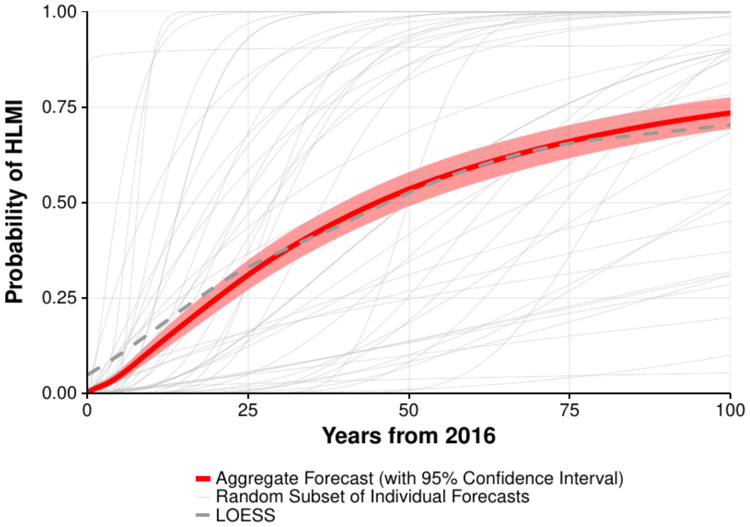
Hoffmann, Jordan, et al. "Training compute-optimal large language models." *arXiv preprint arXiv:2203.15556* (2022).

Besiroglu, Tamay, et al. "Chinchilla Scaling: A replication attempt." *arXiv preprint arXiv:2404.10102* (2024).

Towards AGI

Year	System	Computation	Data	Knowledge
1957	General Problem Solver	kFLOPS		KB
1995	Deep Blue	gFLOPS		MB
2011	IBM Watson	80 tFLOPS		xTB
2017	AlphaZero	100 tFLOPS	0	0
2014<	Tesla Autopilot	x100 pFLOPS	PB	
2021	AlphaFold	100 pFLOPS	TB	
2022	Large language models	10-10k eFLOPS (10^{19})		PB

Human-level machine intelligence



Probability of superintelligence

	Within 2Y	Within 30Y
2016[2]	10%	50%
2022[3]	10%	60%

[1] Bommasani, Rishi, D. A. Hudson, E. Adeli, R. Altman, S. Arora, S. von Arx, M. S. Bernstein et al. "On the opportunities and risks of foundation models." *arXiv preprint arXiv:2108.07258* (2021).
[2] Grace, Katja, J. Salvatier, A. Dafoe, B. Zhang, and O. Evans. "When will AI exceed human performance? Evidence from AI experts." Journal of Artificial Intelligence Research 62 (2018): 729-754.
[3] Katja Grace, Zach Stein-Perlman, Benjamin Weinstein-Raun, and John Salvatier, “2022 Expert Survey on Progress in AI.” AI Impacts, 3 Aug. 2022

The causal hierarchy

Level (Symbol)	Typical Activity	Typical Questions	Examples
1. Association $P(y\|x)$	Seeing	What is? How would seeing *X* change my belief inY?	What does a symptom tell me about a disease? What does a survey tell us about the election results?
2. Intervention $P(y\|do(x), z)$	Doing, Intervening	What if? What if I do *X*?	What if I take aspirin, will my headache be cured? What if we ban cigarettes?
3. Counterfactuals $P(y_x\|x', y')$	Imagining, Retrospection	Why? Was it *X* that caused *Y*? What if I had acted differently?	Was it the aspirin that stopped my headache? Would Kennedy be alive had Oswald not shot him? What if I had not been smoking the past two years?

Quantiative/qualitative subdivisions

Pearl, Judea. "The seven tools of causal inference, with reflections on machine learning." Communications of the ACM 62.3 (2019): 54-60.

Causal inference with LLMs?

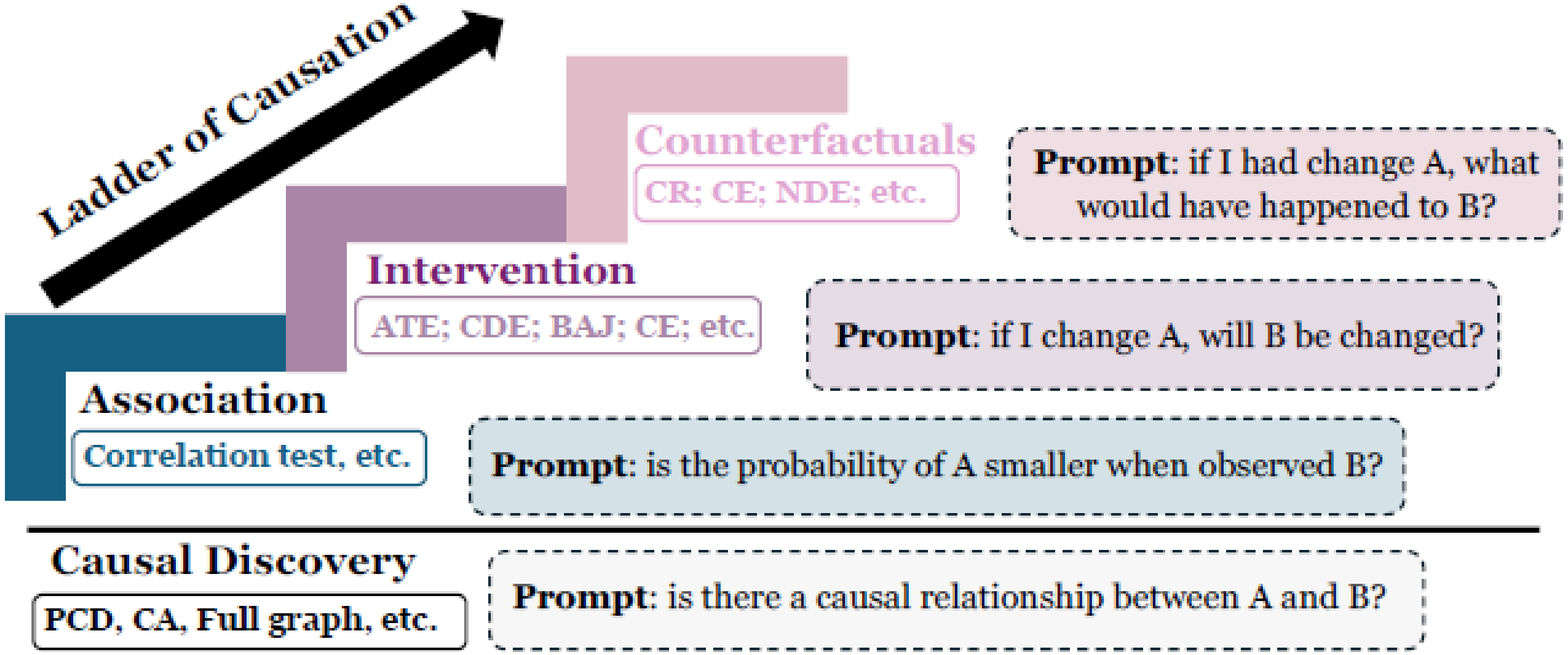
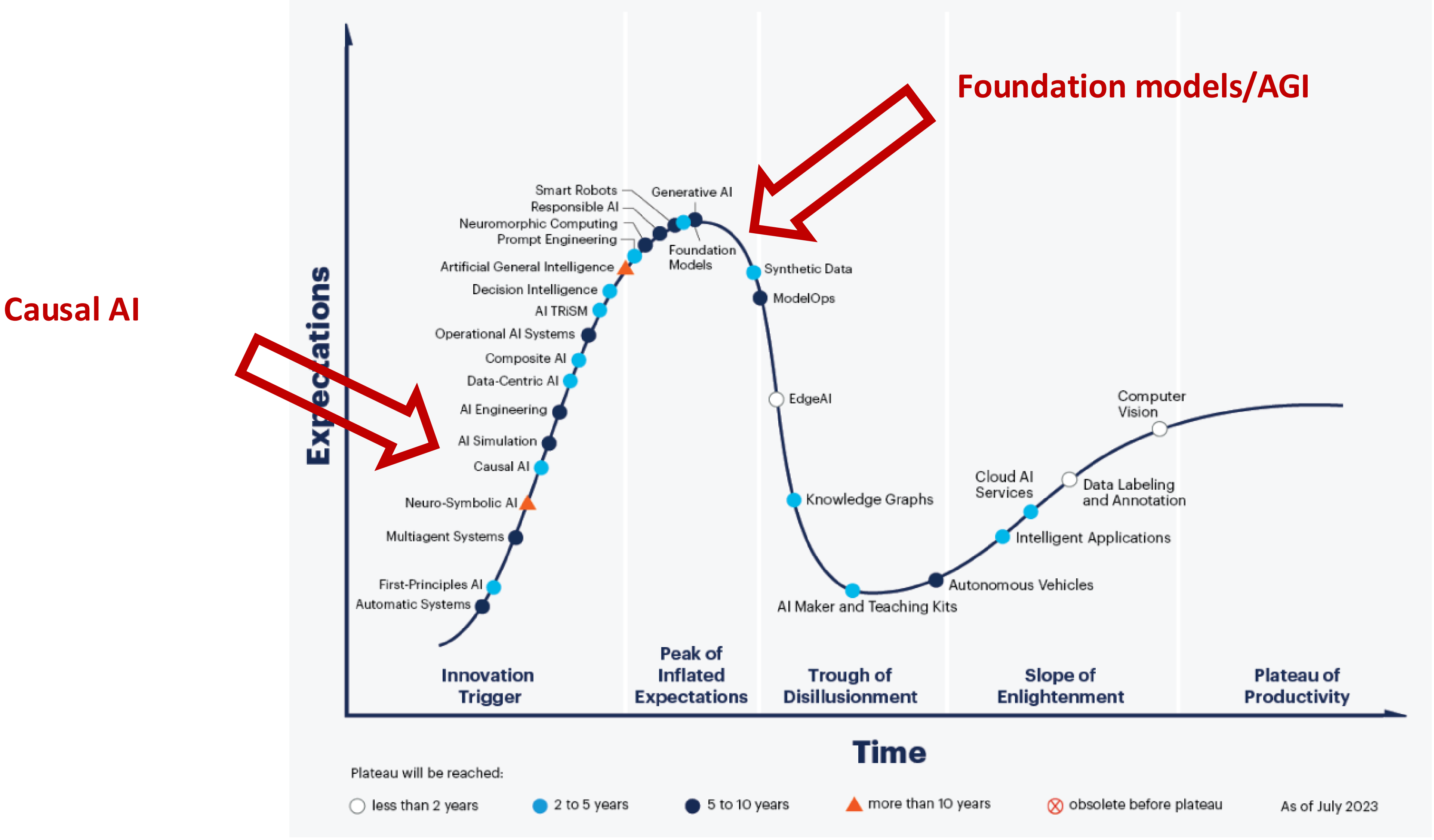


Figure 1: Representative causal tasks, their positions in the causal ladder, and examples of prompts. PCD = pairwise causal discovery; CA=causal attribution; ATE=average treatment effect; CDE=controlled direct effect; BAJ=backdoor adjustment; CE=causal explanation; CR=counterfactual reasoning; NDE=natural direct effect.

