# Responsible-Industry



Responsible-Industry

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# 1.   Introduction

This deliverable updates the previous report on Horizon Scanning (a) (Flick and Stahl, 2015) (hereafter referred to as D1.4a).  A temporal aspect was envisaged for the Horizon Scanning to ensure that the outcomes of the Responsible-Industry project remain current and addressing the future needs of the sector.

In this report, we re-assess the Primary Signals identified in the previous deliverable, as well as re-running the Weak Signal analysis to ensure that we have covered contemporary discussions around health ICT for ageing. This is important as technologies and innovations move quickly in the sector, and since the previous report we have identified more current thinking through the other activities in the project (e.g. focus groups, case studies), which are worth evaluating against the findings of the first report. These evaluations are found in an analysis of the three final documents (section 4) of the Responsible-Industry project against the Weak Signals identified in section 3. Essentially, what this report aims to do is determine how "future-proof" the outcomes of the Responsible-Industry project are.

# 2.   Update to Primary Signals

In this section, we update our resources that feed into the Primary Signals identified in D1.4a. The methodology is based on Amanatidou et al.  (2012) horizon scanning methodology of identifying primary and Weak Signals. For detailed justification and methodological descriptions please see D1.4a. As a result of the Primary Signal research conducted in D1.4a, we found several major sources of information from funders and large organisations that showed the general trends of the sector.  These funders and organisations were determined to have significant influence in the direction of the sector.

For reference, the previous Primary Signals were as follows (numbers refer to the section in the previous deliverable):
4.1 Definitions of "ageing" and "the elderly"
4.2 Concerns about future ageing technologies
4.3 Assumptions and stereotypes about older people and technology
4.4 Ageing in a wider social context
4.5 Operational issues that may impact RRI in industry of ICT for ageing
4.6 Designing technology for ageing
4.7 Future technologies for ageing societies


In this second round of our Horizon Scanning activity, we opted to include research that has been funded by the European Commission as tests for our Primary Signals. This approach was justified by two main reasons. First, the European Commission typically funds research projects that are innovative in

nature, and use advanced ICTs to help tackle societal problems, both current and future. This therefore shows the forward momentum the European Commission has as a funder of future of health technologies in Europe.

Second, EU-funded projects are typically put forth for funding by a consortium of researchers, public authorities, and/or companies from many different EU countries, encompassing a significant breadth of knowledge across the whole of Europe. This allows us a degree of confidence in the knowledge that the European state-of-the-art in research is captured within our analysis.

CORDIS (Community Research and Development Information Service) is the European Commission's public repository of information on all EU-funded research projects. Here, one can get information regarding a research project itself (aims and objectives, funding, its main results, etc.), as well as content that pertains to success stories, news and events directed to the general public and other stakeholders, and open access publications, prepared by the European Commission. We therefore proceeded with including information from CORDIS, i.e., recently completed and recently funded research projects, as we consider, as explained earlier, such findings to be aligned with the Primary Signal research.

In order to identify health ICT projects, we used the following keywords: 'Healthcare ICT' and 'ICT for ageing', and refined our queries by looking into FP7 and Horizon 2020 programmes, further examining the awarding or completion date (to be within the past 2 years). Further, CORDIS publishes thematic collections of research results (i.e., project outputs) for specialised audiences, such as professionals, and researchers with an interest in specific industries, such healthcare, amongst others. For our particular interests, i.e., ICT for ageing, CORDIS published an overview of e-Health projects, under the title "Research and Innovation in the field of ICT for Health and Wellbeing: an overview" (European Commission, 2016), as well as a report on ICT-focused projects, entitled "Innovative ICT for Independent Living"[1]. The large number of projects meant that we had to further refine our results and assess only those that had a direct or indirect impact on ageing populations, supported ageing in place or ageing well, or used unique approaches. This meant that we were able to address the broad range of research in this area rather than make an exhaustive in-depth study of many similar projects that were funded in the same calls. In addition, our aim for the horizon scanning activity is not to present an exhaustive list of all EU-funded projects that pertain to ICT for the ageing population or healthcare, but rather to provide an illustration of what is currently being funded, in line with the eHealth Action Plan 2020, the EU Policies and Initiatives, and the EU research agenda in general. Therefore, what we describe below is only a part of a snapshot of the many, different, innovative ICT-related projects that the EU has recently funded.

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[1] http://cordis.europa.eu/article/id/400060-independent-living-in-an-ageing-society-through-ict_en.html

Along these lines, our research into the CORDIS repository has shown that EU-funded projects relate both to ICTs that aim to support the ageing population (with or without health issues) and their carers and health professionals (including family, doctors, health visitors, surgeons etc.) who are burdened with treating said patients. In other words, we can see that the European Commission has been and is currently funding ICT-focused projects that are mainly directed at a) health and care management and b) (ICT) innovations within the healthcare context.

As far as **Health and Care Management** is concerned, there seems to be particular interest in helping affected individuals in managing mental health issues and supporting the treatment of management of neurological disorders such as Parkinson's disease and Alzheimer's disease.

For the time being, there are several different ICT-focused projects that are still on-going, such as the NYMPHA-MD (2014-2017)[2], MASTERMIND (2014-2017)[3] and PD_manager (2015-2018)[4], or have been recently concluded, like Dem@Care (2011-2015)[5], NoTremor (2014-2016)[6], and NeuroTREMOR (2012-2015)[7].

With regards to the aforementioned projects, we discuss some of their features that pertain to this deliverable.

**Dem@Care** concentrates on supporting the timely diagnosis, assessment, maintenance and promotion of self-independence of people with dementia, and develops on the basis of "a *multi-parametric closed-loop remote management solution* that affords *adaptive feedback* to the person with dementia"[8]. In turn, any collected data are transmitted back to the healthcare professional/clinician, who can monitor the health status of the affected individual, so that they can proceed with preventive care decision-making. This means that Dem@Care builds inescapably on sensors installed around one's home for monitoring purposes (wearables and/or other portable devices) and that these collect and transmit sensitive data (e.g., physiological activities).

Similarly, **NeuroTREMOR** is focused on the ageing population as it examines a new approach for the study, assessment, and suppression of upper limb tremor, which commonly affects the elderly. Its aim is to personalise tremor treatment for different subgroups of tremor patients, by eventually creating and analysing psychological profiles of pathological tremor patients.

[2] http://www.nympha-md-project.eu/
[3] http://mastermind-project.eu/
[4] http://www.parkinson-manager.eu/
[5] http://www.demcare.eu/
[6] http://notremor.eu/notremor/
[7] http://www.g-nec.com/project_Neurotremor.html
[8] http://www.demcare.eu/

**PD_Manager** concentrates on managing Parkinson's disease, a degenerative, chronic disease which affects one's independent living. This particular project aims at modelling patients', carers' and providers' behaviour, so as to educate these groups about the most relevant therapies and propose simple to use and unobtrusive mobile devices (e.g., smartphone, sensor insole, smart pillbox, wristband with several sensors for acceleration, heart rate, etc.) for the monitoring of pertinent data and symptoms.

**NYMPHA-MD** aims to develop a mobile e-health platform for the support of physicians and patients in treating or identifying time crises that have to do with neurological diseases by monitoring the vital signs of patients. These are fed back to the patients and their physicians with effective and easy-to-read visualizations. This is said to enhance awareness and empowerment, but that it requires some personalisation to fit the profile of the patient.

