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D1.3 Assessment Methodology

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Executive Summary

This document describes the assessment methodology for the MARIO project. In brief, that methodology is:

- To align indicator selection with the process and outcome indicators of the European Innovation Platform on Active and Healthy Ageing
- To select assessment methodologies for those indicators customising where needed to the project focus on persons with dementia
- To develop a business model approach that enables the use of qualitative and quantitative methods
- To demonstrate the business model approach through user case and business case couplings that reinforce and are reinforced by project pilot activities

Using this approach, the project has selected 4 process indicators and 19 outcome indicators with which to assess MARIO's impact. The process indicators are mostly related to how MARIO can be considered to contribute to the EIP-AHA. The outcome indicators are mostly utilised to assess how the system will deliver impact to quality of life, the sustainability of health care systems and innovation and growth.

Given MARIO's focus on dementia, statistics related to the prevalence and costs of dementia are included in this report. For the same reason, literature review on methods specific to the assessment of patients with dementia has been conducted and is reported in dedicated sections.

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1. Chapter 1: Introduction

This document is a short report documenting outlining assessment indicators and methodologies, which will be used across the project where evidence of impact is required. Chapter one, presents the objectives of WP1, the rationale and target audience for this deliverable as well as how this deliverable relates to other activities in the project. Chapter two provides background information on the prevalence and resulting costs of dementia care in Europe and specifically across the three pilot sites. Chapter three describes the EU EIP AHA Monitoring Framework, the selection of MARIO assessment indicators that are aligned with the EIP on AHA Monitoring Framework and the methodologies that will be used for their assessment. Chapter four then presents how the indicators can be utilised in a business model approach demonstrated by use case / business case couplings. Chapter five concludes the document.

1.1. Work Package 1 Objectives

WP1 objectives are:

- To introduce MARIO to the pilots settings
- To engage stakeholders of various types across different settings to attain the best possible additions to user specifications
- Using the user specifications, to document the final and best-fit MARIO functionalities
- To develop the data management plan and system architecture to support the intended functionalities
- To develop and document the MARIO Ethical Framework that makes clear the privacy, security and ethical expectations right at the beginning of the project.
- To develop an assessment methodology for the assessment of the benefits of MARIO solutions.

1.2. Rationale and Target for this Deliverable

The focus of this deliverable is to document the outcome indicators and assessment methodology that will be used to assess the impact of Mario Kompai on people with dementia and formal /informal carers and its economic impact related to the cost of care. This document will also outline a business model so that future purchasers can understand the return on investment (ROI) and benefits across different metrics.

1.3. Relations to other Activities in the Project

This deliverable presents the assessment methodology which will be used in WP8 to validate MARIO in the pilot sites.

1.4. About MARIO

The MARIO robot, Mario Kompai, addresses the difficult challenges of loneliness, isolation and dementia in older people through innovative and multi-faceted inventions delivered in three distinct pilot sites- a long stay care residential home in Ireland, an acute hospital setting in Italy and a community setting in the UK. Human intervention is costly from an economic and social perspective but the severity can be reduced and/or mitigated by activities that retain abilities and connectedness and by brain stimulation mediated by robots.

From this unique combination, clear advances are made in the use of semantic data analytics, personal interaction, and unique applications tailored to better connect older persons to their care providers, community, own social circle and also to their personal interests. Each objective is developed with a focus on loneliness, isolation and dementia. The impact centres on deep progress toward EU scientific and market leadership in service robots and a user driven solution for this major societal challenge. The competitive advantage is the ability to treat tough challenges appropriately. In addition, a clear path has been developed on how to bring MARIO solutions to the end users through market deployment.

2. Chapter 2: Prevalence of Dementia and Economic cost of care

Dementia places a heavy burden on carers whether this care is provided by informal carers such as family/friends or by health and social care systems. In this chapter the extent of the dementia epidemic in terms of European prevalence rates and prevalence rates across the respective pilot sites and the resultant social and economic impact of dementia is presented. This information can inform the MARIO Assessment methodology in the selection of outcome indicators and business model development.

2.1. Prevalence of Dementia

Globally, it is estimated that 44.35 million people have dementia and this is expected to reach 135.46 million by 2050 (Alzheimer's Disease International 2013). Western Europe has the highest prevalence of dementia in the world (Ferri *et al.* 2005; Prince 2009) estimated at 7 million in 2013 (Alcove 2013) and a projected increase to 13.4 million by 2050 (Prince & Jackson 2009). It is estimated that one new case of dementia is added every three seconds (Prince *et al.* 2015) and once diagnosed the median years of survival is 4.6 (women) and 4.1 (men) (Xie *et al.* 2008).

The prevalence of dementia across the three pilot sites were also explored and in so doing the most recent prevalence rates for each respective country where the robot, Mario Kompai, will be introduced was sought. The data found reflects the high prevalence rates of dementia across Europe. However, as most dementia prevalence rates are based on estimates, and given the different sources and methods used in the different countries, comparisons need to be interpreted with caution.

The population of Ireland is 4.5 million of whom 535,393 or 12 percent are aged 65 years or older (Central Statistics Office, 2011). The estimated prevalence of dementia in this population is 41,470 people of whom 37,887 are over the age of 65. Most reside in the community (26,104 (63%)) but significant numbers are in long stay residential care (14,266 (34%) (Connolly *et al.* 2014). Furthermore the projected number of people with dementia in Ireland is expected to increase three fold to 132,000 by 2041 (Pierce *et al.* 2014).

Italy’s total population is approximately 61 million (World Population Statistics 2014), of this it is estimated that 1 million have dementia (Alzheimer’s Association Italy 2015). The number of people over 65 with dementia is estimated at 1,272,317 (Dementia in Europe Yearbook (2013). It is also estimated that most people over 65 with dementia reside in the community (1,086,954 (86%) with less numbers in long stay care residential settings (24%) (Alzheimer Europe 2006).

The UK has the highest population across the three pilot sites with an estimated 64 million people (World Bank 2014). Of this, 850,000 people are estimated to have dementia with a prevalence rate of 7.1% in those aged over 65 equating to 1 in every 14th person over the age of 65 (Prince *et al.* 2014). Furthermore, it is projected that this will increase to over 1 million by 2025 and beyond 2 million by 2051 (Prince *et al.* 2014). Approximately 311,730

(36%) people with dementia reside in care homes*[1], of this 180,500 reside in residential care and 131,230 in nursing homes (Prince *et al.* 2014). The remainder (538,270 (64%) reside in the community.

