

SYSTEMS REFERENCE DELIVERABLE

Ethical considerations of artificial intelligence (AI) when applied in the active assisted living (AAL) context

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SYSTEMS REFERENCE DELIVERABLE

Ethical considerations of artificial intelligence (AI) when applied in the active assisted living (AAL) context

INTERNATIONAL
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INTRODUCTION

This document deals with the ethical implications and moral questions that arise from the development and implementation of artificial intelligence (AI) technologies applied in the active assisted living (AAL) context.

The population in all countries is increasingly ageing. Reducing the burden of long-term care for older persons is a major policy issue in every country. Active assisted living (AAL) systems help older persons with daily living activities so that they can live independently as long as possible. AAL can be a solution to this demographic issue.

AAL may use AI technologies to understand the condition of an AAL care recipient and their environment and provide appropriate services at appropriate times. AI-enabled systems must be aware of the decline of the AAL care recipient's physical/cognitive/judgment abilities as they age, and these systems must act appropriately. For instance, AI can determine a life-threatening risk to the AAL care recipient and a privacy concern regarding obtaining and using personal information.

The three issues around AI in general are as follows: concerns about the algorithms and particularly those that have been created by machine learning technology without human intervention; the extent to which these algorithms result in misidentification and misinformation; and the misuse of personal data leading to consequences and harm to individuals.

It is, therefore, necessary to develop general guidelines for the use of AI applied in the AAL context. This document deals with the ethical implications and moral questions that arise from the development and implementation of AI in AAL.

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ETHICAL CONSIDERATIONS OF ARTIFICIAL INTELLIGENCE (AI) WHEN APPLIED IN THE ACTIVE ASSISTED LIVING (AAL) CONTEXT

1 Scope

This document describes ethical considerations that are relevant when developing AAL systems and AAL services.

This document covers AAL-specific issues related to AI that supplement those ethical considerations already addressed in other AI documents. Examples include the WHO and OECD principles of AI and those of the High-Level Expert Group on Artificial Intelligence set up by the European Commission.

This document analyses whether these frameworks for the governance of AI are sufficient to meet the requirements of the AAL environment and in particular to meet the needs of AAL care recipients.

The objective of the ethical assessment is to create concrete and clear ethical guidelines that can be used as checklists in AAL service and system platform design, development and implementation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 63134:2020, *Active assisted living (AAL) use cases*

IEC TS 63134:2020/AMD1:2022

IEC 63240-1, *Active assisted living (AAL) reference architecture and architecture model – Part 1: Reference architecture*

IEC 63240-2, *Active assisted living (AAL) reference architecture and architecture model – Part 2: Architecture model*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1 ethics

moral principles that govern an actor's (person or technical system) behaviour or their conduct of an activity

3.1.2**artificial intelligence****AI**

branch of computer science devoted to developing data processing systems that perform functions normally associated with human intelligence, such as reasoning and learning

[SOURCE: IEC 60050-171:2019, 171-09-16, modified – The domain "<discipline>" has been omitted.]

3.1.3**AAL service****active assisted living service**

action or function of an AAL system creating an added value for customers

EXAMPLE 1 Configuration and maintenance of AAL systems.

EXAMPLE 2 Assistant systems to support the home environment.

[SOURCE: IEC 60050-871:2018, 871-01-04, modified – The note to entry has been deleted.]

3.1.4**AAL user****active assisted living user**

person who uses or benefits from, or uses and benefits from, AAL devices, systems or services

[SOURCE: IEC 60050-871:2018, 871-02-05]

3.1.5**AAL care recipient**

person who receives and consumes AAL care services

3.2 Abbreviated terms

The abbreviated terms are given in Table 1.

Table 1 – Abbreviated terms

Abbreviated term	Full term
EU	European Union
IEEE	Institute of Electrical and Electronics Engineers
OECD	Organization for Economic Cooperation and Development
WHO	World Health Organization

4 Ethical considerations relevant to the AAL context

Many national organizations and international consortia have investigated and published proposed sets of requirements or criteria (for example the EU paper on Trustworthy AI [1]¹, IEEE paper on Ethically Aligned Design [2], OECD Principles [3], WHO Guidance [4] and ISO/IEC TR 24368 [5]) for the creation of AI enabled and autonomous systems encompassing capabilities such as natural language processing, machine vision, machine learning, artificial neural networks, and their related algorithm development.

¹ Numbers in square brackets refer to the Bibliography.

These requirements are proposed with the goal of enabling these systems to be "trustworthy" (EU [1] and OECD [3] use this terminology) and acceptable for use by a broader society.

A common set of requirements emphasized in these activities, based both on the abovementioned sources and including requirements of this document as well, is summarized in Table 2.