What all projects have in common (other than receiving funds from the European Commission) is that they are focused on managing the health and care of a patient suffering from chronic, neurological, likely degenerative disease with the help of advanced ICTs. Because these diseases typically affect the elderly (Parkinson's, Alzheimer's, dementia, etc.), these projects are mostly aimed at this part of the population and the management (rather than treatment) of their health.

The other direction has to do with **Innovating within the Healthcare sector**, and the way work is usually carried out by healthcare professionals, carers, which typically includes, for the interests of this report, knowledge sharing and exchange, ICT-based infrastructure for e- and m-Health (used by health professionals), telemedicine/telehealth, and ICT projects for patient empowerment. Projects found within this pool are usually much larger ones: they involve, for example, the development of EU/US Roadmaps for eHealth and the development of common ICT skills of health professionals across the two continents (CAMEI project[9]); or deal with bridging the gap between EU-funded research results and service provision for active and healthy ageing (HAIVISIO project[10]).

This interest in the management of degenerative diseases that mostly affect the elderly has attracted the interest of the academic community as well. Namely, there have been more than a few Call for Papers from highly impactful academic journals from the Information Systems community, such as Management Information Systems Quarterly, for research papers on "[t]he Role of Information Systems and Analytics in Chronic Disease Prevention and Management" [11], including the use of advanced ICTs, online social communities, mobile and/or portable Information Systems and the likes. In our understanding, taking these

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[9] http://www.camei-project.eu/
[10] https://haivisio.eu/
[11] http://www.misq.org/skin/frontend/default/misq/pdf/CurrentCalls/ChronicDisease.pdf

together shows an increasing interest in and awareness of the impact of such conditions on the economy, and the general welfare of societies, since treating chronic neurological diseases can account for up to 86% of health care costs (CDC 2016). Finding ways to address and manage these issues that affect mainly the elderly requires new techniques and creative approaches. These can significantly contribute towards decreasing the overall cost of healthcare, improving the quality of life that elderly people lead, and helping them to integrate themselves better within their societies, if they so wish.

For the purposes of this deliverable, we consider that these findings are pertinent to the following Primary Signals (numbers refer to the previous deliverable D1.4a):

- *4.4 Ageing in a wider social context,* looking at the broader influence and impact of society on these issues, is important for policy-makers and researchers. Bidding for and receiving funds for research and development projects by the European Commission is quite a competitive process, especially over the recent years, as the financial crisis has deepened. Therefore, the research and innovation taking place as part of an EU-funded project suggest that the main themes covered, along with the approach, the instruments developed and the ICTs used, have caught the interest of policy makers.  It also shows that large amounts of money have been invested in furthering research within the particular streams that are related to healthcare and the elderly. For example, according to the Horizon 2020 Work Programme 2016 - 2017 "Health, demographic change and well-being", the Commission doesn't consider proposals requesting contributions of less than 2 million Euros as viable to address the described challenges. In addition, such research and development projects are usually funded after a European-wide call, the latter having been drafted according to EU regulations and laws, a commonly agreed-upon Research Agenda and so forth, which illustrate the vested interest of the government and the funder. Other interested parties though include the tech industry, the healthcare industry, the ageing population itself, and families and carers.
- *4.5 Operational issues which may affect RRI in the industry of ICT for ageing*, by being potential enablers of RRI. The proven interest of the European Commission in Healthcare ICT projects for the support of an ageing population will lead to higher RRI integration in healthcare research and development since, within the context of Horizon 2020 in particular, RRI is identified as a cross-cutting issue that is required to be actively addressed and promoted by projects and consortia. This is seen to be achievable through public engagement, open access, gender equality, ethics management and other integrated actions that are aimed at fostering the general uptake of an RRI approach by all funded projects. Along these lines, we foresee that the EU-funded projects that address RRI, particularly those in industry such as COMPASS[12] and PRISMA[13] , and those that implement RRI, such as those

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[12] http://www.innovation-compass.eu

mentioned above, are in line with the ideal of developing, promoting and supporting activities for the elderly beyond simply living a healthy life, but rather being able to manage their health-related conditions, and living a life that they themselves value. This also illustrates its relevance to Primary Signal *4.6 Designing technology for ageing*, by showing how ICTs can help with the management of health and ageing in place; and finally

- *4.7 Future technologies for ageing societies*. Several Commission-funded projects deal with some quite advanced and sophisticated ICTs that require the collection of sensitive data from patients and carers. These are then transmitted to other parties (physicians, carers etc.), or aim at behavioural changes, or require that devices are carried around and so forth. Such implementations are meant to help the elderly, but can also potentially create or add to future dystopias, where the individual is constantly monitored and tracked, potentially without being aware. The existing information that is currently available shows that there is high interest in such technologies. However, at the same time, the interest coming from the European Commission, which puts a lot of emphasis on the implementation of RRI in such innovation activities, shows that the scale is likely to tip toward potential utopias rather than dystopias, as by definition, such projects need to include in their structure responsible research and innovation features.

The most interesting finding from this review of Primary Signals comes from a report by the World Economic Forum, in which the Forum calls on to different stakeholders to "collectively undertake actions to improve the health and wealth of older adults" through "investment in, and integration of, innovative technologies for health and wealth by financial services institutions" (2016, p. 3). One of the things that are particularly highlighted in the report in order to increase stakeholders' motivation to continuously innovate is the fact that currently life expectancy continues to increase across rich and poor countries and older adults continue to pursue "meaningful activities"; the extent to which the latter happens, depends on the quality of individuals' health and wealth. As employer contributions and societal investments complement individual financial reserves, there is a greater opportunity for these older citizens to take advantage of incorporating technological innovations into their activities, and therefore feeling more integrated into their communities, enhancing their health, and spending their wealth. This contributes directly to the original Primary Signal 4.5 *Operational issues which may affect RRI in the industry of ICT for ageing* as a potential enabler to RRI as they require innovation to aim for the higher ideal of engagement in meaningful activities rather than simply for older people to be healthy and alive. It also feeds into the Primary Signal 4.6 *Designing technology for ageing* as it gives suggestions for ways ICTs can work toward this aim.

The specific ICTs mentioned in the report fall within two main categories and contribute to Primary Signal 4.7 *Future technologies for ageing societies*: those

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[13] http://www.rri-prisma.eu

that support health (wearable sensors, cognitive analytics, and ingestibles for real-time insights into human behaviour and vitals, connected pill bottles for managing medication administration, and robotics for ageing in place) and those that support wealth management (banking algorithms against financial fraud, insurance products for the promotion of cognitive maintenance). These ICTs are said to improve longevity and delay the onset of ageing by promoting physical and mental well-being and helping the older adult to live independently and age in place. As a result, they receive special attention and stakeholders, such as ICT firms, developers, insurance companies and financial institutions are encouraged to invest in them and continue working toward incorporating them in their product and service portfolio.

However, some issues that may impede and slow down innovation have to do with how data are collected and used by insurers, and industry standards that may be conflicting or not cost effective for ICT firms. For example, several insurance companies are nowadays collecting and using data from personalized healthcare ICT so as to develop new products and services. It is however a question as to how these data are treated with respect to privacy concerns and the insurer's responsibility towards the individual, the society and the state, whether they align with regulatory frameworks and codes of conduct, and most importantly the role of informed consent in those cases of individuals with diminished mental capacity due to age or health conditions. In a similar vein, financial institutions are equally collecting data to develop new offerings and are bound by laws, regulations and codes of conduct.