Ma, Jing. "Causal inference with large language model: A survey." *arXiv preprint arXiv:2409.09822* (2024).

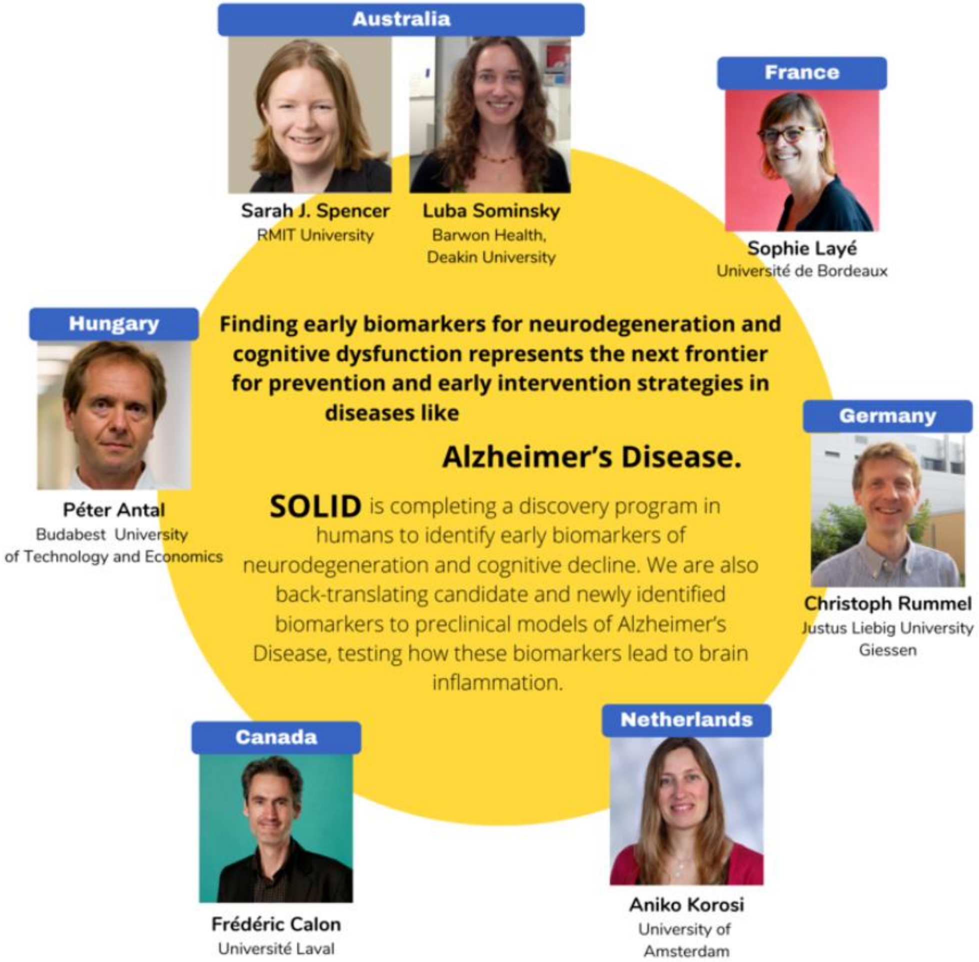
Hype Cycle for AI, 2023 (Gartner)



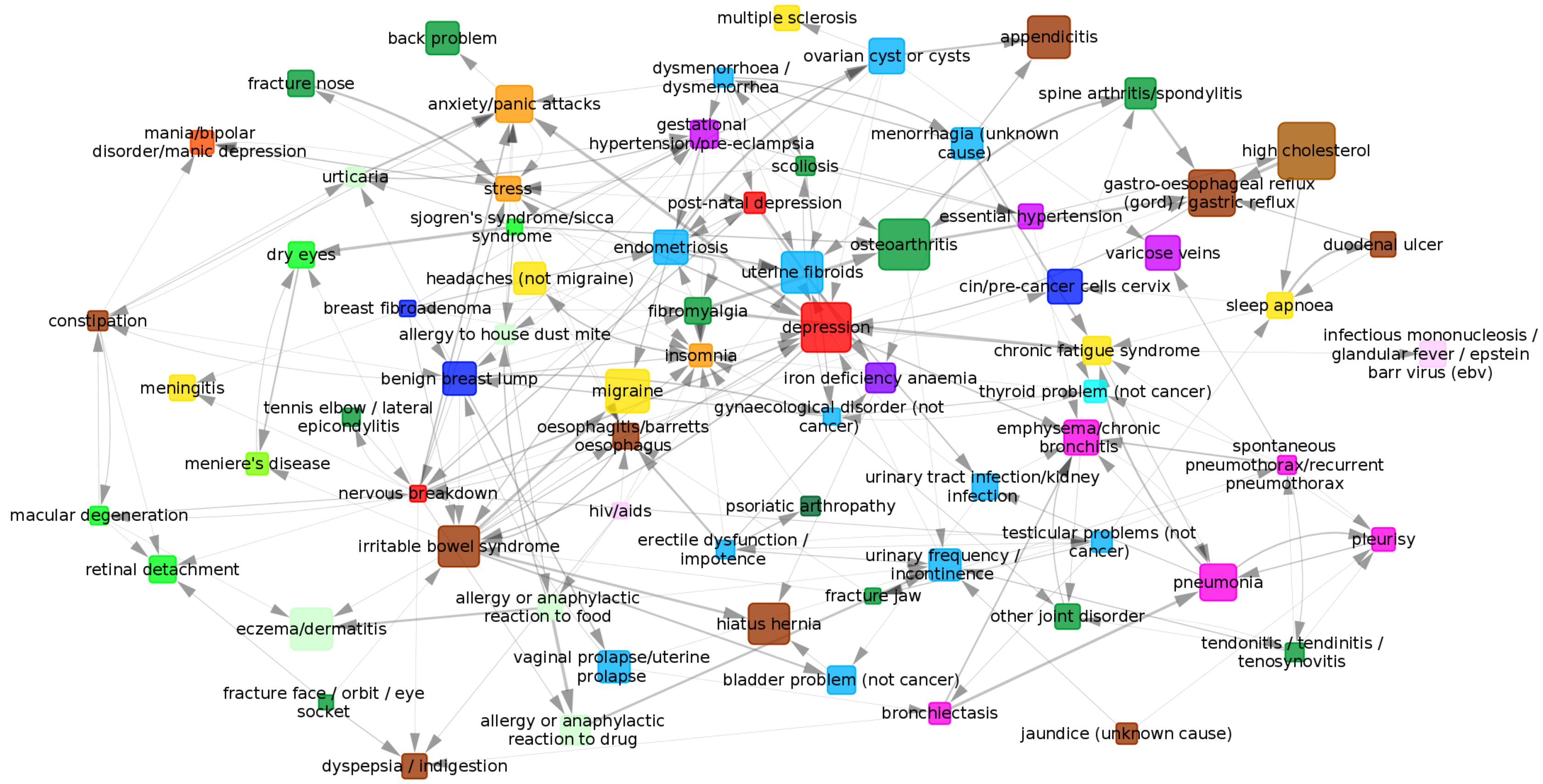
A(G)I in dementia/AD research

SOLID: Effects of early-Stress On Lipid mediators and Inflammation for early Detection of neurodegeneration

The Joint Research Program incorporates seven main partners in a large-scale project with total funding of approximately $CA 2 million from the European Union's Joint Research Program on Neurodegenerative Diseases (JPND). The project, which stems from the Food4BrainHealth International Research Network and the International Associated Laboratory Optinutribrain, brings together the expertise of researchers from France, Australia, the Netherlands, Hungary, Germany and Canada.



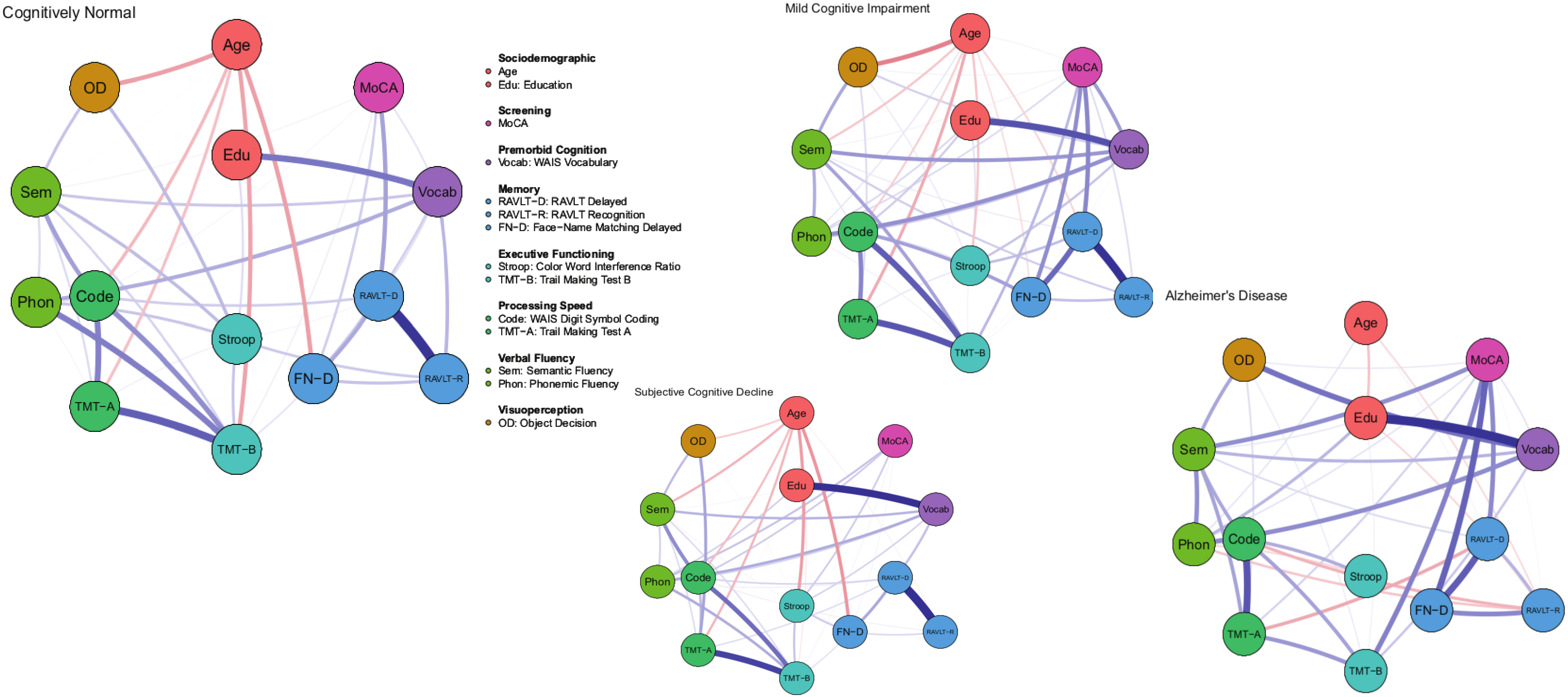
Common complex factors of multimorbidities



Marx, P., Antal, P., Bolgar, B., Bagdy, G., Deakin, B. and Juhasz, G., 2017. **Comorbidities in the diseasome are more apparent than real**. *PLoS computational biology*, *13*(6), p.e1005487.