Table: 1 Total Number of people with dementia, number of people over 65 with dementia, PWD living in the community and living in long stay residential settings across pilot site countries.

Country	Total population	Total number of people with dementia	Number of people >65 with dementia	PWD living in the community	PWD living in long stay residential settings/nursing homes
Ireland	4.5 million	41,470[2] (0.92%)	37,887[2] (91%)	26,104[2] (52%)	14,266[2] (34%)
Italy	61 million	1,272,317[3] (2.09%)	1,263,900[4] (99%)	1,086,954[5] (85%)	176,946[6] (14%)
UK	64 million	850,000[7] (1.33%)	585,000[7] (69%)	538,270[7] (63%)	131,230[7] (15%)

There are also clear gender differences in the prevalence rates of dementia with higher age-specific prevalence rate for women than men. Approximately 66% of people with dementia are women in Ireland (Pierce *et al.* 2014) and in the UK (Alzheimer's Research UK 2015). Likewise more women in Italy have dementia, 857,000 (67%) versus 415,000 men (33%) (Dementia in Europe Yearbook 2013). Women therefore due to increased longevity seem to bear a higher dementia burden than their male counterparts.

These data - related to the respective pilot sites - are based on estimates and different sources and methodologies, making comparisons difficult. However, from the information attained, the following trends or generalised figures can be extracted, which can provide initial planning figures for an assessment methodology, technical specifications, business model, business plan or when extrapolating impact:

- Between 1-2% of the population has dementia
- More than half live in the community with 65% as a hypothesis estimate and the remaining 35% in a care facility
- A high proportion of people with dementia are over 65 years old with 85% as a hypothesis estimate

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[1] *In the UK care homes tend to be "residential setting where a number of older people live, usually in single rooms, and have access to on-site care services. Since April 2002 all homes in England, Scotland and Wales are known as 'care homes', but are registered to provide different levels of care." http://www.housingcare.org/jargon-care-homes-96285.aspx

[2] Connolly et al 2014

[3] Alzheimer Europe (2013)

[4] Piano Nazionale Demenze 2014

[5] Alzheimer's Italia 2015

[6] Alzheimer Europe (2013)

[7] Prince et al 2014

- Approximately 66% of people with dementia are women

A different layer of abstraction can also be inferred from the data.

- There may be room to improve diagnosis (e.g. why 1% in Ireland and 2% in Italy)
- With respect to attaining acceptability, achieving replication and realising business model success, biasing robot features and functionalities toward women over 65 and living at home is one strategy to consider
- The number of people with dementia is significant enough to anticipate high economic impact on society as well as stress on the medical system and caregivers for those providing care to dementia patients living in the community

2.2. Economic impact of Dementia

Across Europe dementia as an illness is ranked higher than stroke, heart disease and cancer combined (Lowin *et al.* 2001) yet health care resources for dementia are lower than each of these respective diseases. In Europe, dementia is estimated to cost €177 billion of which €81 billion is due to direct costs such as hospitalisation and long-term care, and €96 billion is due to the cost of informal care in the community (Wimo & Prince 2010). Examining the economic impact of dementia per person in Europe, Wimo *et al.* (2011) estimated it at approximately €22,000 per year. However significant variations are reported across countries (Jönsson *et al.*, 2006; Ersek *et al.*, 2010 ;). The economic impact of dementia identified in Ireland, UK and Italy reflects the high cost expressed at the European level and are discussed in the following sections.

2.3. Ireland

In Ireland data concerning unit costs for different health and social services is limited therefore Connolly *et al*.(2014), in the most recent work on the cost of dementia care in Ireland, used generic age related cost estimates in their analysis. They also utilised a societal perspective on costs that includes social care costs, opportunity cost associated with unpaid care to people with dementia and productivity losses associated with early mortality. Finally they used data from national sources and data obtained from local or survey data extrapolated to the national level. This work estimates that the total cost of dementia in Ireland is around €1.69 billion per year, almost half of which is due to the cost of informal care provided by family and friends in the community (Table 2). With an estimate of 41,470 people with dementia in Ireland, this gives an average cost per person of approximately €40,500 per year (Connolly *et al*. 2014).

Table 2 Total cost of dementia in Ireland, 2010 (Reproduced from Connolly *et al*. 2014)

	Total cost (€)	%of total cost
Informal care	807,499,128	48%
Health & social care	147,947,223	9%
Long-stay care	731,148,816	43%
Premature mortality	4,339,591	<1%
Total cost	1,690,934,758	

Formal health and social care services for people with dementia are mainly provided in long stay residential care settings. Five different types of long stay residential care settings exist:

Health Service Executive (HSE) Extended Care Units; HSE Welfare Homes; Voluntary Homes; Voluntary Welfare Homes; and Private Nursing Homes. It is estimated that approximately 63% of people residing in these settings have dementia with most residing in either HSE Extended care (3,712) or in private Nursing homes (8,722) (Table 3) . This has significant economic implications due to the high cost of residential care.

Table 3: Number of long-stay residents and percentage with dementia in Ireland, 2008 (Reproduced from Connolly *et al*. 2014)

Type of unit	Number of residents	Percentage with dementia	Number dementia
HSE Extended Care Unit	5884	63.1	3712
HSE Welfare Home	829	63.1	523
Voluntary Home/Hospital	1698	63.1	1071
Voluntary Welfare Home	376	63.1	237
Private Nursing Home	13,826	63.1	8722
All	22,613	63.1	14,266

In the context of dementia the total cost across all long stay residential settings is estimated at €731 million. This results in an average cost of €51,251 per resident per year. While the total cost of informal care i.e. care provided by family/friends in the community is €807 million (Table 2).

Acute care costs associated with dementia calculated on an average cost of €809 per overnight in patient stay and €711 per day case yielded a total cost of approximately €21 million (Table 4). In 2009, the total annual cost of inpatient psychiatric care for people with dementia was €38,684,162. In addition the overall cost of formal care across all health and social care setting was estimated at €147,947,223 in 2010. Of this 44% were due to primary and community care cost, 26% to psychiatric costs and 14% to acute hospital care (Connolly *et al.* 2014).