Table 2 – Key requirements for trustworthy AI

Category	Requirement	Description
Lawful AI	International and national laws and human rights can apply	
Ethical AI	Ethics are moral principles that govern an actor's (person or technical system) behaviour or the conduct of an activity	
	Human agency and autonomy	Individuals have the right to decide how and for what purpose(s) they are using the technology.
	Human dignity	Individuals shall be respected, and technical solutions shall not violate their dignity as human beings and, as importantly, allow vulnerable groups to participate in society. Moreover, humans should be aware that they are interacting with an AI system and must be informed of the system's capabilities and limitations.
	Diversity, non-discrimination, and fairness	Unfair bias must be avoided, as it could have multiple negative implications, from the marginalization of vulnerable groups such as the ageing population and the disabled, to the exacerbation of prejudice and discrimination.
	Privacy and data governance	Individuals shall be able to control access to their personal information and the use of the information by the AI system and system developers and operators.
	Individual and societal well-being	AI systems should adopt increased individual human and societal well-being as a primary success criterion, benefiting all human beings, including future generations. It should be ensured they are sustainable and environmentally friendly.

Category	Requirement	Description
Technical dependability and robustness	AI systems should be technically dependable and reliable in their operation, secure from cybernetic and access controls perspectives, and do not pose unreasonable safety risk to an AAL care recipient's physical or mental health.	
	Reliability, safety and security	AI systems should be safe and secure throughout their entire lifecycle in conditions of normal use, foreseeable misuse, or abnormal conditions
	Human oversight and control	AI and autonomous systems should be subject to human oversight and control at a system level and certain important decisions should remain subject to human review and approval/denial.
	Transparency	The basis of a particular AI system decision (the data, algorithms and business model) should always be discoverable and transparent. Furthermore, AI systems shall be created and operated with the ability to provide an unambiguous rationale for all decisions made and accountability for their outcomes. Moreover, AI systems and their decisions should be explained in a manner adapted to the stakeholder concerned, including an AAL care recipient.
	Accountability	If something goes wrong with an AI or autonomous technology, there should be accountability. Appropriate mechanisms should be available for redress for individuals and groups that are adversely affected by decisions based on algorithms. Auditability, which enables the assessment of algorithms, data and design processes plays a key role in accountability.

The discussion of AI and autonomous systems being used in an AAL context that follows in Clause 5 assumes that all AI-enabled AAL systems will be implemented in a lawful manner. The focus, therefore, is on key ethical aspects as they apply to individual AAL care recipients and users (human agency and autonomy, human dignity; diversity, non-discrimination and fairness; privacy and data governance) and specific safety and human oversight concerns as they should be considered during the design and construction of the AI or autonomous system.

5 Ethical issues associated with AAL assistance

5.1 AAL levels of assistance

AAL systems serve AAL care recipients on four categories or "levels of assistance" based on the physical and cognitive condition of the care recipient and their resulting needs:

- Independent (Level 0) – The care recipient is able to live independently with minimal assistance.
- Some assistance (Level 1) – The care recipient is able to live independently with some assistance required periodically.
- Assistance with IADL (Level 2) – Assistance is required with tasks related to instrumental activities of daily living (IADLs).
 - Examples of IADLs include use of transportation, answering the phone, cooking, housekeeping, cleaning, medication management, financial management, etc.

- Assistance with ADL (Level 3) – Assistance is required with tasks related to activities of daily living (ADLs).
 - Examples of ADLs include the most basic human functions such as walking and moving around, bathing, grooming and getting dressed, continence, food preparation and eating.

The broader category of AAL users include not only those receiving AAL assistance, but also those caregivers supporting the care recipients (e.g. family caregivers/carers, other informal caregivers, formally trained caregivers, medical professionals), or technical AAL systems operators. Irrespective of the type of AAL user, an AI-enabled AAL system shall be aware of the level of assistance required by the AAL care recipient and act ethically as appropriate to their needs.

The increasing physical limitations (declining ability to speak clearly, deterioration in hearing, reduced mobility, reduced visual acuity) typically associated with the increasing levels of assistance imply that systems shall not expect proficient levels of interaction (e.g. clarity of speech for natural language processing systems) from AAL care recipients and machine learning systems shall be trained with appropriate data representative of the AAL care recipient community.

More importantly, cognition, or more precisely the decline in cognitive ability of the AAL care recipient because of progressive dementia or Alzheimer's disease, is a key aspect of the increasing level of assistance required. Cognitive decline will impact how the care recipient can effectively interact with an AI-enabled system and how the system should interact with, and consider actions taken toward the care recipients, while also considering the requests and instructions of the caregivers.

Therefore, in addition to ensuring that the ethical concerns expressed in the use cases in 5.2 are addressed, systems shall (i) ensure data representative of the AAL care recipient community for AI systems based on machine learning is used in any training sets; and (ii) be sufficiently configurable to handle the cognitive limitations of the care recipients and the role and control of any designated caregivers or substitute decision makers on behalf of the care recipients.

5.2 The changing conditions of AAL care recipients

Irrespective of the level of assistance required, not all AAL care recipients will require assistance with all tasks within a category. For example, some may be able to eat on their own but may require assistance for bathing and grooming. Furthermore, the AAL care recipients' conditions may change from level 0 to level 3 over the years. With this change, their degree of physical activity may decline and simultaneously their cognition and decision-making ability may also decline.

These declines, in both physical condition and cognition and self-judgment ability, also affect how AI-enabled systems should learn and react. A couple of simple examples are as follows.