One Primary Signal which has successfully indicated significant change since the last report is the wider social context (4.4). The main change here has been the social context – continued austerity or right-wing populism across parts of Europe and the USA has resulted in significant pressure on healthcare systems due to decreases in funding or politically motivated cuts to specific areas of healthcare funding instead of investment. This will continue to pose challenges for the healthcare sector particularly in terms of the ageing population, and potentially a rise in the use of technological solutions to funding problems. This, however, does not mean the signal itself should change, but that, in fact, the signal is a solid signal that should be watched as a determinant of significant change in the healthcare industry. In the Weak Signals we explore what has happened due to this change in context.

Without being able to see many of these projects' deliberative aspects, it is hard to know whether 4.1 *Definitions of "ageing"* and *"the elderly"* has been a problem for these projects. The European Commission is vague in their use of these terms within the Horizon 2020 context, but it is likely that these are operationalised by projects using stereotypes (4.3). Some of the projects identified are not aimed specifically at older people (e.g. Mastermind, CAMEI), and some focus on the disease rather than the patient (e.g. PD_manager, NoTremor). It may be that there is a movement away from targeting specific demographics of people and concentrating more on the problem to solve. Certainly, dementia and other

neurological disorders can be found in young people as well as older people. We did not find any obvious signals that showed that 4.1 and 4.3 were still problems, though we are limited in that there may just not be data available that can show these problems still exist.

4.2, *Concerns about future ageing technologies*, the projects that involved patient care all include stakeholder testing and evaluation, which is in line with the ethics requirements for the projects. This sort of testing and evaluation can help establish a feedback mechanism that the developers can respond to concerns of the users and other stakeholders, as well as educate them on the usefulness of the technology or otherwise allay their fears. This will continue to be an ongoing requirement for the area of study – if healthcare innovators stop engaging with the public, the public will respond with fear to and distrust of their innovations.

In summary:

| Primary Signal | 2017 signal evidence? | Notes |
|---|---|---|
| **4.1 Definitions of "ageing" and "the elderly"** | Limited | Too-short timescale for this research |
| **4.2 Concerns about future ageing technologies** | Significant | Stakeholder engagement used significantly within European projects |
| **4.3 Assumptions and stereotypes about older people and technology** | Limited | Too-short timescale for this research; requires in-depth reflections by projects on success/failure |
| **4.4 Ageing in a wider social context** | Major | Social context directly affects funding and technological push/pull |
| **4.5 Operational issues that may impact RRI in industry of ICT for ageing** | Limited | European Commission funded projects looked at only – some crossover with industry |
| **4.6 Designing technology for ageing** | Significant | Research and innovation projects often identify new techniques for industry |
| **4.7 Future technologies for ageing societies** | Significant | Looking toward the horizon requires looking at cutting edge research and development |

**Table 1: Summary of Primary Signal research**

4.1 *Definitions of "ageing" and "the elderly":* this is still likely to be relevant but we have no significant data from this round due to the short-scale nature of this repeated research, and the length of funded projects. When the projects research

finish, a retrospective might be able to see if there were problems with the definitions involved.

4.2 *Concerns about future ageing technologies*: this is still highly relevant. New technologies as developed in these projects continue to require stakeholder engagement to ensure viability and practicality, as well as usability and market uptake.

4.3 *Assumptions and stereotypes about older people and technology*: this is connected with 4.1, and is hard to know at this stage of the review. Once again, a retrospective may help with identifying problems in projects that were due to the use of assumptions and stereotypes.

4.4 *Ageing in a wider social context*: the continuation of austerity and cutting of funding is continuing to see the rise of technological solutions to funding problems, such as cutting of costs in public sector healthcare. This is a major signal to watch as the wider social context has significant impact on the development of healthcare ICTs.

4.5 *Operational issues that may impact RRI in industry of ICT for ageing*: RRI is increasingly encouraged in European projects, many of which involve industry partners, and the funding of projects such as COMPASS and PRISMA to further engage industry with RRI activities shows that the Commission is serious about ensuring RRI is embedded into healthcare research and innovation. We would hope that these activities would lower the barriers to RRI uptake across the sector, but this is still a signal to watch, especially as the Commission begins to set out its post-Horizon 2020 plans.

4.6 *Designing technology for ageing*: the best methods for designing technology, especially with vulnerable people involved, continues to be developed. New methods and techniques that come from the research projects within the Commission funding streams eventually make it into industry through spinoffs or financial exploitation of results, so this signal can identify new pathways to potential methods.

4.7 *Future technologies for ageing societies*: cutting edge research done by the Commission funded projects allow for an insight into the next generation of technologies for research. This signal is significant – without looking at the cutting edge, it's hard to extrapolate to the future.


Therefore, these signals are generally satisfactory as general indicators of change, or as long-standing issues that will continue to affect the development of ICTs for health and ageing. We have not identified any other significant factors that are not included in these Primary Signals. Since Primary Signals are supposed to be resistant to change, this is not unexpected. Therefore we believe there is no real update needed for the Primary Signals – the findings here simply further support the existing Primary Signals.

# 3. Weak Signals

## 3.1 Methodology for Identifying Weak Signals

Similarly to the initial horizon scanning report, D1.4a, D1.4b proceeds with a round of searches across social media, technology-focused blogs and news sites, aiming to support the discussion on Weak Signals with up to date evidence on their plausibility. Further, the discussion is complemented by information on EU projects (recently funded or recently completed). Along these lines, Weak Signal searches are based on search terms that have to do with the future of health-related innovations and future ageing technologies. This approach captures potential disruptive technologies, cutting-edge discussions, and societal reactions to breaking news and research, within the scope of the realm carved out by the Primary Signal identification.
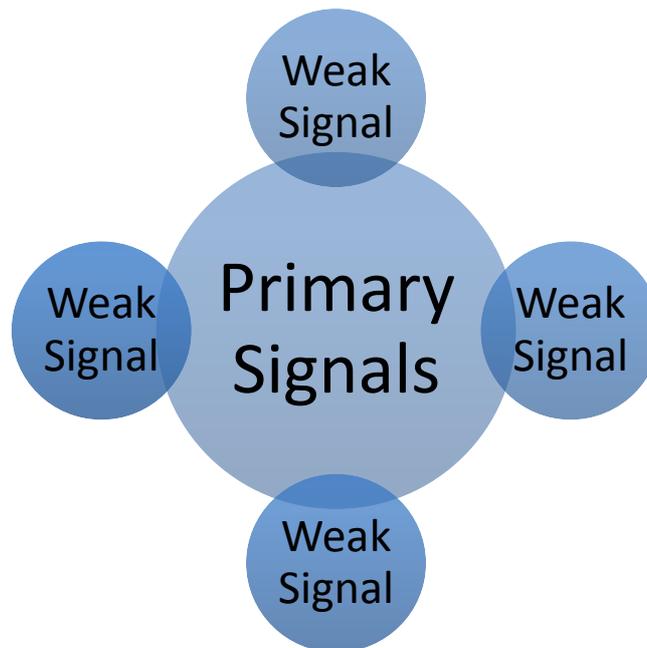


**Figure 1: Relationship between Primary and Weak Signals**

This deliverable is tasked with informing as to whether the discussion surrounding the future of ICT for health and ageing follows the same trajectory as D1.4a and whether the same future representations of technology and the elderly still constitute a concern, or whether the discourse has shifted onto different topics. This means that our queries are focused on the time period following the completion of D1.4a, i.e., May 1, 2015 – January 20, 2017, so as to conduct a follow-up on our earlier research and findings.