Table 4 In-patient and day-case admissions with dementia as the principal diagnosis for admission (Reproduced from Connolly *et al.* 2014)

	Number of in-patient admissions	Average length of stay	Number of day cases	Average cost per in-patient night	Average cost per day case (€)	Total annual cost (€)
65–74	112	42.1	45	809	711	3,845,508
75–84	292	46.6	56	809	711	11,044,944
85þ	201	38.0	31	809	711	6,199,445
All	605		132			21,089,897

In addition for persons with dementia residing in the community the burden of care is mainly on family and friends which also has significant economic impact in terms of the cost of informal caregiving. It is estimated that 26,104 people with dementia reside in the community in Ireland. Using an opportunity cost method and assuming an 8 hour day at a rate of €10 per hour, it is estimated that informal care costs are €807 million per year (Connolly *et al.* 2014).

2.4. Italy

Data concerning the current cost of dementia care in Italy is difficult to identify. In 2006 the estimated number of people in Italy with dementia was 520,000 and the average annual cost per person with dementia at that time was estimated at €60,000 , which consisted of direct costs (buying of benefits and services), and indirect costs (hour care and cost of supervision) (CENSIS 2007). The average cost of care is proportional to the stage of disease and increases with increasing severity of the disease itself (Jonsson, 2009). According to Jonsson (2009) on average 8.8 hours of personal care and 16.4 hours of supervision are provided per day to the person with dementia. Furthermore more recent work indicates that the yearly cost of caregiving and indirect support is more than €13 billion (Peracino, 2014).

Other studies provide different insights on the costs of dementia in Italy. Chiatti (2015) lists the public, patient, and informal care costs of dementia at €20,000 per year of which €4,534 per year is borne by the public sector. The public costs are mainly due to cash for care benefits (€2,324/yr.) and drug prescriptions (€1,402/yr.).

The Allianz Insurance agency (2008) has also published an interesting fact sheet on Alzheimer's in Italy. In it, they estimate the total cost per annum on families and communities at €60,000 per annum where €15,000 are direct cash outlays and €45,000 are indirect costs (lost opportunity cost for persons providing informal care). They also cite the role of the "badante" (in-home live-in caregiver, typically foreigner and typically female and typically with no professional qualification) as strategic and utilised by 41% of families providing informal care. In 82% of the cases, the badante receives payment from the person with dementia. Families accepting responsibility for the costs of dementia represent significant savings for the State. However, if caregivers are not adequately supported in their caregiving roles the high burden and stress experienced by caregivers may lead to increased risk of morbidity and mortality that may counterbalance any savings. The cost of acute care associated with dementia is estimated at €1,221.02 per year per person (Gambina, 2006).

Although now potentially dated, a 2002 study conducted by the Hospital of Verona (Gambina et. al. 2001) provides insights on different types of costs and how they vary between persons in different stages of dementia. In this study, hours of care are estimated as follows: people with mild dementia require an average assistance of 9 hrs/day, those with mild dementia approximately 20 hrs/day and those with severe dementia approximately 22 hrs/day. Considering an average of 18 hrs/day, the study goes on to estimate that 16% of that time (3 of 18) is for assistance and 82% of that time (15 of 18) is for surveillance.

Tables from the study have been translated and reproduced as follows:

Table 5 Average Annual Costs per PWD considering severity of condition in euro.

Type of costs	Slight Dementia	Moderate-Severe	Terminal	Average
Informal assistance	14,793	40,969	42,124	34,737
Formal assistance	2,157	3,702	10,464	4,584
Diagnosis	82	76.25	76	78
Drugs	2,248	1,602	675	1587

Analysis and visits	142	147	493	233
Non pharmacological aids	2	591	1,545	695
Mechanical aids	1.27	10	203	57
Changes inside the house	81	198	564	263
CMAP total	19,508	47,297	56,145	42,235

Table 6 Average Daily Cost of Care Based On Stage of Dementia (Euro)

Type of costs	Slight Dementia	Moderate-Severe	Terminal	Average
Assistance (hygiene, meals, drugs administration	6.69	32.53	38.45	25.89
Surveillance	34.04	79.71	76.96	63.57
Informal assistance (including surveillance)	40.53	112.24	115.41	89.39
House keeping	5.96	9.76	26.42	14.05
Nursing assistance	0.00	0.39	2.26	0.88
Formal assistance	5.91	10.15	28.67	14.91
Total costs	46.44	122.39	144.09	104.31

Table 7 Average Cost Of Daily, Monthly And Yearly Care, Based On Stage Of Dementia, In Euro.

	Cost of Daily care	Monthly care	Cost in a year
First stage	46.44	1,412.57	16,950.60
Middle and sever stage	122.39	3,722.74	44,672.12
Terminal	144.09	4,382.78	52,589.20

Table 8 Cost for Use of Drugs Daily, Monthly, Yearly Based On Severity in Euro

	Daily cost	Monthly cost	Yearly cost
First stage	6.16	187.37	2,248.40
Middle e sever	4.39	133.53	1,602.82
terminal	1.85	56.27	675.25

2.5. United Kingdom

In the UK recent reports estimate that the total cost of dementia is around £26 billion a year which gives an estimated annual average cost of €45,825.27 (£32,250) per person (Prince *et al.* 2014). This €36.9 billion (£26 billion) costing is further broken down into €6.1 billion (£4.3 billion) - healthcare costs and € 14.6 billion (£10.3 billion) - social care costs. These social care costs consist of € 6.3 billion (£4.5 billion) -publically-funded social care, €8.2 billion(£5.8 billion)-privately funded social care,€16.4 billion (£11.6 billion) -unpaid care (cost of €1.9 billion (1.34 billion) hours of unpaid care calculated on replacement and opportunity costs) and €157 million (£111 million) on other dementia costs.

