















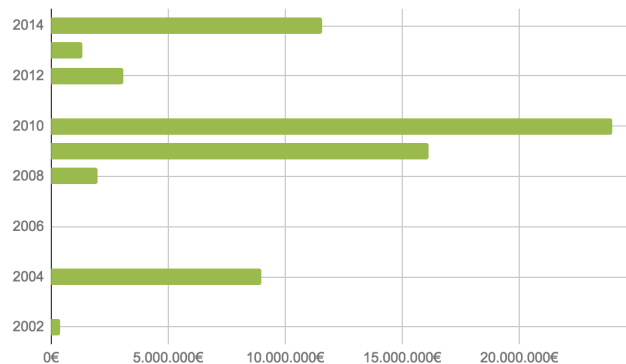




<b>FP7-ICT</b>	14.631.107€	3
<b>FP7-HEALTH</b>	23.993.478€	2
<b>Call 1 – AAL Programme</b>	1.987.368€	1
<b>Call 2 – AAL Programme</b>	1.500.000€	1
<b>Call 5 – AAL Programme</b>	3.065.214,60€	2
<b>Call 6 – AAL Programme</b>	1.333.205,66€	1
<b>Call 2014 – AAL Programme</b>	11.593.072,19€	7

**Table 4. Total investment per year**

<b>Programme</b>	<b>Investment</b>	<b>Projects (N=19)</b>
<b>2002</b>	400.000€	1
<b>2004</b>	8.967.500€	1
<b>2008</b>	1.987.369€	1
<b>2009</b>	16.131.107€	4
<b>2010</b>	23.993.478€	2
<b>2012</b>	3.065.214,60€	2
<b>2013</b>	1.333.205,66€	1
<b>2014</b>	11.593.072,19€	7



**Figure 6. Total investment per year computed as the sum of individual projects' investment for each year**

## 5 DISCUSSION

In this section, we will discuss each of the answers to our mapping questions. As many of the obtained results are interrelated, and the following discussion is better understood taking into account the nature of the programs funding the obtained projects, we will start the discussion by the fifth mapping question regarding the calls the obtained research projects belong to. It can be seen that the majority of obtained results (73.68%) belong to the AAL programme in its different calls. The AAL programme's primary aim is to improve the living conditions of elderly people, while strengthening the international industrial opportunities for SMEs in the area of ICT. Next, 2 of the considered projects belong to the health section of the FP7 programme, which main focus was the translational research (i.e. the translation of basic discoveries in clinical applications) and strengthen the competitiveness and innovative capacity of European health-related industries and businesses. Another 2 projects belong to the FP6- LIFESCIHEALTH programme which was primarily focused on promoting community research through the coordination between regional, national, European and international health frameworks. Finally, one project from the FP7 ICT programme passed the quality assessment criteria. The activities considered for this call areas such as communication networks, network and service infrastructure stability and security, personalised ICT systems and digital content management. From the description of the obtained calls, it can be observed that to a greater or lesser extent all of them promoted the collaboration between different actors with different motivations in the health sector which, when performed over a technological platform in turn resembles any of the definitions given to technological ecosystems [1-3].

In terms of the trends in the development of technological ecosystems, considering the technological platform employed for facilitating the interaction of the different actors the results highlight an amount of solutions that propose web platform based ecosystems. On the other hand, most of the rest of ecosystems make use of sensors in combination of web, mobile or cloud solutions. All the later cases mainly belong to the AAL program where, rather than using available technological frameworks, many of the proposed solutions are customized with different level of integration with health standards, resulting in different proposed architectures and protocols.

The main hypothesis for the above results relies is the scopes of the EU calls, which in turn lead to the different domains the proposed solutions are framed in. In the case of the AAL program solutions are mainly focused on ageing-well, independent living nutrition and assistive services, whereas the FP7 and FP6 health related ecosystem are focused on healthcare solutions for diabetes, cardiovascular disease therapeutics, cardiac patients monitoring, oncology and genetics. Due to being more related to health care, the later proposed solutions implement either standard-based architectures that comply with the different health standards (HL7, ISO/IEEE 11073, IHE IDCO Profile), or are focused in building networks between healthcare stakeholders and thus make use of existing web technologies for building communication means between the different actors.

Regarding the type of partners involved in the projects, it can be observed how research institutions (120), SMEs (47) and end-user organizations (30) are the main institutions that participate in this type of proposals. However, although large companies take part in the projects but in lesser quantity (13), the number is remarkably high taken into account that they are not eligible for funding. These large companies are mainly composed by pharmaceuticals and software providers. Analysing the scope and outputs of the ecosystems they belong to, the main value propositions for this kind of actors relies on the fact that participating in a European project offers a certain number of other opportunities apart from funding such as integrate potential new markets, gain access to innovation technologies developed within the ecosystem or reinforce the brand image.