### 3.1.1 Search Queries

The same set of search queries has been used for this study as was used for the initial Horizon Scanning D1.4a document. Namely:

**Future technologies**: 'future health technologies' and 'future health innovation'

**Innovation motivation**: 'motivation health innovation' and innovation motivation'

**Future companies**: 'future health companies' and 'future technology companies'

**Future environments**: 'future health environment' and 'future health spaces'

**Future elderly**: 'future ageing'

In many cases, and depending on the search engine (described below), these queries did not bring up many or directly relevant results; therefore, more queries were made (as referenced in the following sections) so as to open up further the discussion and increase our understanding with regards to the audience's understanding on the particular themes. Further, in many cases, as described in the respective sections, the discussion appears to be centred around the same themes and subthemes.

### 3.1.2    Search Engines

**Twitter**
Because of the US election and subsequent inauguration of President Trump, much of the discussion around the future of healthcare and the elderly was politically dominated. However, some discussions on Twitter involved US participants looking to other countries for their healthcare models (the Swedish tax & healthcare models were particularly mentioned) and comparing them to the Affordable Care Act or the bill presented at the time by the Trump administration. There was little discussion of specifics related to the search terms.

**Hacker News**
In many cases, threads in Hacker News simply directed us to an external link with no other meaningful discussion accompanying it. In other instances however, these threads gave us the opportunity to dig deeper into users' comments and find other relevant discussions that can contribute to our understanding. All these are referenced in the footnotes. We also considered the Y Combinator funded projects for the last 3 rounds as Weak Signals as these investment periods tend to be very short and minimal compared with EU or other research and innovation funding. Y Combinator is the investment arm of Hacker News – these projects tend to be discussed in Hacker News.

**The Conversation**

Our search within this website brought up several articles of interest, authored in many instances by academics. While analysing the main articles, we also noted the discussions below them, within the comments section. These are included in the discussion below with appropriate footnotes.

**Reddit**
Our search in Reddit brought up several articles, linking on many occasions to external sources, such as The Guardian website, The Conversation, CNN etc. Also, in more than few occasions, the topics of the articles were being discussed within the subreddits, with the most popular discussions taking place in the subreddit r/futurology and r/HEALTH_TECH. These are appropriately referenced within the footnotes.

## 3.2   Findings

These findings are summarised by topic as a result of the analysis of the data collected during the search. These summaries condense the issues found in the tweets, online discussions, and other sources of Weak Signal data as discussed above. Where specific examples are useful, these are referenced directly.

### 3.2.1   Future Technologies

The healthcare market in 2016 has seen some very sophisticated and innovative ICTs coming out of the labs and promising to support, not just the elderly, but many more age groups, in their everyday activities. Even not particularly advanced ICTs, such as those of remote patient monitoring technology, raise questions that have to do with the transmission of sensitive data, like blood pressure, heart rate and the like, with the aim of allowing health care professionals to monitor and diagnose remotely-located patients. These questions have been detected by our previous research for D1.4a and seem to remain pertinent; would the collection and transmission of such data be an invasion of one's privacy or would detecting a critical condition before it escalated justify it? Such questions require an answer and make informed consent and the design of security around such implementations even more critical as health care ICT becomes more advanced and sophisticated. Following up on monitoring and diagnosing devices, for example, there is an on-going project for the development within this year (2017) of a wireless, portable device that helps individuals to monitor and self-diagnose their health condition, just like the Tricorder in Star Trek, by capturing their own vital signs without the intermediation of a health professional[14]. However, as comments reveal, there is an interest sparked by the shift "from the patient-centric to the user-centric", which raises the question as to "how cyber security will evolve as patients slowly become stewards of their own medical data"[15]. In addition, should health

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[14] https://getreferralmd.com/2016/01/healthcare-technology-2016/
[15] http://disq.us/p/1drs2ev

professionals be removed from the process and patients become able to self-diagnose their condition without medical training, it may leave room for misdiagnoses and heavy reliance on the technology that could have negative impact on the patient's health and condition rather than on professional diagnoses and treatement.

Another innovation that may raise further concerns regarding the removal of the health professional (nurses in this case) from the healthcare process is that of robots and other assistive hardware. For example, there are today fully developed robots that assist nurses with lifting and turning patients [16]. One of the basic premises behind developing such ICTs is that far too often nurses can get severely injured while attending to their patients or that they cannot do so on their own due to various circumstances, such as staff shortages or funding cuts.

Robots and similar assistive hardware have been present within hospitals and healthcare environments for quite a while as on some occasions they can deliver patient care with higher levels of safety and efficiency that their human counterparts. The questions that rise from this discussion are whether the process of dehumanising medicine has started and whether the implementation of future technologies within the healthcare setting will lead to a "robot-factory hospital". This future depicts requirements for doctors and nurses to hold programming skills, and presents an overall uncertainty as to "who do you sue if your medical treatment goes tragically wrong and no human has touched you?"[17]. In this article[18], an interesting discussion ignited in the comments area, where commenters touched upon several different issues, ranging from an error-free hospital to "protocol fatigue" and the continuous development desire. Indeed, a robot or AI-driven hospital could potentially lead to hospitals with an improved "track record" as ICTs (robots, AI, etc.) would be operating based on strict protocols which are often obstacles to health practitioners' profession themselves: "These protocols are usually not followed because human hospital staff have so many new protocols and guidelines to read that they get fatigued and are not able to recognize which ones should change their practice and which ones are financially driven. So they usually ignore them all. Not because they are "bad" or "lazy" clinicians, but because the sheer volume of new policy and procedures makes them give up and revert back to the information they found important from their own practice."[19] However, commenters underlined that such ICTs would need again human intervention for updates, maintenance etc., while they would most probably lack the desire to improve constantly their practice (like most healthcare workers do).

Drawing from the discussion on robots for healthcare and robo-nurses, there were a few warnings on their widespread use, particularly within the reddit

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[16] E.g., http://rtc.nagoya.riken.jp/RIBA/index-e.html
[17] https://getreferralmd.com/2016/01/healthcare-technology-2016/
[18] http://theconversation.com/robots-in-health-care-could-lead-to-a-doctorless-hospital-54316
[19] ibid.

community. Within the short sci-fi stories subreddit, a user posted a short story about a technophobe, named Gerald, who kept refusing to get bone strengthening pills or use a hover chair, so eventually his children got him a robotic nurse[20]. Its operation was based on Asimov's "Three Laws of Robotics"[21], which suggested that the robo-nurse should not let any human come to harm. Due to his fragile state, one day Gerald fell off the staircase, which caused the robo-nurse to saw off his legs and give him prosthetic limbs so as to avoid future accidents. While this was a sci-fi story, exploiting edge cases of Asimov's Laws, it certainly reflects back on how well-being, critical conditions and prevention may be interpreted within the context of AI-supported health care. While the author saw robo-nurses as the future of medical treatment, and perhaps found it interesting to have "cool robot arms"[22], other commenters voiced their concerns, hoping "this doesn't happen in the future"[23]. Around the theme of robotic nurses that can lift and carry comatose patients, paraplegic, quadriplegic patients, elderly, obese patients etc.[24] or simply walk around a hospital's emergency department and quickly diagnose critical conditions[25], Redditors highlighted that a human-like robot may help patients feel less overwhelmed and in any case it will help in those situations when being unconscious or feeling unsteady may cause additional problems[26]. However, others mentioned that being diagnosed in an emergency department by a robot rather than by a person may lead to significant time savings, but poses the risk of the patient feeling threatened, overwhelmed etc.[27]; in other words, it brings the discussion into what was mentioned earlier as a humanless hospital, and the risks of missing human interaction.