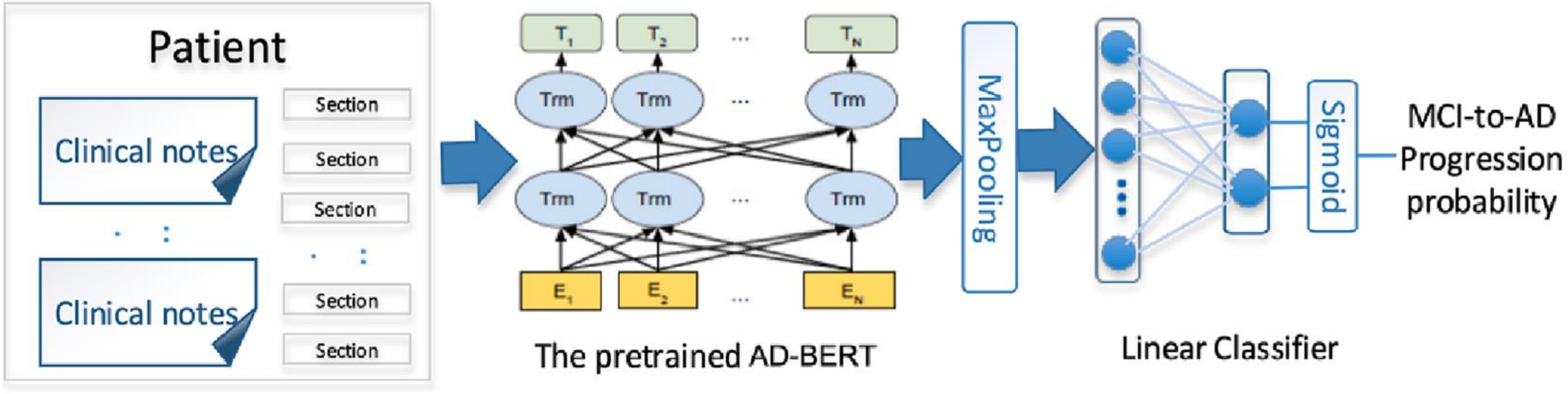
Gezsi, Andras, et al. "**Unique genetic and risk-factor profiles in clusters of major depressive disorder-related multimorbidity trajectories**." Nature Communications 15.1 (2024): 7190.

Dementia and factors of intelligence



Grunden, Nicholas, and Natalie A. Phillips. "A network approach to subjective cognitive decline: Exploring multivariate relationships in neuropsychological test performance across Alzheimer's disease risk states." *Cortex* 173 (2024): 313-332.

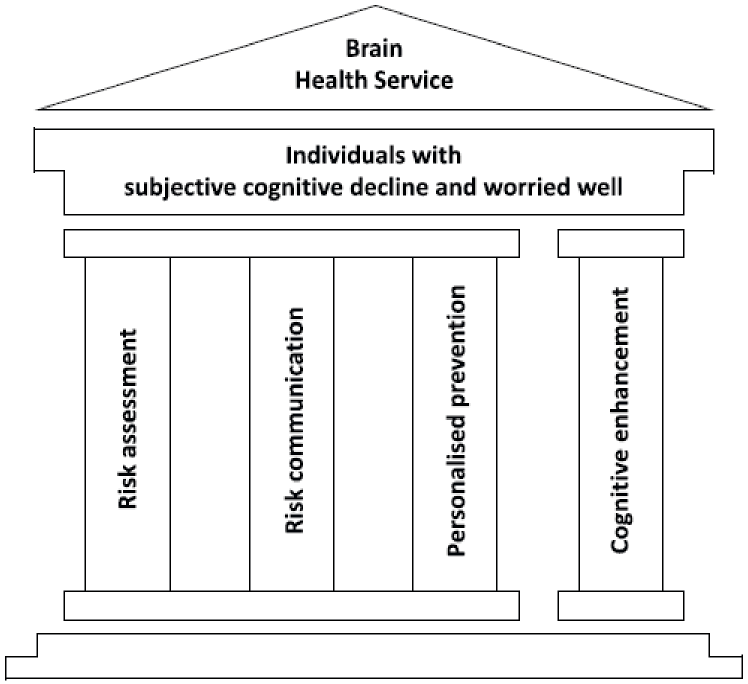
Foundation models in AD research



Mao, Chengsheng, et al. "AD-BERT: Using pre-trained language model to predict the progression from mild cognitive impairment to Alzheimer's disease." Journal of Biomedical Informatics 144 (2023): 104442.

AGI for dementia care

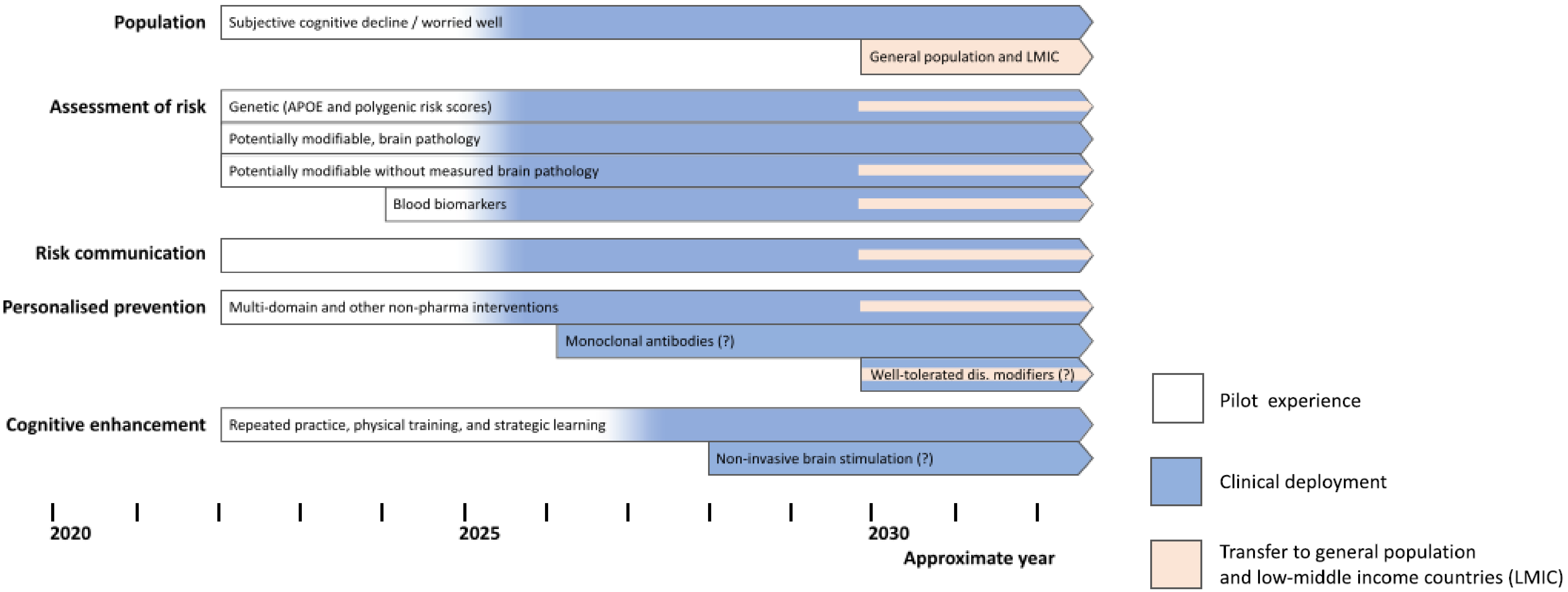
Modifiable risk factors related to dementia/AD



Risk factor	Relative risk[a]	Assessment method	Dementia risk scales[b]		
			CAIDE[S1]	ANU-ADRI[S2,S3]	BDSI[S4]
Genetic					
APOE-ε4 heterozygous	1.9	Real-time protein chain reaction	●		
APOE-ε4 homozygous	5.3				
Potentially modifiable without measured brain pathology					
Early life (age <45 years)					
Less education (primary school only)	1.6	I—International Standard Classification of Education[S5] P—Years of education[S5]	●	●	●
Midlife (age 45–65 years)					
Hearing loss	1.9	I—Pure tone audiometry[S6] P—Whispered Voice Test,[S7] speech-in-noise paradigms or self-report			
Traumatic brain injury	1.8	I—Ohio State University traumatic brain injury identification method[S8] P—Medical history, informant- or self-report		●	
Hypertension (>135–140/85–90)[S9,c]	1.6	I—Ambulatory devices, physician measurement P—Domestic devices, patient self-measurement	●		
Alcohol consumption (>21 units per week)	1.2	I—Quantity-frequency measures with beverage-specific assessment of time frames and binge-drinking episodes[S10] P—Self report		●	
Obesity (body-mass index ≥30)	1.6	I—Waist circumference[S11] and measurement of height and weight P—Body mass index based on self-report	●		●
Late life (age >65 years)					
Smoking	1.6	Self-report of smoking status (pack years, i.e. number of daily packs multiplied by number of years smoking; or current smoking status, i.e. current versus former/never smoker)		●	
Depression	1.9	I—Rating scales e.g. Patient Health Questionnaire (PHQ)[S12] or the Hospital Depression and Anxiety Scale[S13] P—Self-report of feeling depressed or having history of diagnosed depression		●	●
Social isolation	1.6	I—Rating scales, e.g. the Lubben Social Network Scale[S14] or the Duke Social Support Index[S15] P—Self-report of social isolation		●	
Physical inactivity	1.4	I – Accelerometers,[S16] heart rate counters,[S16] smart phone,[S16] or smart watch apps[S16] P – Self-reported measures/questionnaires	●	●	
Diabetes	1.5	I—Fasting plasma glucose levels (≥7.0mmol/l) or HbA1c (≥6.5%), or oral glucose tolerance test to diagnose impaired glucose tolerance[S17] P—Medical history, informant or self-report		●	●
Air pollution	1.1	Further research is needed to establish a practical and clinically relevant measure[S18]			

Frisoni, Giovanni B., et al. "Dementia prevention in memory clinics: recommendations from the European task force for brain health services." The Lancet Regional Health–Europe 26 (2023).

Roadmap for brain health services



Frisoni, Giovanni B., et al. "Dementia prevention in memory clinics: recommendations from the European task force for brain health services." The Lancet Regional Health–Europe 26 (2023).