The average annual health care costs (primary, community and secondary care services used) per person with dementia living in the community is €23,749.98 (£16,704) per year, and

€32,177.07 (£22,631) for those living in residential care. While annual average social care costs per person per year is €31,584.17(£22,214) for people with dementia living in the community and €108,146 (£76,062) for those living in long-term care. It is also estimated that 66% (€24 billion/ (£17.4 billion) of the cost of dementia is borne by people with dementia and their families, either through unpaid informal care giving (, €16.4 billion /£11.6 billion) or for private social care. This is different to heart disease and cancer care costs, where care is provided for free at the point of use through the NHS. For people with dementia residing in the community, unpaid or informal care accounts for almost 75% of the total cost, with the average yearly cost of unpaid/informal care estimated to be in the region of €120 million (£85 million) (Prince *et al.* 2014).

Focusing on assisted living facilities, for example Stockport local authority housing, the cost for people over 65 with high dependency, potentially people with dementia, is estimated at €634.68 (£446.17) per person per week. This increases to €798.69 (£561.46) for those with more advanced conditions requiring nursing standard residential care.

In Stockport within the Older People's Services there is an aim to reduce the number of people placed in residential care throughout the year and currently the target is set at 415 new placements per year. However, there are costs to supporting people at home and currently the Council have an hourly rate for home care of 17.92 (£12.60), and an average package of care of 21 hours a week. This would equate to a cost of approximately €369.86 (£260.00) per week per person with then an annual cost of €19,194.49 (£13,500). In Stockport we can therefore make a direct comparison of costs savings of supporting people in the community at home against the costs of residential placement. Assuming average total costs for 1 residential placement for a year is€36,967.16 (£26,000) with a package of support/care at home at €19,194.49 (£13,500), Stockport can then expect to see savings by supporting people at home of €17,772.67 (£12,500.00).

2.6. Analysis

Differences in types of economic data available, differences in healthcare and social care systems and the calculation approaches used across pilot countries make current direct comparisons problematic. Less recent work undertaken by Wimo *et al.* (2010) on the Worldwide societal costs of dementia: Estimates for 2009 however, does provide some comparison of costs across Ireland, Italy and the UK (highlighted in yellow) in relation to informal care (Table 9). The methods used to calculate costs in this work were based on cost of illness studies and studies examining the amount of informal care. Informal care costs were calculated at 1.6 hours per day (basic ADLs), and 3.7 hours per day (basic ADLs and instrumental ADLs). The cost of informal care itself was calculated based on country-specific figures of average wages (Wimo *et al.* 2010)

Table 9: Cost of Dementia Care reproduced from Wimo *et al.* (2010) p 102.

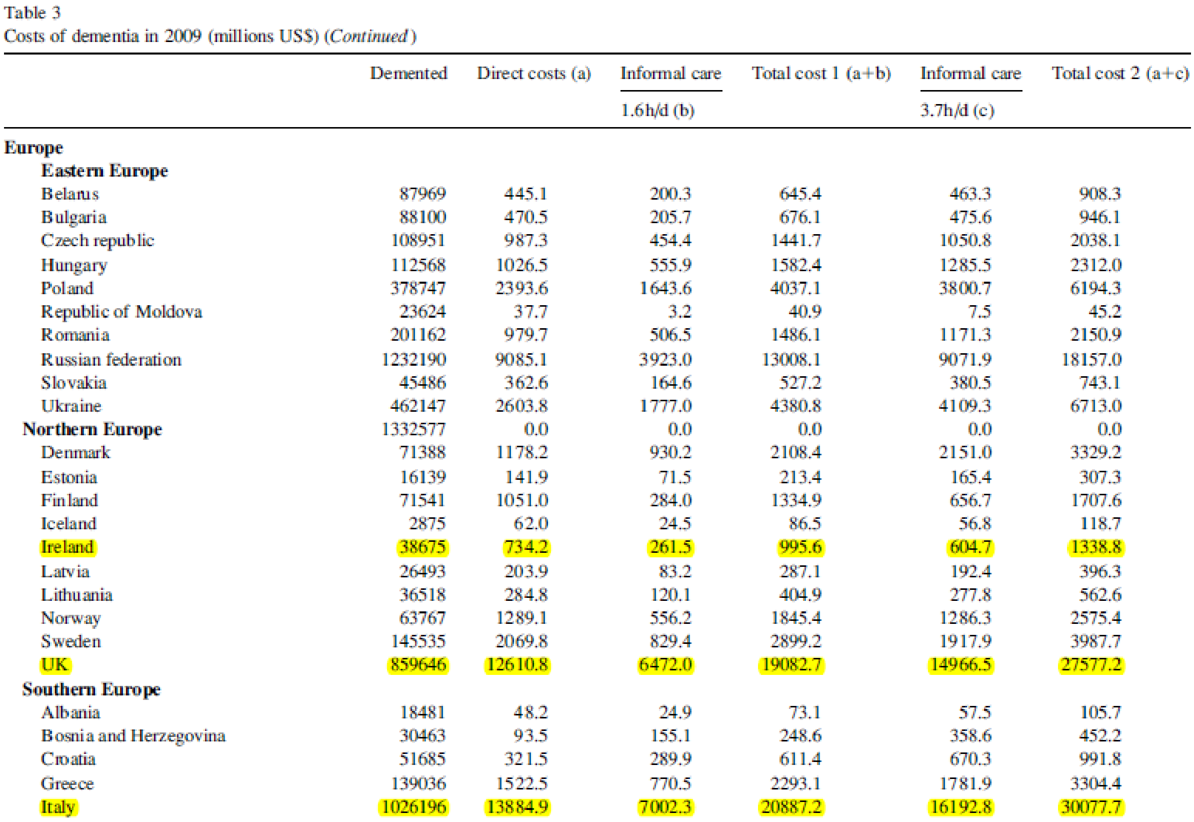


Table 3
Costs of dementia in 2009 (millions US$) (*Continued*)