One other theme that came up within the Reddit community had to do with people's attitudes toward health data logging and the field that has developed

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[20]
https://www.reddit.com/r/shortscifistories/comments/4enk05/robonursethe_future_of_medical_treatment/

[21] http://www.auburn.edu/~vestmon/robotics.html

[22]
https://www.reddit.com/r/shortscifistories/comments/4enk05/robonursethe_future_of_medical_treatment/d24thpv/

[23]
https://www.reddit.com/r/shortscifistories/comments/4enk05/robonursethe_future_of_medical_treatment/d222aft/

[24]
https://www.reddit.com/r/Automate/comments/3h5mkv/robotic_nurse_lifts_and_carries_a_person/

[25]
https://www.reddit.com/r/saskatoon/comments/24v3vn/robotic_nurse_patrick_joins_emergency_staff_at_ruh/

[26]
https://www.reddit.com/r/Automate/comments/3h5mkv/robotic_nurse_lifts_and_carries_a_person/cu4qj29/

[27]
https://www.reddit.com/r/saskatoon/comments/24v3vn/robotic_nurse_patrick_joins_emergency_staff_at_ruh/chayb75/

around the respective ICTs. What commenters highlight is that, many of us are living today in homes that have "smart" elements to them, such as smart meters, TVs, thermostats, health monitors, smartphones, etc., but we do not take advantage of ICTs' full potential, because we often forget to charge, pair, or sync them. In a sense, these commenters argue, this is the reason for not having a superior healthcare service – it's "too much of a hassle"[28]. However, in their opinion, futuristic health logging requires that companies need to lay out the connected technologies that will make it possible, including mastering image recognition, making smart health logging 100% fully automatic[29]. Some Y Combinator investments have been made in this direction, with health data companies funded in 2016 and 2017 such as PatientBank[30] and BloomAPI[31].

Wearable ICTs have been around for quite a while, typically in the form of wearable fitness wristbands, watches etc. However, today there are prototype electronic tattoos, which are said to be able to sense one's vital signs. Further scaling this technology down, it may be possible to create implants or even inject sensors within the body, quickly capturing rich, invaluable data from within. Evidently, such and ICT can give rise to further application areas (post surgery recovery, monitoring of organ functions etc.). Understandably, such a technology is highly intrusive and encompasses increased risk with regards to data collection, data transmission and data processing (what is being collected, more or less than the absolute necessary, what sort of security is used for the transmission, what happens if the technology breaks down etc.) (Prodromakis 2016).

Finally, one of the themes that drew attention was that of bioengineering and "organ-on-a-chip", where it is posited that it is not long until a human organ can be developed fully in a chip. Such advances would reduce the clinical trials cycles by providing more reliable results and speed up significantly the time to market for new and potentially improved drugs (i.e., being life saving). These organs-on-a-chip are basically made out of some synthetic material, about the size of a smartphone, and they carry minute structures to which cultured human cells are attached. Under appropriate conditions, the cells arrange themselves and operate as they would in the human body [32]. This technological advancement guided the discussion along many different dimensions. Commentators highlighted the need to continue with drugs trials on both animal and human subjects since no organ-on-a-chip can fully mimic all absorption, distribution, metabolism, excretion processes happening within a living organism[33]. Others,

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[28] https://www.reddit.com/r/Futurology/comments/55azej/the_future_of_health_data_logging/
[29] ibid.
[30] https://techcrunch.com/2016/08/23/yc-demo-day/
[31] https://techcrunch.com/2017/03/20/yc-demo-day-winter-2017/
[32] https://www.reddit.com/r/Futurology/comments/39kdtr/towards_a_bodyonachipthe_first_organ_chips_are/
[33] https://www.reddit.com/r/tech/comments/3at6h2/the_end_of_animal_testing_humanorgansonchips_win/csgfb6i/

linking this theme with that of robotics and robo-nurses, expressed that while "some of the recent DARPA robotics are impressive for what they are […] eventually we'll begin to design biological machines."[34] Unexpectedly, other commenters voiced a concern whether drug trials on human subjects would stop as a result of this technology because "[v]olunteering as a human lab rat" is a source of income for some[35].

Blockchain technology is a cutting edge method for transactional verification that is being implemented in finance (such as Bitcoin), shipping, diamonds, document management and other areas that require audit trails and verifiable ledgers[36]. Healthcare is an emerging field that this technology is being applied to, with the idea to be able to verify patient records and provide an audit trail of access. Although the technology has been around since 2008 (as the basis for Bitcoin) (Nakamoto 2008), it is only recently being looked at for more traditional sectors such as healthcare (Tierion 2016), particularly within the context of data exchange and record keeping (Rizzo 2016).

As a closing remark, many are trying to predict hype cycles, time to market and when future technologies, particularly those that can be used within the healthcare sector, will be successfully fully deployed in commercial applications. For example, some predict that within the next 5 years or so, social virtual reality can be fully commercialised[37], while others suggest that "[a]ging and age related diseases [will be] stopped by 2042"[38], highlighting that depending on computing power, success with artificial intelligence etc., "anti aging could be just around the corner [and] seems more plausible"[39].

### 3.2.2    Innovation Motivation

Reddit discussions on future technologies in relation to how companies can keep on being motivated and successful in innovating also seemed to emerge out of futuristic movies and TV shows, but concentrating around the fact that there is a

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https://www.reddit.com/r/Futurology/comments/3axhda/silicon_chips_that_mimic_the_function_of_living/cshjfrq/

35
https://www.reddit.com/r/Futurology/comments/39kdtr/towards_a_bodyonachipthe_first_organ_chips_are/cs49xc8/

36 http://www.bbc.co.uk/news/business-35370304

37
https://www.reddit.com/r/TMBR/comments/5ojlsk/i_believe_were_going_to_see_some_very_big/dcoawtg/

38
https://www.reddit.com/r/Futurology/comments/5leqt9/5_10_25_50_and_100_year_predictions/dbv5avy/

39
https://www.reddit.com/r/Futurology/comments/5leqt9/5_10_25_50_and_100_year_predictions/dbv9qzk/

need for funding such innovation activities, and supplying these companies with highly qualified researchers[40].

The election of President Trump also motivated innovation significantly in terms of seeing companies attempt to predict the gaps in healthcare that would arise if the Affordable Care Act ("Obamacare") were to be repealed, and a less accessible health care bill put in place. This has led to investment companies such as Y Combinator (the investment arm of Hacker News) to invest in healthcare technologies[41,42,43,44,45,46], particularly in US healthcare settings for doctor payments and communication, but also in terms of cancer diagnosis, fitness trackers and wearable personal trainers, mental health communications, electrostimulation for incontinence, and health technology initiatives in developing countries. These are considered Weak Signals because startups tend to be invested in as short term opportunities rather than longer term projects such as EU projects – and they feed into the Hacker News conversations on the topic. Overall, however, innovation motivation tends to come from restrictions of activities at a federal level, so the election of  Donald Trump could well see private companies such as these startups attempting to plug gaps in research and development funding that have been cut off by the government.  These US-based projects are also worth looking at because cutting-edge technology developed within the US often finds itself in the EU market in some form.