Technologies supporting people with dementia - 1

Device name (manufacturer)	Functions	Developed for	Level of evidence[a]	Refs
Monitoring				
Google Home (Google)	Calendar reminders, weather and controls lighting and heating through smart phone	General use	Level VII	NR
Find Me Tunstall Watch (Tunstall)	GPS monitoring. Can aid orientation, location tracking and fall detection; offers 24/7 support	Cognitively impaired	Level V	53,58
Wireless movement sensors (Just Checking)	Text and e-mail messages to alert carer. Information on activity and when different rooms are used	Cognitively impaired	Level II	59
Assistive robotics				
Care-O-Bot (Fraunhofer Institute for Manufacturing Engineering and Automation)	A range of applications, including fetch and carry, monitoring, reminders and communication	Older people and cognitively impaired	Level V	60
RAMCIP (EU Horizon 2020 project)	Reminds individuals about daily tasks such as taking medications, brings fluid and food, can detect falls and offers communication via video conference	MCI	Level VI	14
Riken and Robear (RIKEN-SRK)	Can transfer frail people from floor to chair or bed	Older people and disabled	Level VII	NR
Assistive innovations				
Obi	Robotic spoon that allows automatic or semi-automatic feeding	Disabled	Level VII	NR
MARIO (National University of Ireland)	Entertainment and reminders	Older people and cognitively impaired	Level VI	42,61,62
MiRo (Consequential Robotics)	Autonomous robotic dog that reminds user about medications, hydration and temperature, and can contact emergency services	Cognitively impaired	Level VII	NR

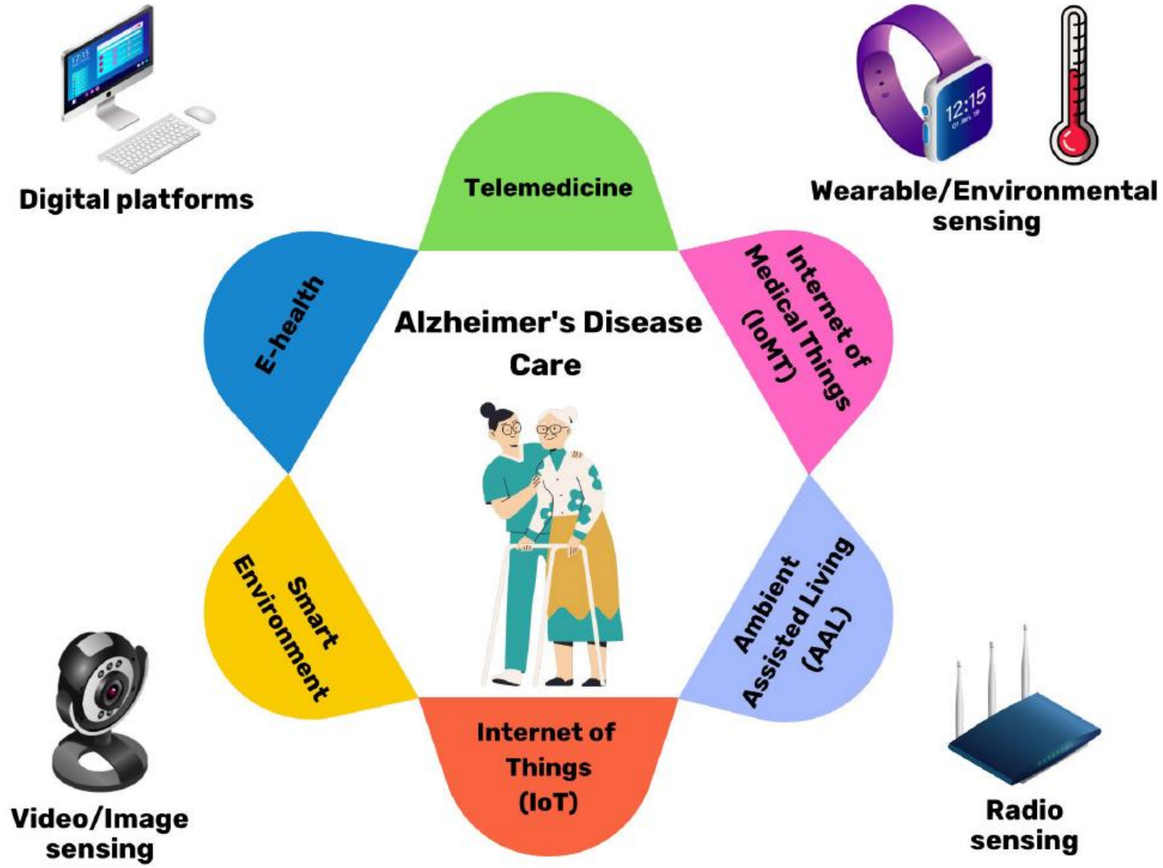
Moyle, Wendy. "The promise of technology in the future of dementia care." Nature Reviews Neurology 15.6 (2019): 353-359.

Technologies supporting people with dementia - 2

Therapeutic robots				
Giraff (Camanio)	Telepresence robot that enables monitoring via remote connection to anyone worldwide	Older people and cognitively impaired	Level III	[63]
PARO (AIST)	Therapeutic pet robot that responds to interaction	Cognitively impaired and children with autism	Level I–II	[28–30,64]
Therapeutic technology				
Skype, FaceTime and Google Hangouts (various)	Communication apps for mobile devices	General use	Level IV	[65]
The Talking Photo Album (CommunicATe)	Photos linked to individual messages that aid reminiscence	Cognitively impaired	Level VII	NR
The Dawn Clock (Dawn Clocks)	Five medication and lifestyle alarms	Cognitively impaired	Level VII	NR
Automated medication-dispensing service (Philips)	Medication-dispensing device	Cognitively impaired	Level VII	NR
Apps				
Luminosity	Brain training	MCI	Level VII	NR
Alzheimer Master	Plays voice recordings to remind individuals to take medication and drink water, etc.	Cognitively impaired	Level VII	NR
Bettercog, COMCOG	Computerized cognitive training programmes	MCI	Level I	[66,67]

Moyle, Wendy. "The promise of technology in the future of dementia care." Nature Reviews Neurology 15.6 (2019): 353-359.

Overview of assistive solutions in dementia care

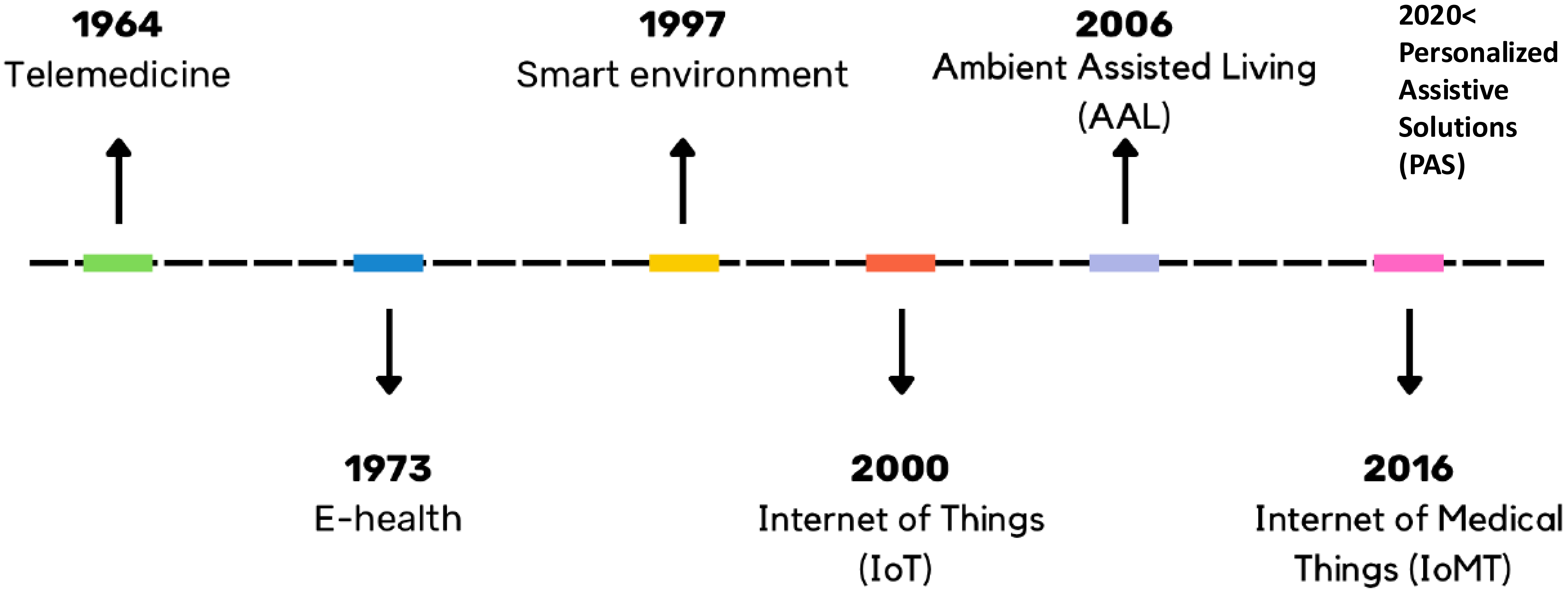


Personalized Assistive Solutions

Faisal, Mohammed, et al. "Robot-based solution for helping Alzheimer patients." *SLAS technology* 29.3 (2024): 100140.

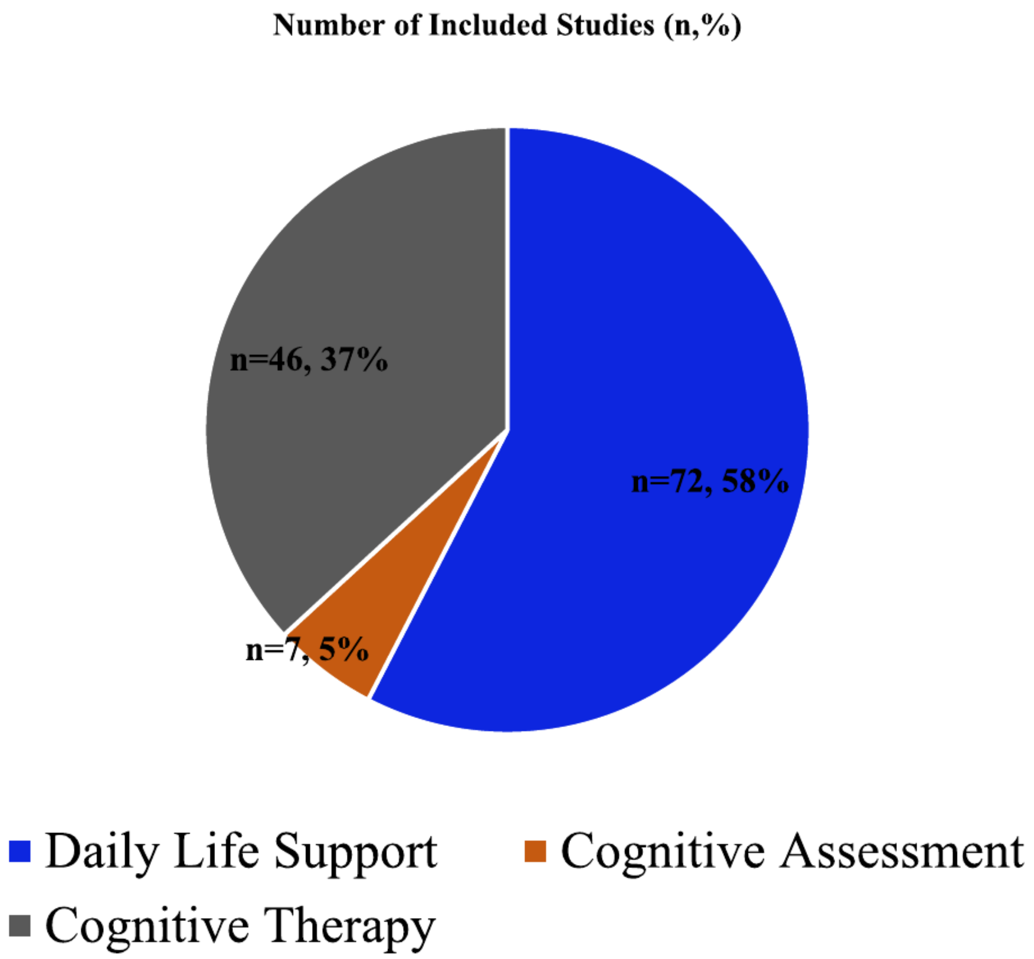
Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer’s Disease Care: A systematic review." IEEE Access (2024).