	Demented	Direct costs (a)	Informal care 1.6h/d (b)	Total cost 1 (a+b)	Informal care 3.7h/d (c)	Total cost 2 (a+c)
Europe						
Eastern Europe						
Belarus	87969	445.1	200.3	645.4	463.3	908.3
Bulgaria	88100	470.5	205.7	676.1	475.6	946.1
Czech republic	108951	987.3	454.4	1441.7	1050.8	2038.1
Hungary	112568	1026.5	555.9	1582.4	1285.5	2312.0
Poland	378747	2393.6	1643.6	4037.1	3800.7	6194.3
Republic of Moldova	23624	37.7	3.2	40.9	7.5	45.2
Romania	201162	979.7	506.5	1486.1	1171.3	2150.9
Russian federation	1232190	9085.1	3923.0	13008.1	9071.9	18157.0
Slovakia	45486	362.6	164.6	527.2	380.5	743.1
Ukraine	462147	2603.8	1777.0	4380.8	4109.3	6713.0
Northern Europe	1332577	0.0	0.0	0.0	0.0	0.0
Denmark	71388	1178.2	930.2	2108.4	2151.0	3329.2
Estonia	16139	141.9	71.5	213.4	165.4	307.3
Finland	71541	1051.0	284.0	1334.9	656.7	1707.6
Iceland	2875	62.0	24.5	86.5	56.8	118.7
Ireland	38675	734.2	261.5	995.6	604.7	1338.8
Latvia	26493	203.9	83.2	287.1	192.4	396.3
Lithuania	36518	284.8	120.1	404.9	277.8	562.6
Norway	63767	1289.1	556.2	1845.4	1286.3	2575.4
Sweden	145535	2069.8	829.4	2899.2	1917.9	3987.7
UK	859646	12610.8	6472.0	19082.7	14966.5	27577.2
Southern Europe						
Albania	18481	48.2	24.9	73.1	57.5	105.7
Bosnia and Herzegovina	30463	93.5	155.1	248.6	358.6	452.2
Croatia	51685	321.5	289.9	611.4	670.3	991.8
Greece	139036	1522.5	770.5	2293.1	1781.9	3304.4
Italy	1026196	13884.9	7002.3	20887.2	16192.8	30077.7

The more recent cost data obtained for Ireland, Italy and the UK presented in this chapter begin to provide information that can be utilised in the selection of outcome indicators, business model development and also in selecting technical functionalities. From the data we can infer:

- Costs are significant (e.g. billions) and attract the attention of governments, insurance companies, researchers.
- Residential care (e.g. a state run or private facility) is one of the highest health care costs associated with dementia. If the transition to such settings can be delayed (or avoided) by supporting the person with dementia for longer in their own homes, a substantial economic savings may be realised over time. Metric(s) to measure and quantify this benefit should be considered.
- Hours related to surveillance (about 80%) heavily outweigh hours related to assistance (about 20%) for the caregivers of people with dementia. Reduction of surveillance hours may be considered as a target both in terms of functionality and as an assessment metric. Hours related to assistance may also be considered.
- Although in-home care is often cited as being cost-effective or cost-saving to the state, studies that consider the indirect cost (lost opportunity) by families providing in-home care, the cost of in-home vs. residential care are similar (between €60-95k). What changes is who bears the burden of the costs (families vs. the state) and the nature of the costs (direct for residential care and indirect for family care). The benefit/burden of

these indirect costs may be in the interests of all parties and some clarity on this is made available in the Stockport setting and analysis.

- An interesting issue identified in the Italian data related to potential concern about care provided by persons without proper training or knowledge of dementia. If the service robot can create a stronger link between the qualified care community and informal caregivers (either through training, resource availability or otherwise), this may be a benefit.

What is also not captured in the economic analysis is the anticipated positive impact on the quality of life of both people with dementia, caregivers and family members. These will be discussed in the next chapter.

3. Chapter3: European Innovation Partnership on Active and Healthy Ageing Monitoring Framework

In this chapter the dynamic European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) Monitoring Framework is presented along with MARIO's potential alignment and added value to the EIP-AHA Open Action Groups. The potential MARIO outcome Indicators and their mapping to the EIP-AHA Monitoring Framework is described. In line with the dynamic and evolving nature of the EIP on AHA monitoring framework, as the project evolves, the potential indicators outlined here will be reviewed and updated as appropriate.

3.1. Background on the EIP on AHA and its monitoring framework

Innovation partnerships are part of the European Commission's "Innovation Union." From the Innovation Union homepage (2015):

> *"Innovation Union is the European Union strategy to create an innovation-friendly environment that makes it easier for great ideas to be turned into products and services that will bring our economy growth and jobs."*
>
> *"European Innovation Partnerships are a new way of bringing together public and private actors at EU, national and regional levels to tackle the big challenges we face…"*

One of the targeted challenges by the Innovation Union is the ageing population and this has led to the formation of the Innovation Partnership on Active and Healthy Ageing (European Commission 2014). From the EIP on AHA information leaflet (European Commission, 2012)

> *"The EIP on AHA gathers stakeholders from the public and private sectors cross different policy areas. Together they work on shared interests, activities and projects to find innovative solutions that meet the needs of the ageing population."*

The overarching goal of the EIP on AHA is to add two healthy life years to the average healthy life span of European citizens by 2020. It has three priority areas for action. They are:

- Prevention, screening and early diagnosis
- Care and cure
- Active ageing and independent living

These priority areas have led to the formation of six Action Groups. They are:

- Finding innovative ways to ensure that patients follow their prescriptions and treatments
- Finding innovative solutions to better manage our own health and prevent falls
- Helping to prevent functional decline and frailty
- Promoting integrated care models for chronic diseases, including the use of remote monitoring
- Deploying ICT solutions to help older people stay independent and more active for longer
- Promoting innovation for age-friendly and accessible buildings, cities and environments

The desired outcome of the EIP on AHA is a “Triple Win” for Europe consisting of:

- Improvement of the health status and quality of life of European citizens, with particular focus on older people
- Long-term sustainability and efficiency of health and social care systems
- Enhancement of the competitiveness of EU industry through business and expansion of new markets

3.2. Monitoring Framework

Two types of indicators are utilised to assess progress toward the desired outcomes of the EIP on AHA. They are:

- **Process Indicators**: Which in their most general sense capture and characterize the level of activity within the EIP on AHA and trends in the changes of those activities within the EIP on AHA. Activities are generally reported through commitments in the actions group and surveys conducted to the action groups and members of the EIP.
- **Outcome Indicators**: Which in their most general sense capture progress toward the three targeted outcomes / the “triple win.” Progress is assessed through indicators assigned to each of the three outcome pillars and are reported through the action groups.