- Since many AAL systems use the AAL care recipient's personal data to provide services to the AAL care recipient, the consent of the AAL care recipient should be obtained in advance regarding the use of the AAL system. For an AAL care recipient in level 0, the prior consent of the user is obtained without problem. On the other hand, in the case of a Level 3 AAL care recipient, it is appropriate to seek the consent of not only the AAL care recipient but also of designated parties such as his/her family members or other substitute decision makers. No matter what level the AAL care recipient is, the principle of protecting the dignity of that person shall not be violated.

- All individuals have the right to engage in activities that can involve putting themselves at risk. However, as cognition declines, it is possible that users will make a request of a system that puts their own safety at a higher level of risk. In this case, the AI/autonomous system shall determine if the level of risk is still appropriate before acting (or allowing the activity through inaction) while maximizing the AAL care recipient's autonomy. Two use cases where different decisions can be made are as follows:
 - the AAL care recipient requests assistance to go for walk outside on a cold day; the AI system allows this without notifying other family members (respecting autonomy and privacy); while conversely,
 - the AAL care recipient, in greater pain one morning, requests the dispensation of a quantity of pain medication which can be harmful from an AI-governed dispenser; the AI system should deny this request to minimize potential harm to the care recipient.
- As a care recipient's cognitive and judgement abilities continue to decline, there can be an increased need to have a human review the user requests and the AI decisions to ensure they remain appropriate for the individual.

5.3 Some AAL use cases and their ethical considerations

5.3.1 General

Some key use cases of an AAL system involving AI-enabled, autonomous, and machine learning systems are described in 5.3.2 to provide context and assist potential AAL system developers and operators to understand the ethical considerations and potential questions that can arise. For convenience and consistency, the use cases described in IEC TS 63134 shall be referred to; the use cases are grouped together in this document (although ordered differently) into the same five categories as are given in IEC TS 63134:2020, and IEC TS 63134:2020/AMD1:2022.

These are illustrative examples only and are not all-inclusive by any scope of consideration. See IEC TS 63134:2020 and IEC TS 63134:2020/AMD1:2022 for additional examples of general AAL system use cases.

5.3.2 Health and wellness

a) Personal health check

- Short description: the care recipient wears, or is monitored by, sensors that collect his/her vital signs and transmit these to a monitoring centre. The system uses AI to monitor the incoming data, assessing any changes in ongoing physical or cognitive health or potential concerns, notifying the user and/or physician of these concerns.
- Ethical considerations
 - Respect for autonomy: should the AI system limit the potential movement or other actions of the AAL care recipient due to a decline in abilities? Should government authorities be informed of changes that may impact broader population safety (e.g. flag for suspension of an AAL care recipient's automobile driver's licence)?
 - Diversity, non-discrimination, and fairness: decisions and actions should be consistent for all users, but how do (should?) actions change with decline in cognitive ability?
 - Data privacy: should the AI system warn family members of negative changes? Who should see the care recipient's data beyond the monitoring clinician?
 - Safety: when and under what conditions should the AI system act (e.g. send notifications) to minimize danger/increase safety of the care recipient?
 - Human oversight and control: this should be left to the individual user, if capable, or the monitoring clinician, to decide as to who is informed of the AAL care recipient's personal health information.

b) Advanced medication dispensing and monitoring

- Short description: the AI system controls the dispensing of medication to the care recipient including reminding the user of prescribed medications, tracking that medication has been taken (adherence), and potentially informing others of the level of adherence. The smart dispenser may also provide "on demand" medication such as that to reduce pain.
- Ethical considerations
 - Respect for autonomy: how much control should the AI-enabled system exert over the dispensing of optional medication? Who determines what this threshold is (user? physician? drug company?)
 - Data privacy: who should the AI system warn if the care recipient is not adhering to prescribed medications, or requests too much? When do safety concerns override privacy?
 - Safety: as the care recipient's levels of cognition decline, should the system cease to dispense certain medications? Should it allow the dispensing of a high, potentially dangerous amount of medication? In countries where physician-assisted death is legal, should there be any limit and should this change the AI system's actions?
 - Human oversight and control: the AI system should "be aware" of when safety concerns such as potential overdose occur and not act (dispense additional medication) without approval of the physician or pharmacist overseeing the AI system.

c) Falls detection and notification

- Short description: a system monitors the care recipient within their home and notifies a caregiver or service when the AAL care recipient has fallen. More advanced systems may analyse the data, learn AAL care recipient patterns, and potentially begin to predict a greater likelihood of falls and/or recommend preventive measures such as falls prevention exercises or use of a walker.
- Ethical considerations
 - Respect for autonomy: care recipients have the right to put themselves at risk (although not other persons) even in situations of cognitive decline. For example, society does not limit patients to their beds even if they have a high risk of falling when getting up from bed. The system should not take actions that can impact these rights.
 - Human dignity: should the AI system (if capable) warn the care recipient of potentially risky behaviour?
 - Data privacy: should falls that have no consequences (e.g. injuries, inability to get up) be tracked and reported? If so, to whom? Should changes in mobility that an AI may detect also be reported or could this end up in inappropriate restrictions being placed on the AAL care recipient's mobility within the home?
 - Safety: while caregiver notifications in the case of safety issues (e.g. falls with injury) are expected, how does the AI determine what is a safety issue and what is not?
 - Human oversight and control: it should be left to the individual user if capable, or monitoring clinician, to decide as to who is informed of the AAL care recipient's personal health information. When a human can be kept in the loop (notified of a fall) it is possible that an action such as calling an ambulance or other response will have to be subject to human approval.