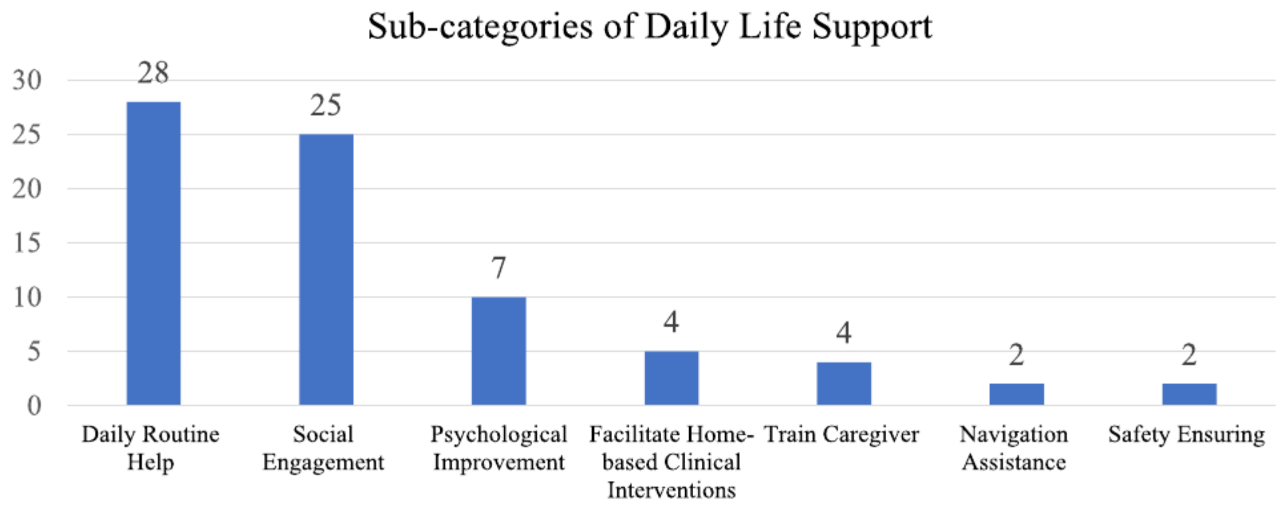
Chronology of technologies



Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

Use of robots in dementia care





Faisal, Mohammed, et al. "Robot-based solution for helping Alzheimer patients." SLAS technology 29.3 (2024): 100140.

Data types in technologies

Sensing Technology	Involved Sensors	Application Field Technology						
		Telemedicine	E-health	IoT	Smart Environment	IoMT	AAL	PAS
Inertial	Accelerometer, Gyroscope, Magnetometer	[32]		[43] [46]	[36] [37] [38] [39] [41] [42]	[60]	[13] [49] [51] [55]	[63]
Physiological	Heart rate, Oxygen, Blood pressure			[12] [45] [48]	[35] [37] [41]	[14] [56] [57] [58] [59] [60] [61] [62]	[50]	[63]
Environmental	Pressure, Temperature, Light, Gas, GPS	[9] [32]	[33]	[12] [43] [44] [45] [46] [47] [48]	[11] [35] [36] [37] [38] [40] [41] [42]	[14] [58] [60] [57]	[13] [49] [50] [52] [54] [55]	[15] [63] [17] [64] [65] [66]
Radio Signals	Wi-Fi, BLE, mm-Wave							
Video	Video, Image	[31]		[12] [16] [46]				[17]
Digital Platforms	Mobile App, Web Portal, Questionair		[10] [34] [18]	[48]			[53]	[15] [17]

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

Cognitive assessment tests in PAS

Type of robot	Extracted features	Cognitive assessment test
Pepper robot	Visuospatial/Executive, Language and Attention, Naming, Abstraction, Delayed Recall, Orientation	Montreal cognitive assessment (MoCA)
Giraffe robot	Based on Cognitive Screening Test	TMT and BT
Qbo robot	Based on the Cognitive Screening Test and Activities of Daily Living	DemTect
NAO robot	Time Elapsed, Transition Test, Currency Conversion, Storytelling, Complex and Repeat Statement, Object Identification, Personal Questions	Was Not Mentioned
Telenoid	Patients' conversational data	Clinical Dementia Rating (CDR)
Omni	Simple reaction times, Position tracking, and Stabilization tasks	Clinical Dementia Rating (CDR)

Outcome	*Questionnaire*	*References*
Cognitive/ memory functions	MMSE; Severe MMSE (sMMSE); CNS Vital Signs; Cambridge Neuropsychological Test Automated Battery (CANTAB); Global Deterioration Scale (GDS); Clinical Dementia Rating (CDR); International Classification of Diseases and Associated Disorders (ICD-10); Functional Independence Assessment (FIM); Degree of Daily Life Independence Score for People with Dementia (DDLIS-PD)	Kase et al., 2019,Kubota et al., 2020,Lee et al., 2020), Maddahi et al., 2020, Obayashi et al., 2020, Stogl et al., 2019)
Robot impact	Apathy Inventory (AI); Neuropsychiatric Inventory (NPI); Apathy Scale for Institutionalized Patients with Dementia Nursing Home version (APADEM-NH); Quality-of-Life Scale (QUALID) Quality of Life in Alzheimer's Disease; Rating Anxiety in Dementia; Geriatric Depression;	(Feng et al., 2019, (Heerink et al., 2013), Lee et al., 2020), (Rudzicz, Wang, Begum, & Mihailidis, 2015), (Vostry & Zilcher, 2019)
Social bonding	Observational Measurement of Engagement (OME); Observed Emotion Rating Scale (OERS); World Health Organization's ICF	(Di Nuovo et al., 2019, Obayashi et al., 2020)
Cognitive impairment	Rowland Universal Dementia Assessment Scale (RUDAS); MoCA	(Gerłowska et al., 2018), (Tsardoulias et al., 2017)
Behavior monitoring	Human skeleton-based detection; Cohen-Mansfield Agitation Inventory-Short Form (CMAI-SF)	(Gerłowska et al., 2018, Kuwamura et al., 2016, Sandoval & Favela, 2017)
Reality orientation	Nishimura Mental State Scale for the older people (N-M scale); Normal ADL; Hierarchic Dementia Scale-Revised (HDS-R)	(Korchut et al., 2017)

Karami, Vania, et al. "Socially Assistive Robots for Individuals with Alzheimer's Disease: A Scoping Review." Archives of Gerontology and Geriatrics (2024): 105409.

E-health-based technologies

Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[10] (2022)	Create an Android-based assistive healthcare application for caregivers of Alzheimer's patients to manage daily tasks, medications, and improve patient memory with brain games	Mobile Technology	NA	Lack of empirical evidence on the app's effectiveness in improving patient outcomes or reducing caregiver burden
[33] (2021)	Propose a knowledge-powered personalized virtual coach for diet and nutrition assistance to Alzheimer's patients or caregivers.	Cloud-based architecture	NA	Limited generalizability beyond Alzheimer's population.
[34] (2017)	Enroll technology-enabled caregivers to assess caregiver burden, depression, anxiety, and sleep disturbance.	Technology-enabled caregivers	NA	Reliance on limited assessment tools
[18] (2017)	Provide additional helpful information about scheduled events in a user-friendly and enjoyable manner.	Semantic web application (CAPTAIN MEMO) based on the OntoMemo dynamic ontology.	NA	Limited consideration of ethical issues

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

Smart-environment-based technologies

Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[11] (2022)	Create a computational framework for smart homes that enhances awareness for individuals with AD. Utilize context-aware tools, predict behavior and uncertain events, simulate errors and behaviors, enable interventions, provide realistic activity simulations, and validate with real users	Cognitive Modelling	NA	No distribution of errors among stages or criteria provided
[35] (2020)	Design a novel IoT-based solution for tracking activities and monitoring health of Alzheimer's patients.	IoT, Cloud Computing	NA	Reliability limitations of IoT devices used.
[36] (2020)	Present two approaches for simulating the behavior of individuals with Mild Cognitive Impairment (MCI) and AD using behavior trees and error injection.	AI (behavior trees)	Motion, light/RFID	Limited generalizability, sample size, and real-world complexities. Data collection, measurement accuracy, and ethical considerations.
[37] (2020)	Develop and implement a medical system using IoT to improve the quality of life for individuals with AD and reduce caregiver burden.	IoT	Motion processing unit sensor, GPS module, heart rate sensor, microcontrollers, LCD display, accelerometer/gyroscope, Buzzer, Arduino Nano, Node MCU ESP8266	Ethical concerns about privacy, autonomy, and informed consent.
[38] (2019)	Propose a framework for monitoring patients with Alzheimer's and other dementias in their homes using sensors to gather contextual information.	Conceptual framework	NA	Limited scope, not applicable to other cognitive impairments or disabilities.
[39] (2019)	Develop an assistive system that recognizes the intent of Alzheimer's patients in completing daily tasks and guides them towards successful completion.	AAL technology	RFID sensors, Bluetooth module/Arduino	Limited coverage of day-to-day activities, excludes social interaction and cognitive stimulation.
[40] (2018)	Propose a cost-effective AI-enabled system to enhance the quality of life for Alzheimer's patients.	AI, IoT, Cloud Computing	Light, Bulb, Smartphone	No empirical data on system effectiveness or user-friendliness
[41] (2015)	Develop a Tele-health system based on IoT technology for monitoring elderly individuals with AD remotely.	IoT and RFID	ECG wireless sensor, UHF passive wearable RFID wristband/RFID.	Study conducted on a limited number of participants
[42] (2015)	Support Alzheimer's patients in living independently within their living rooms, providing necessary emergency assistance and support.	Activity tracking and monitoring	Kinect device, NFC readers/Smart Phone	No consideration of implementation and maintenance costs