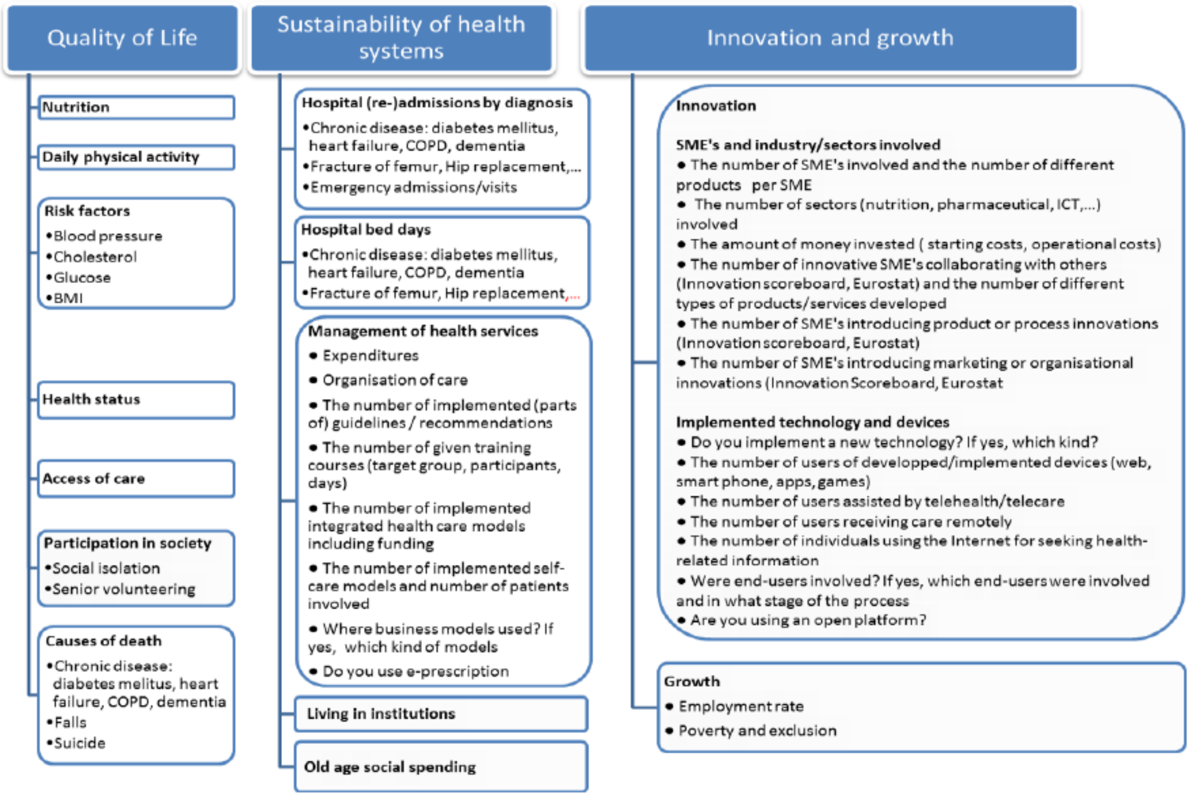
The development and reporting of these indicators has taken place between JRC IPTS, DG CONNECT and DG SANCO within the context of the “Monitoring and Assessment Framework for the EIP on AHA (MAFEIP) project. (European Commission 2012). Selected reports (deliverables) are available on the Joint Research Centre Information Society Unit webpage under the MAFEIP project. These reports and the referenced webpages have been utilised by MARIO to understand the EIP on AHA and how MARIO can contribute to the monitoring and reporting activities within the EIP.

With respect to the **process indicators**, they are clustered and typically reported via graphs and tables in the following categories.

- Involvement in Action Groups
- Involvement in the commitments: regions/ countries, stakeholders and their sector of activity
- Target groups and their coverage with quantitative information
- End-user involvement
- Added value of the EIP on AHA
- Mobilisation of resources

With respect to the **outcome indicators**, an initial monitoring framework based on a building block approach of indicators was established in November of 2012. The initial framework is reproduced in Figure 1. Since that time, methods and best practices in the assessment of these indicators has been in progress by the action groups and by the EIP overall.

Figure 1. EIP on AHA initial Monitoring Framework (5 November 2012) reproduced from the 2014 MAFEIP First Report on Outcome Indicators



Quality of Life

- **Nutrition**
- **Daily physical activity**
- **Risk factors**
  - Blood pressure
  - Cholesterol
  - Glucose
  - BMI
- **Health status**
- **Access of care**
- **Participation in society**
  - Social isolation
  - Senior volunteering
- **Causes of death**
  - Chronic disease: diabetes melitus, heart failure, COPD, dementia
  - Falls
  - Suicide

Sustainability of health systems

- **Hospital (re-)admissions by diagnosis**
  - Chronic disease: diabetes mellitus, heart failure, COPD, dementia
  - Fracture of femur, Hip replacement,...
  - Emergency admissions/visits
- **Hospital bed days**
  - Chronic disease: diabetes mellitus, heart failure, COPD, dementia
  - Fracture of femur, Hip replacement,...
- **Management of health services**
  - Expenditures
  - Organisation of care
  - The number of implemented (parts of) guidelines / recommendations
  - The number of given training courses (target group, participants, days)
  - The number of implemented integrated health care models including funding
  - The number of implemented self-care models and number of patients involved
  - Where business models used? If yes, which kind of models
  - Do you use e-prescription
- **Living in institutions**
- **Old age social spending**