### 3.2.3    Future Companies

An interesting discussion in the Reddit community brought together healthcare and cryptocurrencies, within the context of developing a new start up company. While an entrepreneur-Redditor was seeking comments and opinions, they shared their team's vision of this new company, where the aim was to create a marketplace where users could get paid in cryptocurrencies for sharing their healthy choices. Other stakeholders (e.g., insurance companies and employers) would be strategic partners by exchanging the generating cryptocurrencies for money in the way of monthly payments, so as to provide incentives for a healthier lifestyle[47]. Commenters discussed how there is a need for such companies to exhibit that they care about a healthy or healthier society, and that rather than involving just insurance companies, universities and local shops could also participate in such schemes, but that probably "the only people who

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https://www.reddit.com/r/Futurology/comments/5gvls0/westworlds_future_of_artificial_intelligence_is/

[41] https://techcrunch.com/2016/03/22/y-combinator-demo-day-winter-2016/

[42] https://techcrunch.com/2016/03/23/y-combinator-winter-2016/

[43] https://techcrunch.com/2016/08/22/y-combinator-demo-day-summer-2016/

[44] https://techcrunch.com/2016/08/23/yc-demo-day/

[45] https://techcrunch.com/2017/03/20/yc-demo-day-winter-2017/

[46] https://techcrunch.com/2017/03/21/demo-day-y-combinator/

47

https://www.reddit.com/r/Anarcho_Capitalism/comments/334jdx/i_need_help_on_a_startup_idea/

would buy would be large corporations who have a financial incentive to keep workers healthy (not taking sick leave)"[48].

Other discussions were concentrating on how firms and organisations will operate their business processes as ICTs become more and more embedded into them. For example, one Redditor created an entry titled "In the future, companies will advertise the fact that they have human workers."[49] To this, other commenters highlighted that some companies actually already advertise themselves as such, offering examples where humans roll up baby diapers and pack them rather than machines, and commenting that it is more about quality matters rather than business ethics [50]. However, other commenters responded with sarcasm: "Our employees are completely organic. In addition to their role in the company, they also perform biological functions." [51] On the other hand, an issue that concerns users is that, in the future, people might be able to build ICTs (machines, robots etc.), that can be so efficient that any human-made product may be regarded as being possibly defective or of a poorer quality and that therefore, advertising the existence of humans within any organisation will not be on the basis of highlighting the quality of their products or services[52]. Instead it may be based on human welfare or charity.

### 3.2.4    Future Environments

Following from our previous work on D1.4a, it seems that the focus remains largely the same around the theme of future environments. Namely, the most significant signal derives from age-related structural changes taking place over the recent years: a better quality of life, advances in health care and a steep decline in birth rates across the globe (Yakita 2017), continues to give rise to an increasingly ageing population. A recent report (2016), issued by the UK Government Office for Science, titled "Future of an Ageing Population" (Government Office for Science 2016), has sparked the interest of the Centre for

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[48]

https://www.reddit.com/r/Anarcho_Capitalism/comments/334jdx/i_need_help_on_a_startup_idea/cqhobce/

[49]

https://www.reddit.com/r/Showerthoughts/comments/5t55hk/in_the_future_companies_will_advertise_the_fact/

[50]

https://www.reddit.com/r/Showerthoughts/comments/5t55hk/in_the_future_companies_will_advertise_the_fact/ddkeing/

[51]

https://www.reddit.com/r/Showerthoughts/comments/5t55hk/in_the_future_companies_will_advertise_the_fact/ddkp7oz/

[52]

https://www.reddit.com/r/Showerthoughts/comments/5t55hk/in_the_future_companies_will_advertise_the_fact/ddktvf8/

Ageing Better's CEO Anna Dixon[53] and that of several commenters in the Futurology subreddit[54].

Mrs Dixon, in her article, titled "The future of an ageing population needs a response today"[55], points to some interesting facts and findings of the aforementioned UK report. For instance, one of the most important topics highlighted is that the demographic changes currently happening, require an urgent response as an ageing population suggests that other aspects are also changing; for example how people work, how, when and what they learn, the environments in which they live and work, the health and social care infrastructures they (need to) access and the ICTs they (need to) use. Ultimately, how these issues are addressed – or not – will affect and impact on whether today's and tomorrow's elderly will be excluded or included in future communities.

Reddit commenters discussing the report highlight some interesting ideas and draw comparisons between the UK reality and those of other countries, like Italy, France and Japan, which have already experienced negative impact due to their ageing population. In these countries, while ICTs can help with supporting ageing in place, healthy living, managing chronic diseases etc., they can only be as good as the context within which they are used, and how other economical factors can or will be tackled: "Oh, you mean medical widgets. Try that, too, but the issue is economic, not biological as even if you get the widgets the aged will have to pay for them. If you think that ageing will be solved with a cheap magic bullet, read into the biology." [56]. Among these commenters, there are others who are quite optimistic about the future and see possible a more advanced, highly ICT-reliant, ageing in place: "technology will solve this issue. first services will become cheap or even free. AI and robots will take care of elders. after that 150 will become the new 25. those who live long enough to see 2030 will become the oldest of the new immortal cyborg race. to be clear, I'm being serious"[57], to which a commenter responded by saying: "And if "ifs" and "buts" were candy and nuts, we would all have a merry Christmas. Don't talk about "technology" the way

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[53] https://futureofageing.blog.gov.uk/2016/09/27/future-of-ageing-needs-response-today/
[54]

https://www.reddit.com/r/Futurology/comments/5iuekf/the_future_of_an_ageing_population_needs_a/
[55]

https://www.reddit.com/r/Futurology/comments/5iuekf/the_future_of_an_ageing_population_needs_a/
[56]

https://www.reddit.com/r/Futurology/comments/5iuekf/the_future_of_an_ageing_population_needs_a/dbb85hx/
[57]

https://www.reddit.com/r/Futurology/comments/5iuekf/the_future_of_an_ageing_population_needs_a/dbb9dck/

fundamentalists talk about "God". "Lord Jesus gon fix everything wen we git raptured"."[58]

This gives rise to two types of concerns, which can be seen as either contradictory or complementary in a way. First, it may be the case that some people put too much faith in ICTs to solve current, but most importantly, future problems. However, as is the case with age-related structural problems of any given society/community, future environments require a more fundamental, top-down approach, involving policy makers, governments and other high-level stakeholders, in order to create spaces where the ageing population can experience equal opportunities, healthy living and so forth. Second, inspired by that, or as a response to that, a segment of the population appears to be rather pessimistic or at perhaps unconvinced that ICTs can solve such issues, and therefore whether they can be used to create future environments where the elderly can be cared for, age well, and enjoy themselves.