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

IoT-based technologies

Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[12] (2022)	Develop a secure IoT assistant-based system for Alzheimer's Disease providing psychological support and secure info sharing.	IoT, CNN, steganography, S/MIME protocol	Microphone, buzzer, earpiece, NEO 6MV2 GPS module, Raspberry Pi 3	Privacy/security concerns, accuracy and reliability limitations, ethical considerations
[16] (2022)	Develop a wearable camera-aided device and Bluetooth ear-complementary device prototype integrated with AI technology. Improve awareness for Alzheimer's patients and reduce caregivers' burden	AI, IoT, HAAR cascades algorithm	ESP32 camera, Smart Phone	Technical issues with the smart specs technology used. Impact on intervention effectiveness and data reliability
[43] (2021)	Develop a nursing system with IoT devices that includes communication, location tracking, fall detection, and early warning services for aging and dementia patients	IoT, RNN, LSTMs	IMU, accelerometer, gyroscope, GPS positioning chip, MCU	Ethical considerations related to data privacy, security, and informed consent may not be adequately addressed
[44] (2021)	Build an IoT-enabled global tracking system and mobile app for people with AD. Create a wearable tracking device using GPS technology and integrate it with an internet-connected system for real-time access	IoT, Wireless Network, GPS technology	Neo-6m GPS module, SIM800L Mini GSM/GPRS module, Arduino	May not address the long-term sustainability, scalability, or adaptability of the system
[45] (2021)	Propose the DCARE model for monitoring Alzheimer's patients, develop a prototype, and evaluate it using the DCARE Dataset Simulator Tool.	Ambient Intelligence, IoT	Wearable sensors, Smart Watch	Limited caregivers and patients used the prototype. Insufficient time to collect insights on engagement and effectiveness. synthetic data instead of real sensor data.
[46] (2020)	Propose an architecture for an Internet of Health ecosystem, including Alzheimer's prediction using movement data and tracking abnormal behaviors.	IoT, deep learning, fog computing, cloud	Gait sensors, Bluetooth board sensors	Limited evaluation, limited access, ethical considerations.
[47] (2018)	Develop an RFID-based localization system for patients with memory loss.	IoT, RFID	Mat Pressure Sensor, RFID Reader, RFID Tags	Privacy concerns, limited scope
[48] (2018)	Use IoT and a mobile application to support Alzheimer's caregiving and prevent caregiver burnout.	IoT	Smartwatch	Limited consideration of ethical issues

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AAL-based technologies

Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[13] (2022)	Address senior health deterioration, propose an Alzheimer's IoT solution, and evaluate accuracy using sensors in patients' homes. Enhance security with AES and assist patients and families	ML, IoT, CNN	Motion sensor, pressure, moisture sensors, Arduino, Raspberry Pi, RFID, Zigbee	Limitations in accuracy, reliability, or security of the IoT technology used. Limited generalizability
[49] (2019)	Develop a system for reminding patients of daily tasks and medication, monitoring falls, and sending location coordinates.	Assistive Technology	GPS module, GSM module, LCD, buzzer, accelerometer module, ADC converter/Arduino Mega	Sample size, privacy, and security concerns.
[50] (2019)	Create a tool to evaluate the well-being of patients and support healthcare decision-making.	iBeacon technology, ICT, Localization Algorithm	Raspberry pi3 (Antenna)	Potential bias, limited generalizability, subjective assessments, ethical considerations.
[51] (2019)	Enhance patient and family support through a real-time Ambient Assisted Living (AAL) system using Internet of Things (IoT) and Augmented Reality (AR) concepts.	IoT and Augmented Reality (AR)	Relay actuators, sensors, smartphones/glasses	Small sample size, limited generalizability.
[52] (2019)	Detect location of misplaced objects, display names of friends/relatives on AR display, monitor navigation, and send location to caregiver.	Augmented Reality (AR)	Switch, camera, accelerometer/gyroscope, display, microcontroller, Bluetooth module/glasses	Cost and accessibility concerns
[53] (2018)	Develop a mobile application using AR to assist individuals with early-stage AD.	Mobile Technology, Augmented Reality	NA	Limited generalizability due to small sample size
[54] (2018)	Develop a system to address wandering episodes and falling risks for dementia patients using deep learning and a smartwatch.	Deep Learning	Smartwatch	Limited coverage due to reliance on smartwatch
[55] (2017)	Enable Alzheimer's patients to live independently within their living rooms while providing necessary emergency assistance and support.	Machine learning technologies	Kinect device, NFC readers/Smartphone	Lack of consideration for implementation and maintenance costs

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

IoMT-based technologies

Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[14] (2022)	Create a remote monitor system for AD using Health Remote Monitoring Systems (HRMS) to triage and follow-up with people living with dementia. Reduce burden on staff and unnecessary hospital visits.	ML, AI, IoT, Logistic Regression Algorithm	Heart rate, Arterial oxygen, Body temperature, GSR, Smart Watch	Technical limitations of the remote monitoring system could affect effectiveness
[56] (2021)	Offer a continuous mechanism using IoT-based sensors to monitor various parameters of Alzheimer's patients and enhance their quality of life	IoT, Cloud Computing	Esp8266, LM35, Pulse sensor, gyroscope, LCD, buzzer, resistor, LEDs, Atmega 328 Micro-Controller	The system has technical limits and cannot guarantee the complete normal routine
[57] (2021)	Develop a cost-effective and user-friendly smart wearable device integrated with a software application for Alzheimer's patients.	IoT, cloud computing (Ubidots)	GPS module, pulse sensor, temperature sensor, OLED Display, Help Button/Node MCU	Small sample size limits generalizability. Focuses on specific population (mild to moderate AD).
[58] (2021)	Propose a wireless-sensing smart wearable medical device (SWMD) for Alzheimer's patients, monitor vital biomarkers, falls, and provide GPS location.	Cloud Computing	ESP32, Maz30100, buzzer, LCD, gyro sensor, oximeter sensor, temperature sensor, SIM800L, battery 2000mA/Smart Watch	Prototype tested with limited number of patients/caregivers.
[59] (2019)	Propose an IoT-based assistive tool for Alzheimer's patients and caregivers, providing health monitoring and assistance.	IoT	Esp8266 12e, Pulse sensor, OLED display, Battery, Servo Motor, Piezo buzzer, Hc-05 Bluetooth module, Neo 6m GPS tracker/Arduino Uno	Prototype system, dependency on Wi-Fi connection.
[60] (2018)	Design a device to monitor health parameters in Alzheimer's patients.	IoT	Pressure Sensor, Heart Rate Sensor, Temperature Sensor, Arduino Nano	Limited generalizability due to sample size not specified
[61] (2018)	Develop a portable device resembling a clock to aid elderly individuals in daily activities.	IoT	Pulse Sensor, Temperature Sensor, GPS, NodeMCU ESP8266	Effectiveness not supported by evidence

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

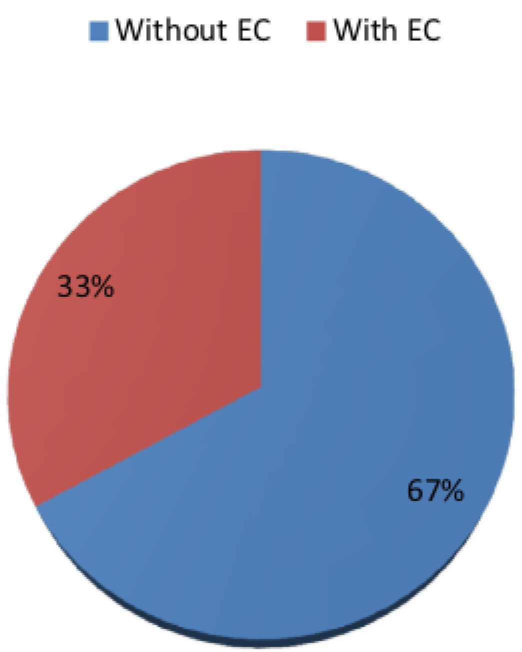
PAS-based technologies

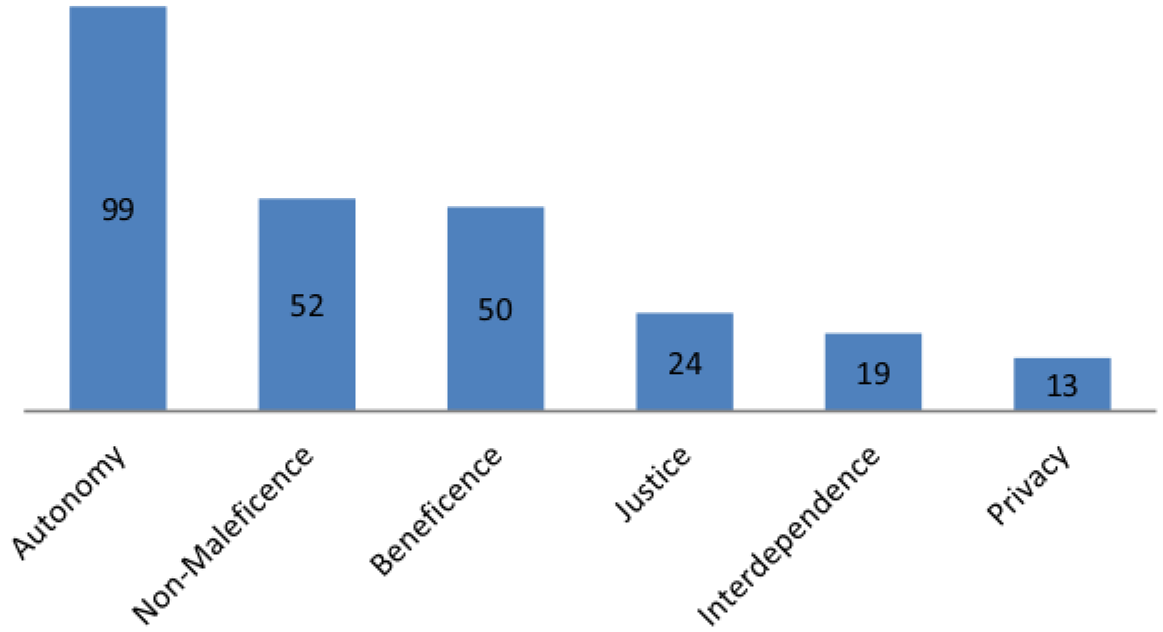
Ref. (Year)	Objective	Methodology/Technology	Sensors/Controller	Limitations
[15] (2021)	Develop a chatbot named AlzBot for Alzheimer's patients, enhance socialization and location tracking to reduce caregiver burden.	Mobile app with Chatbot	Motion sensor, Smart Phone	Lack of clinical validation of the app's efficacy.
[63] (2020)	Design an innovative system for monitoring Alzheimer's patients, including location tracking, heart rate monitoring, and assistance in self-administration of drugs.	IoT	GPS module, GSM module, heart rate module, buzzer, accelerometer module, power supply, LCD/Arduino Mega	Validation and cost considerations.
[17] (2020)	Create an application acting as a personal assistant for Alzheimer's patients, including features like face recognition, wandering and fainting detection, assistance in finding a way home, reminders for daily chores and past life, and organizing and planning jobs.	Machine Learning	Accelerometer and gyroscope sensors, Smart Watch	Personalized assistance and practical implementation.
[64] (2020)	Design and implement a wearable device for accurately determining the 2D location of Alzheimer's patients using a BP-ANN.	Deep Learning - BP-ANN	ZigBee-based XBee S2C anchor nodes, mobile node/ZigBee-based XBEE S2C anchor Nodes	Time-consuming strategy, limited optimization, and movement during experimentation.
[65] (2018)	Ensure safety and well-being of Alzheimer's patients by tracking their position during daily activities and social interactions.	iBeacon technology	iBeacon devices, Raspberry Pi3	Limited scope and resources
[66] (2016)	Detect AD using EEG data and classify it using support vector machines. Monitor patients using GPS and GSM technology.	Support Vector Machine	GSM, ARM cortex M3 LPC 1768, GPS antenna, power supply, LCD display, GSM and GPS module, PC and RS 232 kit/ARM cortex M3 LPC 1768.	Use of a single biomarker (EEG signal) and limited scope of monitoring system

Ali, Muhammed Toqeer, et al. "ICT-based solutions for Alzheimer's Disease Care: A systematic review." IEEE Access (2024).