5.3.3 Self-management of daily life activities at home

a) Safety monitoring and control of appliances use

- Short description: appliances such as stoves or toasters are monitored to ensure they are used properly and safely, and turned off when not in use.
- Ethical considerations
 - Respect for autonomy: should the monitoring and control system restrict the user from turning on the appliance (e.g., a stove and kettle) if there is chance the user will injure themselves? Is there a threshold of danger?
 - Human dignity: the user should not perceive themselves as being "under the control of" the AI system when all they want to do is make tea!
 - Data privacy: should external caregivers be informed if the AAL care recipient leaves the stovetop or oven turned on? Is there a pattern or threshold where safety concerns override privacy concerns?
 - Safety: what controls should exist to ensure the safety of the user while allowing respect for autonomy and dignity as above?

b) Assistance with eating (cueing)

- Short description: as cognitive ability declines, care recipients often lose interest in eating or drinking. AI-enabled devices, often in human-like form, have been shown to be effective in verbally cueing AAL care recipients to continue to eat their meals.
- Ethical considerations
 - Respect for autonomy: an AAL care recipient should always have the right not to eat even though this may put them at risk. How "forceful" should the AI system be in its efforts to encourage behaviour? Should caregivers be notified if the AAL care recipient continues not to eat or drink?
 - Human dignity: the language that is used in the cueing shall be respectful of the AAL care recipient, not be berating or disrespectful. Furthermore, the AAL care recipient should be fully aware (to the extent to which they are able to understand) that the AI system is not a human even if in human-like form.
 - Diversity, non-discrimination, and fairness: language used in cueing shall be culturally sensitive, which may change in accordance with the background. Also specific diets can be culture-specific, and this should be considered in the creation of the algorithms:

In the context of AAL, there would be specific considerations as to language used and diets in the specific AAL cueing application, even though language is a consideration in all AI applications.
 - Data privacy: what data should be reported to the caregivers?

c) Behaviour monitoring

- Short description: in the early stages of assistance (level 0 or 1) the care recipient's behaviour is monitored and the AI builds an understanding of behaviour patterns, mobility and balance, eating and drinking, security and safety activities (e.g., locking their door), and potentially risky behaviours. It is assumed that this is being done to increase the ability of the AAL care recipient to continue to live on their own in their own home for longer.
- Ethical considerations
 - Respect for autonomy: should the system be able to limit the AAL care recipient's actions (see examples, such as moving or using appliances) or report actions without the permission of the AAL care recipient? Given a sufficient level of cognitive ability, the user should be able to determine what gets controlled and reported.
 - Human dignity: the user should not feel that they are being aggressively monitored and therefore be afraid to act in case the action is reported to the caregiver.

- Diversity, non-discrimination, and fairness: monitoring and system actions shall consider race (e.g. facial recognitions) and cultural background.

The consideration of race in facial recognitions and cultural sensitivity is applicable in all AI applications and hence is not AAL specific, however it should be reinforced in the context of AAL.

- Data privacy: there shall be limits on who can see the behavioural data. Should AAL care recipients' cognition continue to decline, who controls the ability to set data reporting limits?
- Safety: the monitoring system should not present any increased safety issues to the AAL care recipients. Moreover, when can an AI-enabled system determine there is a potential safety issue with the monitored person and take action?
- Human oversight and control: in the context where a system may have control as well as monitoring ability, significant system actions (perhaps excluding time-sensitive safety concerns) should be subject to human review and control.

5.3.4 Social interaction

a) Social interaction via a smart TV

- Short description: an AI-enabled TV set has the ability to establish two-way audio and visual communication between the care recipient and external parties. This will likely be done under voice control (rather than touch). This is not different technically from other devices today, but the TV display and camera will likely be mounted in a prominent position in the AAL care recipient's living space.

– Ethical considerations

- Respect for autonomy: the audio/video connections, initiating or accepting a call, shall be under the control of the user in all (or perhaps only most) cases.
- Human dignity: the system should not automatically enable the camera, leaving it to the control of the AAL care recipient, in case the AAL care recipient is in an inappropriate condition (e.g., improperly dressed).
- Diversity, non-discrimination, and fairness: the system shall allow for different accents in voice control and use of the control language. As ability to clearly speak can decline in AAL care recipients, the system should learn about this decline and react appropriately.

In the context of AAL, while any AI-based voice control application shall consider a variety of accents and choice of language (cultural) and would not be specific to AAL, the declining ability to speak clearly and/or limits to the choice of vocabulary would be very AAL specific (so the example is partly non-AAL specific, but partly AAL specific).