Innovation and growth

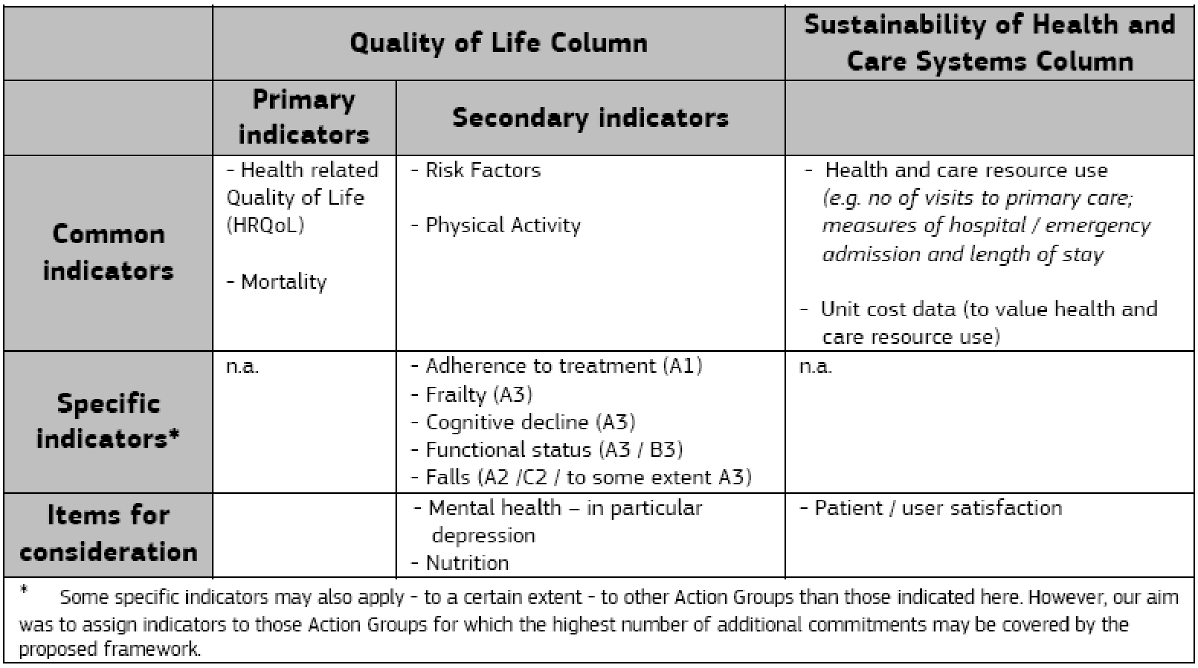
- **Innovation**

  SME's and industry/sectors involved
  - The number of SME's involved and the number of different products per SME
  - The number of sectors (nutrition, pharmaceutical, ICT,...) involved
  - The amount of money invested (starting costs, operational costs)
  - The number of innovative SME's collaborating with others (Innovation scoreboard, Eurostat) and the number of different types of products/services developed
  - The number of SME's introducing product or process innovations (Innovation scoreboard, Eurostat)
  - The number of SME's introducing marketing or organisational innovations (Innovation Scoreboard, Eurostat

  Implemented technology and devices
  - Do you implement a new technology? If yes, which kind?
  - The number of users of developped/implemented devices (web, smart phone, apps, games)
  - The number of users assisted by telehealth/telecare
  - The number of users receiving care remotely
  - The number of individuals using the Internet for seeking health-related information
  - Were end-users involved? If yes, which end-users were involved and in what stage of the process
  - Are you using an open platform?
- **Growth**
  - Employment rate
  - Poverty and exclusion

Review and implementation of the Monitoring Framework as shown in Figure 1 is reported in two reports, the “First Report on Outcome Indicators 2014” and “Second Report on Outcome Indicators 2014.” Both are available for download at the MAFEIP homepage. These reports have resulted in a reconsideration of the initial monitoring framework which is shown in Figure 2. In this provisional monitoring framework, indicator types are categorised as Common, Specific or Items for Consideration. These indicator types are further sub-divided into Primary or Secondary indicators. A mapping is conducted for the Quality of Life and Sustainability of Health Systems columns. In the Second Report on the Outcome Indicators, it is identified that there are deficiencies in the Innovation and Growth column indicators of the initial monitoring framework. In specific that some are process indicators and others are outcome indicators not well suited for assessment. A reconsideration and revision of this column is in progress and not available at this time.

Figure 2. Provisional proposal for the outcome indicators (reproduced from the MAFEIP 2014 Second Report on the Outcome Indicators).



	Quality of Life Column		Sustainability of Health and Care Systems Column
	Primary indicators	Secondary indicators	
Common indicators	- Health related Quality of Life (HRQoL) - Mortality	- Risk Factors - Physical Activity	- Health and care resource use *(e.g. no of visits to primary care; measures of hospital / emergency admission and length of stay* - Unit cost data (to value health and care resource use)
Specific indicators*	n.a.	- Adherence to treatment (A1) - Frailty (A3) - Cognitive decline (A3) - Functional status (A3 / B3) - Falls (A2 /C2 / to some extent A3)	n.a.
Items for consideration		- Mental health – in particular depression - Nutrition	- Patient / user satisfaction

* Some specific indicators may also apply - to a certain extent - to other Action Groups than those indicated here. However, our aim was to assign indicators to those Action Groups for which the highest number of additional commitments may be covered by the proposed framework.

As MARIO develops a mapping of its activities to the EIP-AHA Monitoring Framework, it is noted that the monitoring framework is a work in progress and the assessment of the indicators themselves (and how to combine them for contributions to the goals of the platform) are under discussion.

In considering the current status of the Action Groups and progress toward indicator reporting, there is a webpage dedicated to the activities of the actions groups (http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-ageing&pg=commitment). It is updated annually.

It is also useful to consider one method for reporting to the EIP on AHA monitoring framework via the use of an Outcome Questionnaire. Such a questionnaire is provided as an annex to MAFEIP Second Report on the Outcome Indicators. It is reproduced in this report as Annex 1.

3.2.1 MARIO's Alignment with the Process Indicators

The second invitation to contribute to the Action Plans closed on 28 February 2013. The last progress update occurred on 1 December 2014. The MARIO project has contacted the EIP on AHA at EC-EIP-AHA@ec.europa.eu to inquire if the platform is open to the contribution of projects such as MARIO either as a project (one entity) or as individual partners (multiple entities). In the event there is a positive response, MARIO can align with the process indicator reporting process that has in the past occurred via survey of the platform participating members to capture the metrics listed in Section 3.1. Internally as a project, the indicators we can track and report are outlined in Table 10. Table 11 presents MARIO's potential alignment and added value to the EIP-AHA Open Action Groups.

Table 10: MARIO EIP-AHA Process Indicators

Mario Process Indicator #	Name	Description / Methodology
MPI-1	Participants	Number of participants MARIO contributes to the EIP-AHA either directly or through its networking, dissemination, communication and exploitation activities (e.g. by bringing a non-project party to the platform)
MPI-2	Action Groups	Number of Actions Groups MARIO actively contributes to*.
MPI-3	Commitments	Number of unique commitments made by the MARIO project**
MPI-4	Added Value	This indicator is a written description / mapping of how MARIO contributes to the aims of the EIP-AHA and its open action groups. Table 12 demonstrates this indicator at the time of this deliverable

* Contribution will require contact with the Action Group leader and agreement that MARIO fits with the current goals/activities of that Action Group.