Dilemmas

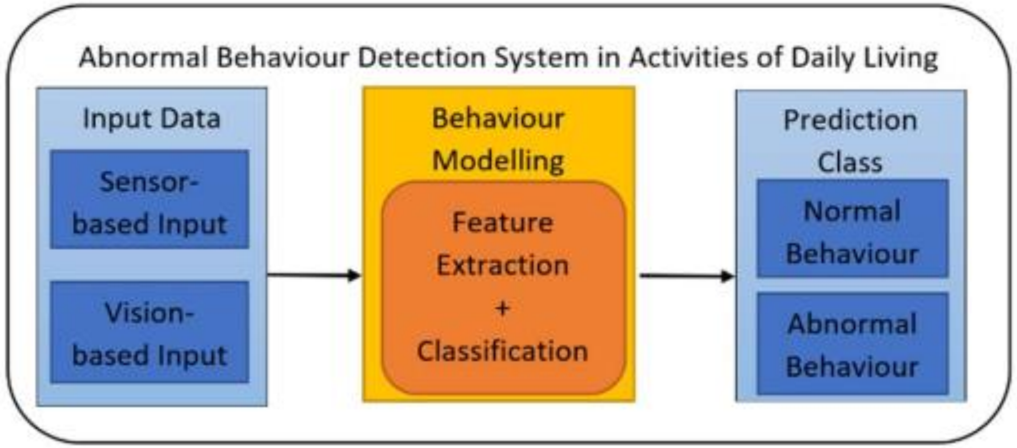
Ethical considerations in intelligent assistive technologies for dementia

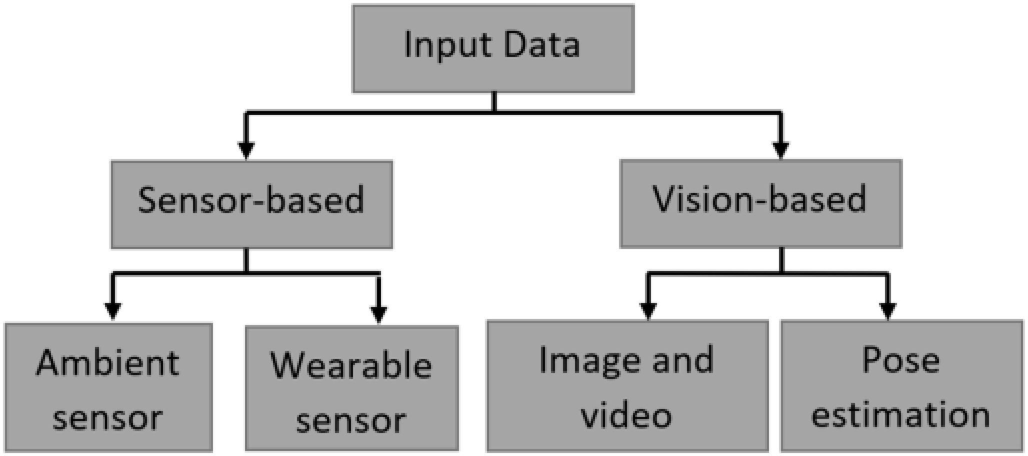




Ienca, Marcello, et al. "Ethical design of intelligent assistive technologies for dementia: a descriptive review." Science and engineering ethics 24 (2018): 1035-1055.

Abnormal Behavior Detection in Activities of Daily Living





Abnormal Behavior Types		References
Accidental	Fall detection	[13]–[16], [18], [22], [23], [52], [53], [68], [94], [98]–[100]
	Electrical appliances	[30], [63]
	Lost	[43]
Non-accidental	Elderly suffering from dementia	[3], [24], [29], [36], [45], [51]
	Rule-based/ threshold indices	[19], [31]–[33], [38], [41], [70]
	Loss of appetite and urinary tract infection	[37]
	Elderly suffering from Alzheimer	[62]

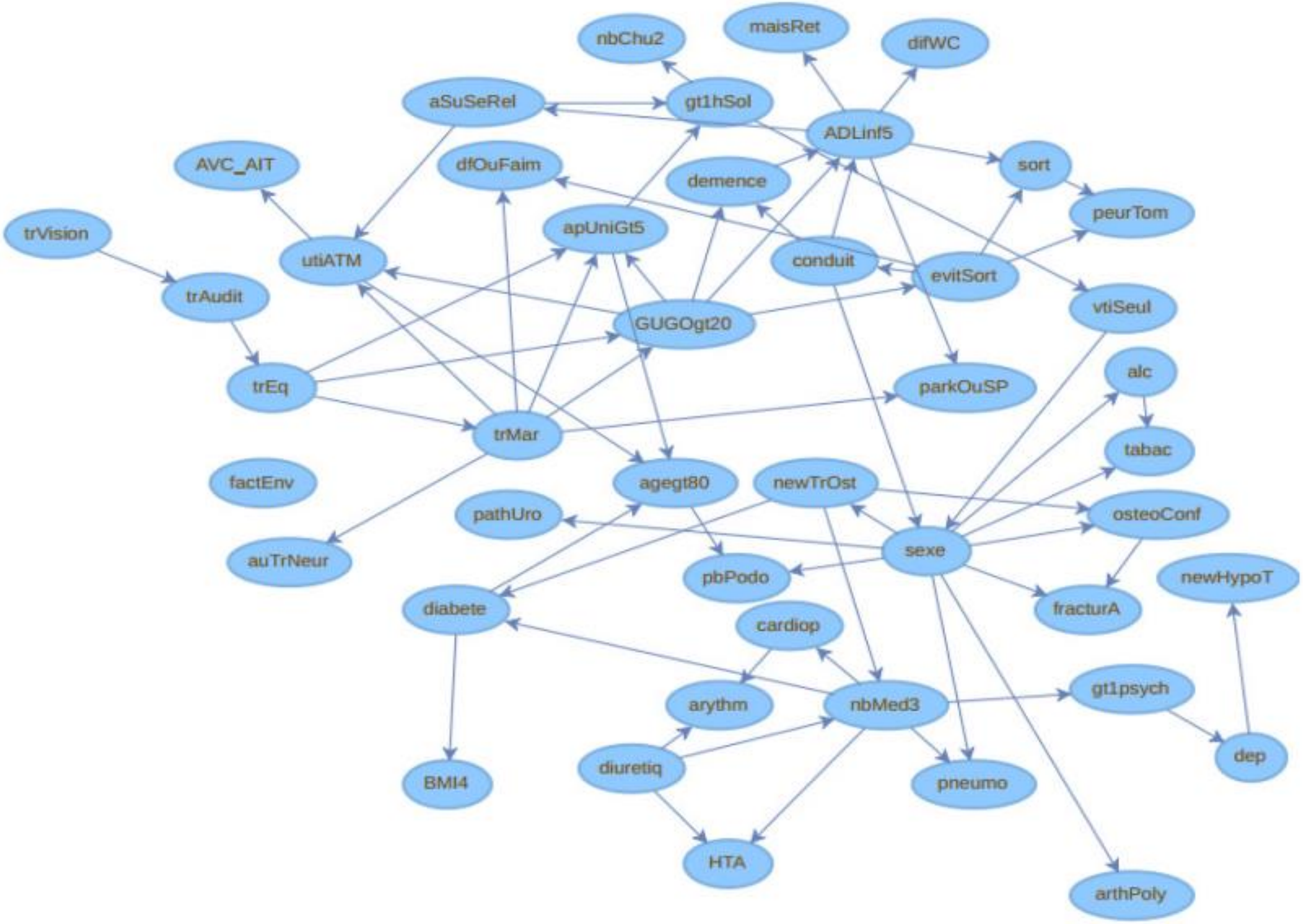
Challenges:

- **Lack of real-life datasets**
- **Limited actions are studied**
- **Vast variation of ADL**
- **High false alarm rate**
- **Limited to one location**

Tay, Nian Chi, et al. "A review of abnormal behavior detection in activities of daily living." IEEE Access 11 (2023): 5069-5088.