The stakeholders considered in this work include not only those that correspond to the institutions that take part in the proposal, but also those who might benefit or be interested in the solutions developed in the projects. Regarding the nature of these stakeholders and end-users, they correspond to older persons, informal carers, pharmaceuticals, patients suffering different diseases, doctors and scientists. As for the technology sector the main stakeholders consist in software providers/developers and ICT solution providers. In terms of the particular scope of the proposed ecosystems, those related to the AAL program are clearly biased to senior users and formal and informal carers, whereas doctors, pharmaceuticals and patients are mostly found in the FP 6 and 7 projects.

Regarding the distribution of projects over time, ecosystem related projects have been developed between 2009 and 2018. Prior to that, two projects that belonged to the FP6 programme implemented an ecosystem related to healthcare. In both cases they consisted in large networks of R&D institutions over a web-based platform that provided services for enrolment of patients in clinical research, a suite of data analysis tools and protocols as well as a huge database of shared data between the participants. Even though the average duration of the projects is 3years, there is one particular FP6 project related to oncology - biological data that extended during 6 years and which results and services are still available. Call 1 and 2 of the AAL programme and the FP7 projects started in 2009-2010, whereas from 2013 only AAL health related ecosystem projects are found. The overall distribution of projects implementing ecosystem solutions is consisted with the evolution of technological / software ecosystems over time [14], as the first definition was introduced in 2003. Later, the number of publications related to software ecosystems until 2015 had increased linearly since 2003, with two peaks in 2011 and 2014.

Also, the above results are related with the amount of dedicated resources for this kind of projects. However, FP7 projects launched around 2010 involved a greater number of participants, and as such their budget is way higher than in other project proposals. In fact the 7 out of 19 projects that belong to the sixth and seventh Framework Programme comprise more than the 70% of the total associated budget, while the remaining 30% has been dedicated to the AAL program in its different calls.

## 5.1 Threats to validity

It has to be noted that, as with any research method, there could be threats to its validity and limitations in the current mapping. The first threat is that the inclusion of all the relevant projects in the field of ecosystems in healthcare is not guaranteed. This threat was mitigated by combining different databases and manual searches. However, as can be depicted from the results, the number of projects that have reached the final stage after applying the quality criteria is quite low. The main reason from this is the scarce information that can be gathered once the projects have finished, even after applying different search strategies and looking for information from different sources as described in section 3. It should be noted that this does not mean that the projects analyzed have not been successfully carried out, but that the information relative to their outputs could not be accessed.

Also there are two threats to internal validity in this systematic mapping. The first threat is that most of the projects do not provide accurate descriptions or references for the ecosystem they implement, as in most cases it is not the main objective of the project. The second threat is related to the identification of values for classification criteria which again was not obvious in many cases. For that reason, some of the retrieved information had to be inferred from different sources, discussed and analyzed closely by all of the authors of the paper.

Finally, a threat to validity which is specific for this particular research is the bias in the results that could be introduced due to the nature of the funding programs that guide the scope and goals of the financed research. Again, this was mitigated by searching in different EU programs and calls and including a wide range of funding periods.

## 6 CONCLUSIONS

This paper presents a systematic mapping review in the domain of European research projects focused on technological ecosystems in the health sector, which has been performed to try to investigate and understand how the European health community interprets and addresses the emerging ecosystem approaches. The review was focused on seven mapping questions and the main findings are:

- most of the rest of ecosystems make use of web platforms, in many cases in combination of sensors, mobile or cloud solutions
- the solutions are mainly focused on focused on ageing-well, independent living and health-related research communities
- when the solutions are AAL centred often consist of ad-hoc architecture. On the contrary, health related projects usually make use of standard-based solutions;
- partners include research institutions, SMEs, end-user organizations and large pharmaceutical and ICT provider companies.
- Projects and associated budget cover the 2003 – 2018 period, with in 2010 in 2014 correlated with the dates of the project calls.

Finally, trying to apply traditional mapping methodologies employed in research fields in the scope of European projects turned out to be a difficult task, as it is particularly difficult to find the necessary information related to finished projects. In this sense, some initiatives are being carried out such as the new AAL Market Observatory commissioned by the AAL Programme. This project will run until December 2018 and will provide a review of trends and perspectives in the field of AAL, annual reports on market and investment information, and a searchable database of relevant technologies (<http://www.aal-europe.eu/market-observatory-for-aal>).

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