- Data privacy: limits shall be placed on who has access to the call data and this shall only be released under the control of the user. Moreover, the users should have the ability to limit the visual information conveyed (e.g. background and living space), possibly limited by default.
- Safety: could a situation arise when an AI-enabled device might initiate an outbound call, or allow an inbound call to connect, if the AAL care recipient is incapable (like the falls and behavioural monitoring systems above)? In the case of an incoming fraudulent call, should the AI consider the cognitive ability of the AAL care recipient and be allowed to block (audio, video or both) these potential calls?
- Human oversight and control: it may be appropriate to flag certain incoming calls and call patterns (e.g., scam calls, inappropriate telemarketing) to human oversight to allow setting conditions to block these calls in the future to protect this vulnerable population.

b) Social robots

- Short description: the development of robots that provide social interaction is well underway. Social robots engage the care recipient in conversations, observe and try to interpret facial expressions (e.g. emerging anger), and can take human form and have facial expressions of their own.
- Ethical considerations
 - Respect for autonomy: should the AAL care recipient develop emotional attachment to the social robot, who would deem whether this is acceptable? The user should have the autonomy to refuse the use of the robot, or they should be able to refuse that the robot be taken away once introduced.
 - Human dignity: should the AI-enabled system appear to be a human, or should it be made clear that the AAL care recipient is interacting with an AI/robot that only looks human? Would this affect the efficacy of the AAL system?
 - Diversity, non-discrimination, and fairness: social robots should consider the cultural background of the AAL care recipient, languages, and understand facial expressions. Moreover, the system shall ensure that ongoing machine learning does not allow the system to make discriminatory or insulting cultural references irrespective of the interactions with the AAL care recipients.
 - Data privacy: all discussions or other interactions between the AAL care recipient and the social robot shall be kept confidential.
 - Safety: in the case of autonomous robots, the devices shall adhere to all safety protocols and standards associated with human interaction. For conversational robots the use of any therapeutic approaches (e.g. cognitive or behavioural) shall be limited and used only with the knowledge of the AAL care recipient or responsible caregiver.
 - Human oversight and control: the social robots should monitor the interactions/types of interactions and if deemed potentially inappropriate then they should be reviewed by a human. It is possible that changes will need to be made to the system or how it interacts if interactions are deemed inappropriate.

5.3.5 Mobility**a) Smart walker**

- Short description: a wheeled walker not only assists the AAL care recipient with the physical aspects of their mobility but has the capability to understand the AAL care recipient's desired destination and is able to provide directions and lead the individual to that destination.
- Ethical considerations
 - Respect for autonomy: the device should permit the user to select any destination, with very limited restrictions.
 - Human dignity: the device should be able to assist the AAL care recipient if they become lost or confused, learning appropriate ways to gently guide the AAL care recipient to their home or to another known or safe location.
 - Diversity, non-discrimination, and fairness: if a natural language interface is used the system shall deal with accents, specific cultural ways of speaking, and speech deficits. Also, the system should allow for different levels of physical deficiency and limitations to mobility.
 - Data privacy: access to location records and other information on where the AAL care recipient has been, or currently is, shall be restricted, private data. Only an override by a limited number of individual(s) in the case of a potential safety issue should allow this to be unblocked.
 - Safety: the device shall understand the physical capabilities/limitations of the AAL care recipient and not allow them to be put at physical risk (e.g. navigate the AAL care recipient into the middle of a busy street that they cannot cross in time).

- Human oversight and control: should the AAL care recipient request to be taken to a destination that may be unsafe, or the route may be unsafe, the request should be reviewed by a human and approved if appropriate.

b) Wandering detection and diversion (WDD) for persons with dementia

- Short description: in some cases AAL care recipients with dementia are exit seeking and frequently try to leave their residences. Given the outside weather (e.g. extreme cold, every year cases are identified where persons have died after exiting their residences in the winter) or potential for AAL care recipients to get lost, allowing this to happen puts the person at risk. A WDD system may interact with the person to try to dissuade them from exiting (e.g. encourage a return to bed during the night) or failing that to notify a caregiver that the care recipient is trying to (or has) exited the residence.
- Ethical considerations
 - Respect for autonomy: should the system prevent the person from exiting the residence (e.g. automatically lock/prevent unlocking a door)? At how much risk is the person allowed to put themselves should they wish to exit?
 - Human dignity: the system shall consider the dignity of the person when interacting, ensuring it does so in an appropriate manner (e.g. encouraging, rather than using berating or controlling language).
 - Diversity, non-discrimination, and fairness: any systems that depend on facial recognition shall consider racial differences in their development and training data.
 - Data privacy: access to the data collected by the system in its interactions with the person must be controlled. Since, by definition of this use case the person is considered cognitively impaired, data access control shall be provided to the appropriate family caregiver or other substitution maker.
 - Safety: these systems are put in place for safety reasons and should not increase risk to the persons. For example locking the doors to prevent exit may put the AAL care recipient at risk if there is a fire or other appropriate reason for them to exit the premises.
 - Human oversight and control: decisions on exiting may need to be reviewed by a human in some circumstances to balance autonomy and safety of the person.

c) Autonomous vehicles

- Short description: autonomous vehicles may be used by care recipients (without their own vehicles or who have lost the ability to drive) as a convenient means to get to medical appointments, social engagements, or go shopping.
- Ethical considerations
 - Respect for autonomy: in general, the autonomous vehicle should not stop the care recipient from determining their destination. However, certain controls may need to be in place for persons with cognitive impairments (e.g. not allow a destination that is inappropriately hundreds of kilometres away).
 - Human dignity: all interactions between the AAL care recipient and the vehicle shall be courteous and respectful, even if the person requests an inappropriate destination.
 - Diversity, non-discrimination, and fairness: autonomous vehicle AAL services shall be available to all potential AAL care recipients irrespective of race or cultural background.
 - Data privacy: access to ride information (who, where, when, etc.) should be closely controlled. While the vehicle company may require the data for services planning, it should be restricted to deidentified data wherever possible (e.g. to medical appointments at clinics or doctors' offices). Are there situations, e.g. a missing person, where this data should be more easily accessible by the appropriate authorities?