With regards to the theme of mortality, or immortality, this remains an interesting discussion topic for commenters, following from our previous deliverable, although it now appears to take a different turn. In our previous deliverable, we highlighted that users are concerned about (their) online social media accounts, and how these could be potentially managed beyond their death, creating a false concept of presence of the departed/deceased. In this second round, we found that the theme of (im)mortality remains pertinent, but now commenters begun considering how ICTs and medical advances can potentially be used for indefinitely prolonging people's lives. In an article titled "I wonder if humans in the distant future will look at aging in the same way that we look at smallpox, dysentery, and measles."[59], the highest rated comment is one that reads "Did you hear? He died of aging! Oh my gosh... I don't understand why mothers won't vaccinate their children against such preventable diseases."[60]

Drawing comparisons between this statement and known, preventable diseases of today, ageing is compared here to measles, tetanus, poliomyelitis and the likes. Some of these preventable but highly communicable diseases have a huge social and economic impact on the society and an equally grave impact on the affected individuals and families, but thanks to medical advances, vaccines are now nearly eradicated world-wide (e.g., smallpox, poliomyelitis)[61].

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[58] https://www.reddit.com/r/Futurology/comments/5iuekf/the_future_of_an_ageing_population_needs_a/dbf8lhk/

[59] https://www.reddit.com/r/Showerthoughts/comments/4fypk5/i_wonder_if_humans_in_the_distant_future_will/

[60] https://www.reddit.com/r/Showerthoughts/comments/4fypk5/i_wonder_if_humans_in_the_distant_future_will/d2d3ll5/

[61] http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-communic-vpd.htm

Although vaccinations remain controversial in some parts of society (following the autism/vaccine debacle), it is plausible for people to think that in a distant future, ageing could be eradicated. Together with this, the accompanying economic, personal and societal impact could also be diminished. However, whether this would be desirable or feasible is a different discussion, and some users do highlight some of the negative aspects of such a future environment. For example, a user suggests that "It would suck if immortality is developed anytime soon - it would probably only be available for the ultra wealthy and powerful. Ideology is hard enough to change even when the entire population is replaced every ~100 years or so. Now imagine the wealthiest and most powerful humans never dying - and therefore their worldviews will never die either - sounds like some sci-fi dystopia to me."[62] Similarly, another commenter warns "Pray that doesn't happen, or else we would have an Overpopulation problem"[63]. In short, while futurologists do like the idea of prolonged longevity, of immortality and the many, different possibilities of the high-tech future, at least on a conceptual basis, they do acknowledge that should ICTs and medicine allow for this, then there would be significant concerns: overpopulation, the welfare of populations, particularly of the elderly, who would be those with or in power (political and economical) and able to access 'immortality', as they would be able to control eventually the dominant ideology of future environments – and ultimately control everything else.

One article in The Conversation on "[h]ow new technologies are shaking up health care"[64] (Usherwood 2015), discussed that health apps, broadband internet, bio-sensitive wearable technologies, home-based sensors, point-of-care testing, and smart dispensers, among others, help in making possible "[a] changing world"[65]. Within these future environments, these advances make possible the asynchronous communication between patient and clinician, unless a face-to-face interaction is required (in case of e.g., surgery), where the clinician is guiding the patient's decision-making process and facilitating their condition's management. Effectively, as the author suggests, ICTs collapse time and space, making possible the delivery of healthcare anytime, anywhere. In the comments section, commenters are less optimistic and rather conservative regarding rolling out such applications, as they could potentially dehumanise healthcare: "I don't know? Maybe? Depends on what the motivations are for it I would say. You want it to become a clinical 'health industry'? Where we are the 'consumers' of diagnostic tools, interlaced by a screen and a human voice? I don't want that, and I doubt anyone ill would feel comforted by it too. A world where only the rich can

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[62]
https://www.reddit.com/r/Showerthoughts/comments/4fypk5/i_wonder_if_humans_in_the_distant_future_will/d2dkv5e/
[63]
https://www.reddit.com/r/Showerthoughts/comments/4fypk5/i_wonder_if_humans_in_the_distant_future_will/d2d33ge/
[64] http://theconversation.com/how-new-technologies-are-shaking-up-health-care-42318
[65] ibid.

afford a humanized healthcare, the rest of us left to the diagnostics by machines and remote? A cheaper way perhaps, but one lacking empathy, human intuition and intelligence."[66] However, one commenter, a researcher himself, links these ICTs to the Internet of Things, suggesting the possibility of new machine-to-machine (M2M) applications, whereby data gathered from one's mobile device are sent automatically to a data centre for processing, such as in the case of mapping the spread of an infectious disease.

Another article commented that "[r]obots in health care could lead to a doctorless hospital" and asked the question of whether "the new hospitals being built now [are] ready for a robotic future?" (Jaiprakash et al. 2016). While much attention is being paid to whether robots can perform better, worse or equally well to their human counterparts, whether when a patient faced with the choice would choose to be treated by the robot or the nurse, and whether there is in fact room for a robot within the health care industry, less attention is paid to whether the hospitals, as physical spaces, are ready to accept robots. The discussion seems to revolve around the concept of "focused factories", where new hospitals tend to be highly specialised for particular procedures, and therefore the entire workflow is highly streamlined and designed around these procedures, often borrowing ideas from the lean processing field.

### 3.2.5    Future Elderly

One of the most interesting findings about what the future of elderly people might look like derives from one article published in The Conversation. The article discusses that the teenagers of the past, those who used to play arcade video games like Pac-Man and the likes, are now getting ready to step into their retirement years. But it further highlights that many of these teenagers of the 80s (and possibly 90s) have never really stopped playing video games, but rather they perhaps changed into a different form of a gamer (De Schutter 2016). While the older-age gamer population is indeed not as large as high school, college and university students, studies have found that, in Europe in 2012, 27% of people between 55 and 64 played video games (ISFE 2012), in Australia in 2015, 41% of people between 65 and 74 played video games (Brand and Todhunter 2015), and that in the USA in 2015, 27% of gamers were over 50 (ESA 2015).

This suggests that, fast-forward some years, the future elderly are likely to be experienced gamers, which may have significant health outcomes: they may remain engaged in some enjoyable activities, remain sharp mentally-wise, be part of a wider, online-community in some cases and so forth. After all, there is evidence that there are many benefits in playing video games, such as social

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[66] ibid.

connectedness[67], cognitive function (Stanmore et al., 2017), etc., all of which could be beneficial to the elderly.

This article attracted some interest, as is evident from the comments section. One commenter, being involved in this scene, mentions that "it seems that many older adults are still afraid of the "digital world"", which sparks a quite lengthy response from another user, who is an older adult herself. She highlights that for some senior citizens, not playing video games should not be interpreted as them being ""afraid" of the "digital world"", but it may be the case that it is simply not equally rewarding or challenging enough. She goes on discussing that "instead of playing video games (which keep me sitting down, inside, staring at a screen and on a keyboard or game joystick) I prefer to be outside, bicycling or hiking. If you don't think that riding a mountain bike at my age challenges the brain and body..you're wrong. (…) Moreover, I've been involved with computers since the late 1960s, when I was a systems analyst/programmer in the military (were you even born yet?) I've had my own computer for over 30 years (mine, not the family computer.) I don't know anyone my age who is "afraid of the digital world." We're often frustrated by badly designed interfaces, and annoyed by people who see gray hair and glasses and think "doesn't know anything" (looking at you, certain computer stores!) but it's not fear." This particular comment feeds into the reality that affects older adults, i.e. several of today's or tomorrow's ICTs are not designed for them or with them in mind, but they rather target an entirely different user group.