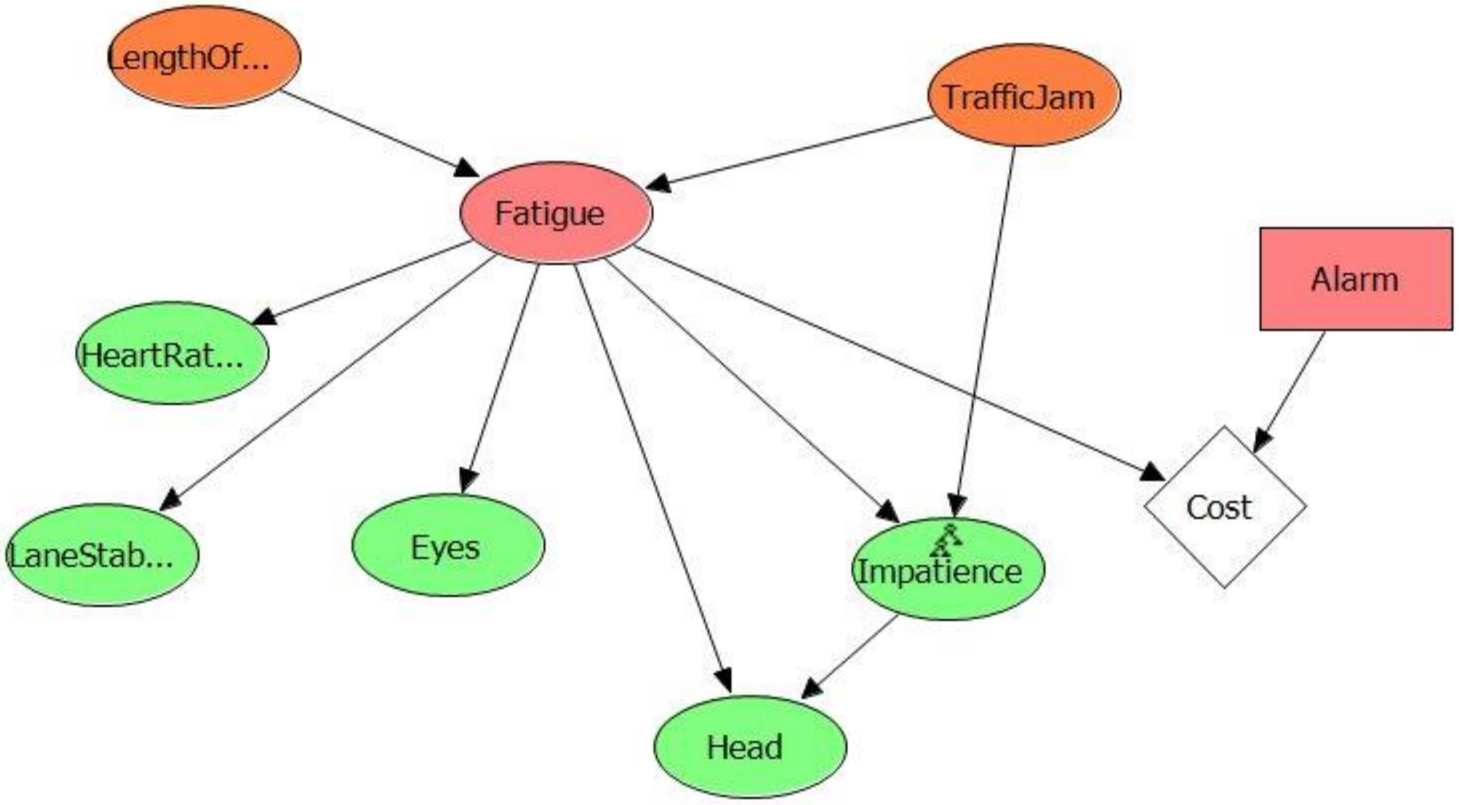
Complex models in fall detection..

"Gondos óra" program in Hungary



Sihag, Gulshan, et al. "Evaluation of risk factors for fall in elderly using Bayesian networks: A case study." Computer Methods and Programs in Biomedicine Update 1 (2021): 100035.

Advanced driver-assistance system (ADAS)

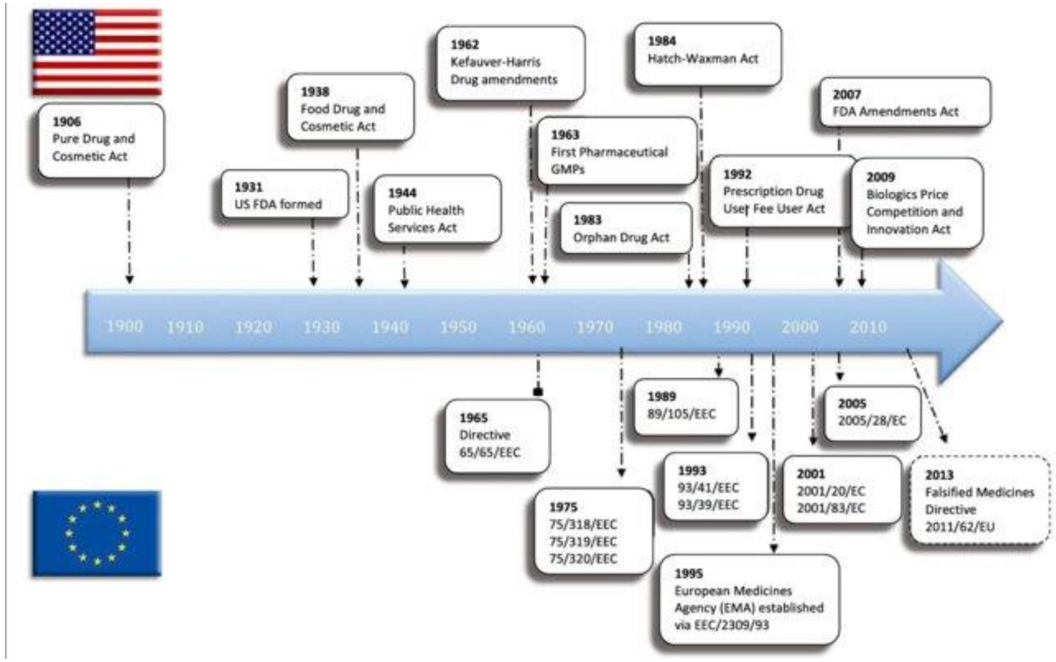


Standards and regulations

The new Vehicle General Safety Regulation starts applying today [2024]. It introduces a range of mandatory advanced driver assistant systems to improve road safety and establishes the legal framework for the approval of automated and fully driverless vehicles in the EU. The new safety measures will help to better protect passengers, pedestrians and cyclists across the EU, expectedly saving over 25,000 lives and avoid at least 140,000 serious injuries by 2038.

Moyle, Wendy. "The promise of technology in the future of dementia care." Nature Reviews Neurology 15.6 (2019): 353-359.

Regulation for drug discovery



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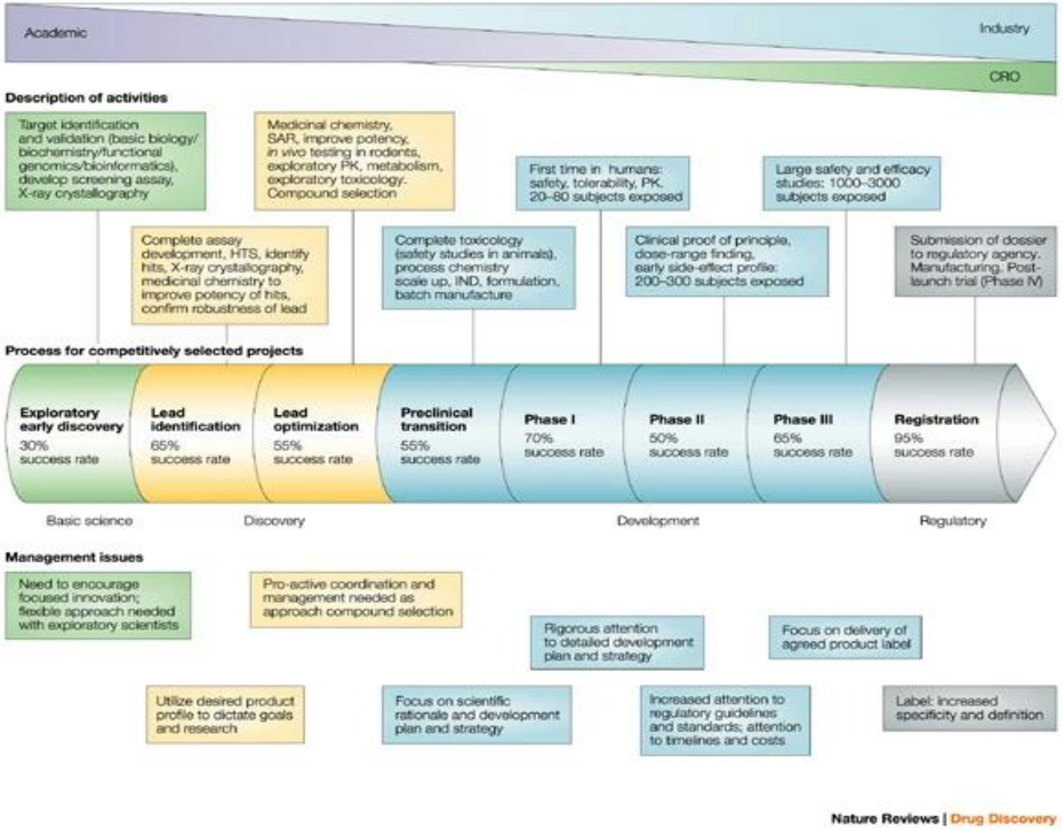


Nwaka, Solomon, and Robert G. Ridley. "Virtual drug discovery and development for neglected diseases through public–private partnerships." *Nature Reviews Drug Discovery* 2.11 (2003): 919-928.

Issues and principles for HC-AI

hcaim human centred artificial intelligence masters

Issues in AI ethics

1. Autonomous weapon systems
2. Privacy
3. Fairness and bias
4. Trust and transparency
5. Job safety
6. Robot rights
7. Long-term AI prospects

Principles

- Safety
- Trustworthy
- Accountability
- Regulation
- Human rights and values
- Un(bias)ed
- Fairness
- Privacy
- Shared power
- Diversity and inclusivity
- Collaboration
- Transparency

Russel-Norvig: Artificial Intelligence. A Modern Approach (4th edition)

Novel solutions for HC-AI

Theory

- **Privacy-preserving AI**: federated learning
- **Trustworthy AI**: structured/causal inference (XAI)
- **Human-compatible AI**: collaborative inverse reinforcement learning
- **Machine teaching**: reinforcement learning with human feedback
- **Artificial general intelligence**: foundation models, transfer learning

Practice

- Automated programming
- Collaborative workflow systems
- Testing/Auditing
- Ecosystem

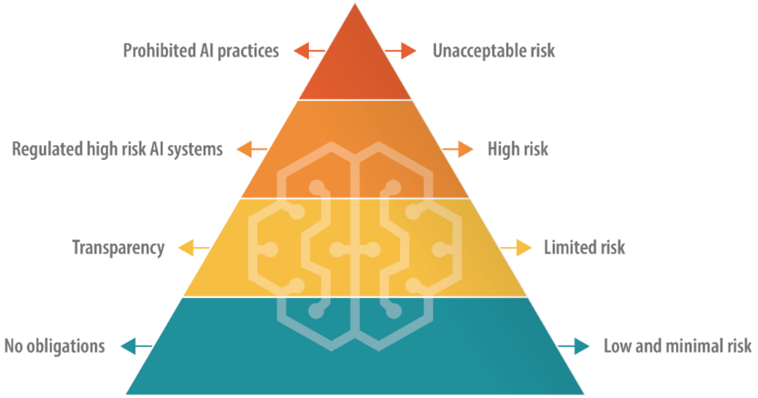
Ethics

- Rights for digital assistants/twins

Society & law

- Medical device regulation
- The EU AI Act

AI regulations



Data source: European Commission.

AI Act

https://hcaim.bme.hu/en/hcrai/

USA

Executive Order on Safe, Secure, and Trustworthy Artificial Intelligence

2018 | 2023 June | 2023 June | 2023 October | 2024 August

Proposal for AI Act

HCAIR

„Human-centred Regulation of AI"
workshop @ BME

EU

Accepted
Active: 2026

Thank you for your attention!