- **Safety:** while respecting AAL care recipient autonomy, the AI-enabled vehicles should not allow AAL care recipients, particularly cognitively incapable AAL care recipients, to put themselves at risk (e.g. exiting the vehicle at an inappropriate location). How can autonomous vehicles ensure this? Is an understanding of the AAL care recipient's cognitive capability a required condition of use?
- **Human oversight and control:** to balance dignity/autonomy and safety, should the AAL care recipient request to be taken to a destination that may be unsafe, or if the route may be unsafe, or the cost incurred potentially be too high, the request should be reviewed by a human and approved only if appropriate.

5.3.6 Prevention and management of chronic conditions

a) Shopping and nutrition planner

- **Short description:** an AAL care recipient living alone can require assistance in managing a healthy diet as well doing their grocery shopping. An AI-enabled assistant will help the AAL care recipient select appropriate meals and related ingredients that are appropriate in the management of a chronic disease (e.g. diet is particularly important to diabetics) as well as ordering and delivery.
- **Ethical considerations**
 - **Respect for autonomy:** while diet management is important, the system should focus on recommendations and not prohibit the ordering of specific foods favoured by the AAL care recipient.
 - **Human dignity:** while alternate recommendations are appropriate, the AI-enabled system should not override AAL care recipients' preferences in choice selection, treating the AAL care recipient as if they are incapable. Conversely, including AI-enabled restrictions or guidelines such as a maximum quantity ordered at one time (or within a short period), are appropriate to ensure the AAL care recipients do not do something they did not intend.
 - **Diversity, non-discrimination and fairness:** there should be no restrictions on food selections based on race or cultural background; in fact, the system should be knowledgeable of specific cultural preferences (e.g. African, western, or Asian foods) and allow these selections as appropriate to the AAL care recipient's dietary needs.
 - **Data privacy:** food selection information should not be made available to advertisers without the expressed consent of the user(s). In addition, decisions about whether to advise the caregivers about diet and food selections must be considered carefully to balance the AAL care recipient's autonomy and privacy against the appropriateness of their selections.
 - **Safety:** there shall be sufficient security in the system so that it does not potentially recommend inappropriate foods. Furthermore, the inclusion of advertisements which can entice users to select inappropriate foods, should be prohibited.
 - **Human oversight and control:** capability should exist for questionable requests to be reviewed by a human while maintaining autonomy and safety. But human imposed restrictions here should be very limited.

b) Disease progression monitoring and notification

- **Short description:** similar to the falls and behaviour monitoring use cases above, this application monitors physiological symptoms appropriate to the care recipient's chronic disease (e.g. blood sugar levels and weight for diabetics; blood oxygen saturation levels for COPD patients, etc.) and sends an alert if there may be adverse events or significant change in disease conditions that may require medical intervention.
- **Ethical considerations**
 - **Respect for autonomy:** the users should have control over who receives any alerts and related data, beyond the patient themselves. For example, while a medical professional such as the family physician might be notified of a potential concern, the user may restrict other family members from seeing measures or notifications
 - **Human dignity:** the monitoring technology shall be non-intrusive and any interactions with the AAL care recipients shall use respectful language.

- Diversity, non-discrimination and fairness: the thresholds and event triggers shall consider different racial backgrounds implying any machine learning training sets must include broad racial examples.
- Data privacy: control over data access by third parties (medical personnel, family members) shall be fully under the control of the user.
- Safety: the monitoring aspects of the system shall not increase the risk to the users (e.g. difficult to use devices).
- Human oversight and control: the monitoring clinician shall remain in the loop and while clinical interventions may be recommended by the AI system (e.g. changes in medication, diet), the final decisions on whether to implement these interventions should be left to the clinician.

5.4 Key requirements for AI-based AAL systems

The use case analysis given in 5.3 identifies key ethical requirements of trustworthy AI in the context of AAL.

Owing to changes in the abilities of AAL care recipients, human agency and autonomy, human dignity, diversity, non-discrimination, and fairness, privacy and data governance, reliability, safety and security, and human oversight and control are key requirements that need AAL specific considerations. These requirements are considered carefully in the process of developing, installing and operating AI-enabled AAL systems.

Table 3 summarizes AAL-specific considerations which provide the key requirements for AI-based AAL systems.