Finally, as suspected initially, today's and tomorrow's older adults continue on working beyond their 60s. Today, it is forecasted that, in 2024, 40% of US men aged 65-69 and 17% of men aged 75-79 will be still in the workforce. In the UK there is a similar outlook, where men aged 65-69, in 2014, participated in the workforce by 24.2%. Such figures suggest that not only will tomorrow's older adults remain active and keep on contributing in their societies, but, most importantly, they will not be dependent on others, at least not for as much as in the past (Scherbov and Sanderson 2016). In turn, this means that a country's economy will not have to sustain as many non-workers as originally predicted (old age dependency ratio). Also, this suggests that the healthcare sector most probably will not have to take up this additional pressure, since, evidently, older adults are in a much better condition, both physically and mentally, since they are able to remain within the workforce.

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[67] https://heritageliveincare.co.uk/blog/health-benefits-for-elderly-gamers/

# 4. Evaluation

We have shown in this report that there are ongoing, engaged public conversations about future possibilities within the public realm. However, we need to consider whether and how the Responsible-Industry implementation plan responds to, allows for, or incorporates these discussions. This section looks at the aspirational (4.1) guidance (4.2) and policy (4.3) final implementation documents and analyses the output against the findings of this report. In this section we see how the RRI practices set out in these documents can be understood in the context of the Primary and Weak Signals.

## 4.1 Benefits of Responsible Research and Innovation in ICT for an Ageing Society

This document rightly identifies that there is an increasing market share and interest from the public in healthcare technologies (Responsible Industry Consortium 2017a, p. 4). It also rightly identifies the increase in focus on RRI-related activities from an EU funding perspective (ibid., p. 4).
The case study of Evondos Oy (ibid., p. 5) shows an emergent ICT healthcare system that lies firmly in the realm of smart technologies that allow for ageing in place – providing medication dispensing for patients who are living at home and/or who have dementia-related illnesses. It also shows that Evondos Oy has taken the initiative of understanding the context into which this technology might be placed by sending technical designers to the places where it is envisaged taht the technology will be deployed. Similarly, the Dutch smart meter case study (ibid., p. 7) is a set of much older technologies, but shows that the same concerns surrounding privacy are relevant today – and that not carrying out RRI activities can have significant negative impact on a company. This echoes the concern users had for some of the new technologies depicted in the Weak Signals.

Many of the technologies that have been mentioned in the Primary Signals have been raised in the report (ibid., p. 6), but those in the Weak Signals tend to be more advanced than the identified potential areas for technological innovation in the report. For example, brain-computer interfaces are mentioned, but only in the context of vital sign monitoring, whereas the conversations have moved on to "organs on a chip". Robotics is also mentioned, but the detail is minimal: it seems that the classic care robots are implied here and not some of the more advanced visions of dystopian decision-making.

The Key Performance Indicators on page 9 allow companies to identify methods for measurement of RRI activity. As found in the Future Companies Weak Signal, increased transparency of companies, their hiring practices, and their engagement with society and the environment will be the future in a highly

technologically-enabled society. The KPIs, however, ought to be grounded in higher level organisational theory, but also flexible in order to accommodate current thinking and expectations of technology.

Overall, this document is an inspirational document aimed at CEOs and MDs that accurately reflects the benefits of enacting RRI principles as well as the potential issues that could be experienced if this is not done. The concerns raised here are generally applicable to the technologies and aspects discussed at the cutting edge, but likewise show how quickly technologies move on. However, this is not necessarily a problem, as the underlying principles of RRI contained in this framework document (as well as the guidance document discussed next) continue to be relevant to these identified Weak Signal technologies, contexts, and concerns.

## 4.2    Guide for the implementation of Responsible Research and Innovation (RRI) in the industrial context

The Guide (Responsible Industry Consortium 2017b) is aimed at senior executives, project managers, or those able to enact RRI principles within their companies. It provides little context other than the potential benefits of RRI activities, and mostly revolves around business practices and value chains where RRI can be of use. Certainly, according to the Weak Signal research, there is a desire for societal expectations to be met that is reflected in the Guide (ibid., p. 7). Although the list of technologies on p. 7 may have been current when the Delphi study was run, some remain currently on the cutting edge (brain-computer interfaces), but technologies that collect, store, and analyse data are likely to be ongoing innovations as highlighted by the Weak Signal analysis. Equally, the list of social and ethical issues on p. 7 contains some issues that were found within the Weak Signal analysis. Concerns about bodily integrity and dignity (as with the discussions on future dystopian robots), authenticity and identity (also with the discussions on robots and future robot hospitals), safety (organs on chips), and other social expectations about the benefits that health innovations might provide are similar to those on the Guide's list.

The framework itself is not particularly assessable against the horizon scanning approach, as this is more suited to the context of the framework, and the general values and methods it involves, but there are some aspects that can be compared to the scanning activity that we carried out in this report. For instance, the lack of resources discussed on page 12 of the Guide is increasingly likely, with reduced funding for science and innovation and lower value economies due to right-wing populist governments, so it may be that only part of the framework could be implemented in these countries.

Although it seems unlikely that all companies will end up being purely robot-driven, it may be that a hybrid workforce emerges. This is not specifically

addressed by the Guide, though RRI practices embedded into organisations would ensure that there are humans assessing the ethical and social impact of the workforce they employ, and that an ethical culture along with some sort of ethical review process will take into account potential losses of jobs for employees, putting people before profit. This is a complex value conflict, however – if all companies in a sector are moving toward robotic workforces, it may be worth re-training existing employees rather than simply keeping them on for this sake.

## 4.3   EU Policy Options

The short EU Policy Options document (Responsible Industry Consortium 2017c) is the final official document of the Responsible-Industry project, aimed at EU policy makers. It provides a vision of the policy future for the EU and beyond and has several messages aimed at policy makers: raising awareness, engaging industry, and optimising regulation and promoting voluntary codes.

These are all supportive of the work done for this report; awareness and engagement of the public and industry are paramount in ensuring the future capabilities of ICT for health and ageing, as well as predicting the future impacts of the technologies in order to ensure the correct amount of regulation is imposed. Voluntary codes are one way to deal with a positive regulatory environment, but there will always be the concern that future companies (as current companies) are likely to be well ahead of regulators in terms of how they work and innovate, with regulation and policy racing to "catch up".

# 5.  Conclusion

This Horizon Scanning report wraps up the forecasting approaches for the project and evaluates the outputs of the project on its "future-proofing" by considering the final framework guidance documents against the horizon scanning methodology implemented in this report.

It builds on the previous Horizon Scanning report and, although no major new signals are found for the Primary Signal aspect, new contexts and nuances of those Primary Signals since the initial report show that even the base levels of technology moves relatively quickly. However, most movement was in the Weak Signals – cutting edge discussions that occur outside of the structured discourse of academia and long-term project funding, and in startups, online discussions, and other reactive media.

It finds that, generally speaking, the final implementation framework is able to handle cutting edge activity and is likely to be useful in the future as well as at present.

The main issues that will need to be kept in mind when looking toward future policies and contextualisation of ICT for health and ageing are: the technologies themselves, the motivation for companies to innovate, and what the natures of future companies, environments and the elderly are likely to be. These are constantly evolving and need to be considered by companies looking to innovate as well as policy makers in their deliberations.

# 6.   References

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