Table 3 – Summary of AAL-specific considerations

Requirement	Specific considerations
Human agency and autonomy	• Does the AAL care recipient have the right to put himself/herself at risk? • Is the system able to limit the AAL care recipient's actions or report actions without the permission of the said AAL care recipient? • How much control should the AI-enabled system exert over the user? • Who determines what the control threshold is?
Human dignity	• Does the user understand that they are being monitored? • Does the user turn on/off the system by himself/herself? • Is the system able to assist the user without the user's permission if his/her abilities are declined/lost? • Does the user understand that the AI system is not a human even if in human-like form? • Is the language used gentle and appropriate in manner? • Should the system warn the user of potentially risky behaviours?
Diversity, non-discrimination, and fairness	• Does the interaction with the system reflect the AAL care recipient's race, religion, culture, and other background? • Does the system understand different accents? • Does the system allow different levels of physical limitations? • Especially, does the system understand an order by voice from the AAL care recipient when he/she loses the ability to speak clearly?

Requirement	Specific considerations
Privacy and data governance	- Are the interactions between the system and the AAL care recipient kept confidential? - Does the system share the AAL care recipient's data to other parties outside of those persons permitted in advance? - When do safety concerns override privacy? Who should share the AAL care recipient's data to other parties, beyond those persons permitted in advance? - Who controls the ability to set data reporting limits when the AAL care recipient's levels of cognition continue to decline?
Reliability, safety and security	- How does the system determine what is a safety issue and what is not? - Does the system prevent the provision of unsafe recommendations to the user? - When and in what conditions does the system act to minimize danger and increase the safety of the user, while allowing for autonomy and human dignity? - Does a physical system such as robot maintain safe interaction with the AAL care recipient?
Human oversight and control	- Do experts such as a physician or pharmacist oversee the system? - Do experts receive immediate emergency notices from the system? - Do experts receive immediate notice from the system when the system malfunctions? - Do experts review the system operation periodically (weekly/monthly)?

However, there is no AAL-specific consideration relating to individual and societal well-being, transparency, and accountability. It is recommended to use ISO/IEC TR 24368 and other documents to review these requirements in the process of developing, installing and operating AI-enabled AAL systems.

5.5 Technical, operational, and governance considerations of AI-based AAL systems

5.5.1 General

AI systems should be technically dependable and reliable in their operation, secure from cybernetic and access controls perspectives, and shall not pose unreasonable safety risks to an AAL care recipient's physical or mental health. This is particularly sensitive in the case of an AAL care recipient who may suffer from physical or cognitive limitations as described in Table 3 and who may not be aware of the impacts of an action by the AI/autonomous system.

The following is a discussion regarding technical and operational considerations, such as privacy, accountability, transparency, and overall system oversight and governance of AI-enabled systems in their use for vulnerable AAL populations. Table 4 summarises the ethical and societal considerations as described in ISO/IEC TR 24368 [5] and AAL requirements have been added which are specific for the AAL context.

NOTE Only specific considerations in the AAL context are highlighted in this document which go beyond the ethical and societal concerns mentioned in ISO/IEC TR 24368.

Table 4 – Relation to ethical and societal considerations described in ISO/IEC TR 24368

Considerations in ISO/IEC TR 24368	Considerations in the context of AAL
Privacy Privacy considerations include the following: 1) are communication mechanisms available to where issues related to privacy can be raised? 2) are any processes in place for end users, or other stakeholders directly or indirectly affected by the AI system, to report experienced privacy concerns? 3) are any processes in place for relevant stakeholders to respond to privacy concerns and to take such feedback into account (when not deemed ungrounded) to improve the AI system? 4) when a user is unwilling to share all data required to buy, rent or otherwise access a service or product, is the user refused the services or products in their entirety or are alternatives offered? 5) how carefully have risks linked with the collection and storage of personal data been assessed? 6) are there any internal data governance mechanisms in place that include traceability of how the personal data was obtained? 7) has the internal data governance and handling of personal data been respected, is the data traceable or re-identifiable? 8) has the need to collect informed consent been properly handled? 9) can the user or other stakeholder fully and similarly exercise its rights on its personal identifiable input data and personal identifiable output data? 10) is the data subject informed about how valid consent is given and if needed, or requested by the data subject, how such consent can be revoked? 11) have applicability of definitions of privacy been assessed and considered/acted upon in the context (sector, geographical area, etc.) where the AI system is being developed and deployed? 12) what data flow and verification capabilities are being provided to ensure that the collected information is used as intended? 13) are there features to support the ability of data subjects to review the presence, relevance and accuracy of personal information collected about them?	Specific considerations in the AAL context highlighted in this document: If an AAL care recipient is not able himself/herself to judge whether or not to use an AAL service, it shall be necessary to obtain the informed consent of the relevant stakeholders such as family members or legal representatives. The following are modified with respect to ISO/IEC TR 24368: NOTE In this document, "AAL user" means "AAL care recipient and relevant stakeholders". Relating to list items 1, 2 and 3 in Column 1 of this Table 4: • Provide communication mechanisms between the AAL user and the AAL service provider so that the AAL user can report experienced privacy concerns. Relating to list items 5, 6, 7 in Column 1: Put in place internal data governance mechanisms that include: • tracing and re-identifying personal data, and • risk assessment linked with the collection and storage of personal data. Relating to list items 8, 9 and 10 in Column 1: • Obtain informed consent that enables the AAL user to fully and similarly exercise its rights on its personal identifiable input data and personal identifiable output data. • The AAL user shall be informed about how valid consent is given, and if needed, how such consent can be revoked.
Accountability Accountability considerations include the following: • is there a nose to tail trail of decisions made in relation to the AI system? Can the AI system be disabled in case of deviation from intended outcomes and be evaluated to predict potential misuse? • is a strategy and process in place for both testing and monitoring that creation or reinforcing bias in data and in algorithms are avoided? • are the implemented algorithms tested with regards to their reliability, correctness and reproducibility and are reliability and correctness measures and reproducibility conditions under control? • how and where will the test methodology, results, and changes based on results be documented?	The following are modified with regards to ISO/IEC TR 24368: • Implement a nose to tail trail of decisions made in relation to the AAL system. The AAL system can be disabled in the event of deviation from intended outcomes and be evaluated to predict potential misuse. • Implement algorithms tested with regards to their reliability, correctness and reproducibility and make sure that correctness measures and reproducibility conditions are under control.

Considerations in ISO/IEC TR 24368	Considerations in the context of AAL
Safety and security Safety and security considerations include the following: - are communication mechanisms available to where issues related to safety and security can be raised? - are there any known safety and security impacts of the AI system in the use of the system or in the event of failure according to its intended functions (i.e. providing wrong results, being unavailable, or used for a task for which it has not been tested)? - what technical measures will be taken to protect any collected data against loss and unauthorized access, destruction, use, modification, and disclosure?	In addition to the considerations and guidelines shown in ISO/IEC TR 24368, this document mentions that: It is necessary to provide higher safety and security measures for AAL care recipients in level 2 and/or level 3 than for level 0 and/or level 1 AAL care recipients. To facilitate the understanding of "higher safety measures", provide references to the documents relating to safety including functional safety standards that SyC AAL is developing.
Transparency and explainability Fairness and non-discrimination Human control of technology Professional responsibility Promotion of human values	Nothing specific to AAL can be found in these considerations and guidelines. It is necessary to mention a potential risk / possible harm to humans, based on the AI system's predictions, recommendations or decisions.
International human rights Respect for international norms of behaviour Community involvement and development Respect for the rule of law Sustainable environment Labour practices	Nothing specific to AAL can be found in these considerations and guidelines.

5.5.2 Technical and operational considerations

These considerations for AAL systems are not significantly different from those proposed for AI and autonomous systems being developed for the broader population. Some additional considerations for technical developers and AAL system operators are listed below.

Security:

- AAL care recipients may have less awareness of when a system is acting inappropriately (e.g. when an inappropriate amount of medication is dispensed, or if an autonomous vehicle is being rerouted). Therefore, security against external intrusion is of extreme importance.
- To avoid potential abuse (e.g. emotional, financial, physical) generated by the system, there shall be strict controls over what external users are authorized to ask the AI system to do. For example, a system that provides financial transaction support, such as purchasing groceries, should not be allowed to order and pay for groceries for other persons; this would be a form of financial abuse.
- Logging of directions and changes by external human operators shall be ensured to be able to trace back any inappropriate actions to the user. This also relates to the issue of accountability outlined below, but focuses on deliberate actions by known external users.

Transparency:

- It shall be made clear to the system users, the AAL care recipients and, more importantly, for their family or designated caregivers, what the AI system can do, where its limitations might be, and what AI systems may be appropriate for the level of assistance required by the AAL care recipient. Caregivers (family or formal) should not have unrealistic expectations of the level of care available from the AI system.
- Furthermore, the users should be able to receive a plain language explanation of why the AI system made a particular system. For cognitively impaired individuals who may question why something is happening or not happening, this explanation shall be very simple and be expressed in appropriate language (something often difficult for even human caregivers to communicate). Conversely, the caregivers and system operators may need a detailed understanding of the rationale that went into a decision of action by the AI system.

Accountability:

- Similar to discussions in IEC 63240-1 and IEC 63240-2, the AI system developer and/or operator shall be accountable for decisions or actions taken by the AI system. Given the vulnerable and fragile nature of the care recipients there is an even greater opportunity for an incident to arise. The requirements of IEC 63240-1 and IEC 63240-2 shall be followed.
- A human should retain ultimate control where appropriate, and be involved in the decision-making process where a clearly safe path or ethically balanced decision is not obvious to the autonomous system.
- In accordance with the transparency consideration above, all actions and decisions should be logged for an appropriate period of time, in case it should be necessary to review and determine accountability (user, developer, operator) for a system action.

5.5.3 Operational governance considerations

As discussed in 5.5.1 and 5.5.2, ethical considerations and technical trustworthiness considerations can be built into the AI-based AAL systems by the developer. Use of appropriate data sets for machine learning (including AAL care recipients across the level of assistance for which a system might be intended), proper attention to algorithm development and testing, and data protection and controls, will go a long way to ensuring proper development.

However, ongoing governance of the AI-based system in operation is also required. Whether the system is largely "static" or in many cases where machine learning systems continue to evolve in terms of operations, there shall be ongoing oversight of the system. Actions and decisions shall be tracked. A determination of whether these are still appropriate shall be made, generally for the broad population of users but also right down to level of whether decisions are appropriate for each individual AAL care recipient should they continue to decline. Operational governance processes and governance bodies (e.g. representatives of the user community, health care ethicist, operating organization representatives) should be established by each AAL system operator.