** Commitments are coordinated with Action Group leaders and typically are aligned with an instance of reporting an outcome indicator. Each MARIO pilot could represent a commitment and/or each MARIO pilot could be organised into multiple commitments or the MARIO project could be aggregated into one overall commitment.

Table 11: MARIO potential alignment and added value to the EIP-AHA Open Action Groups

AG #	Name	MARIO potential alignment	Alignment "Strength" (1-5 stars)
A1	Adherence to Prescriptions and Treatments	Contribution to AIM 1 (patient centred solutions) possible via patient electronic alerting of need to take medication and monitoring Contribution to AIM 2 (empower patients and caregivers) via access to information and resources that empower patients and caregivers Contribution to AIM 4 (R&D of appropriateness of prescription) by prescribing appropriate medications based on the vital signs	****
A2	Falls Prevention	The robot chassis is large enough to potentially consider adding handles (although this is not currently planned). Their presence would assist in falls correlated to getting up and potentially sitting down. Programming could include some aspect of	*

AG #	Name	MARIO potential alignment	Alignment “Strength” (1-5 stars)
		providing stability while the person is standing or in movement.	
A3	Functional decline and frailty prevention	This group has aims related directly to the screening, prevention and mitigation of cognitive decline and dementia. MARIO research and its resultant application target exactly this.	****
B3	Integrated Care	MARIO is an enabling technology that makes integrated care aims feasible (increased home-based care, integrated care and holistic management of chronic conditions)	***
C2	Independent Living	Action group targets technology driven solutions, interoperability, and documentation of business model concepts and economic viability – each of which MARIO conducts research upon	****
D4	Age Friendly Environments	Deals with policy, support programs and spatial environments (buildings/cities) designed for older persons. MARIO relates in making service robots part of community support programs (Stockport). MARIO may also contribute if the robot interacts with other sensors placed inside the home to carry out advanced functionalities.	***

3.2.2 MARIO’s alignment with the Outcome Indicators

Table 12 below shows a mapping of MARIO to the EIP-AHA Monitoring Framework (Figure 1) to include its last available suggestions for revision (Figure 2). In some cases, MARIO uses a different name (column 2) than that of the monitoring framework (column 4). This is in part to emphasise areas of focus in MARIO (notably resilience and loneliness) and in part that the framework still needs indicator development in some areas (especially Innovation & Growth and to a lesser degree Sustainability of Health Systems).

With respect to the types of indicators, “*Primary Indicators*” are defined in the revised monitoring framework as those “that are relevant across all commitments and all actions groups and in particular are well suited to establish a link to the triple win and headline target.” “*Secondary Indicators”* are instead those that “require more elaborate modelling” for their linkage to the triple win and headline target and that may not be common to all commitments or action groups. “*Specific Indicators”* may only apply to one or a combination of action groups and “*Items for Consideration*” are indicators listed in the initial monitoring framework that have not yet found evidence to continue with them moving forward or have yet to be studied and validated in detail by the EIP-AHA.

Limitations as they apply to MARIO are also important to address. Some of the commitments (pilot actions or studies) being considered in the EIP-AHA literature are long term, large-scale activities. In MARIO, users may be exposed to the robot for short periods at a time. The ability to measure and assess changes in mortality or depression or other indicators may therefore not be directly possible but will instead need to rely on survey, extrapolation and relation to other studies. In addition the ability to measure and assess changes in cognitive decline is particularly challenging as it's likely that cognitive impairment will decline overtime irrespective of MARIO as the disease progresses, and therefore without a control group comparison is difficult to determine.

It is also the case that some indicators relate to the person directly in the pilot (e.g. heart rate change after pilot activities is a clear simple example). Other indicators relate to pilot organisations (does the community anticipate persons staying at home longer?). Other indicators yet relate to the project collectively or potential of the MARIO system at large (e.g. what intellectual property has been generated or what is the potential savings in health the health care system for service robot deployment based on MARIO results).

A last remark on the indicators is that many of the health and cognitive indicators have overlapping aspects/redundant aspects as do their assessment methods. Primary indicators in part are intended to roll up the impact of secondary indicators. The quantification of individual indicators and combinations of indicators to the EIP-AHA targets of triple win and 2 year life extension are the topic of a broad study and research effort.

Table 12: MARIO Outcome Indicators and their mapping EIP-AHA Monitoring Framework

#	Name	Monitoring Framework Pillar	Framework Indicator	Framework Indicator Type	Mario Mapping / Anticipated Result	Assessment Methodology
MOI-1	HRQoL	Quality of Life	Health Related QOL	Common + Primary	MARIO contributes to several aspects of this multi-dimensional indicator (physical, mental, emotional and social functioning) by providing companionship, access to social and care networks, monitoring, and targeted stimulation or customised care applications. It is anticipated that a higher proportion of persons will assess their health to be better and a higher accessibility of care will be realised through MARIO functionalities.	Combination of: • Comprehensive Geriatric Assessment (CGA) • Quality of Life AD (QOL-AD) The method suggested by the Framework reports will also be investigated and potentially used (EQ-5D).
MOI-2	Cognitive Decline	Quality of Life	Cognitive Decline	Specific (A3) + Secondary	Customised care applications (My Hobbies / My Life) target stimulating the older person It is anticipated that MARIO may delay cognitive decline or provide triggers that persons access their memories.	Mini Mental State Examination (MMSE)
MOI-3	Mental Health	Quality of Life	Mental Health – in particular depression	Item for consideration + Secondary	Presence of service robot, use of life memory reminders, access to social networks via the 4 Connect Modules to mitigate depression. It is anticipated that a smaller proportion of persons will report feeling depressed and/or that depression will be less severe.	Cornell Scale for Depression in Dementia (CSDD) used on appropriate patients at each of the pilots as suitable.
MOI-4	Physical Activity	Quality of Life	Physical Activity	Common + Secondary	Personal interaction that stimulates the individual and applications to increase physical activity Physical exercises proposed by the robot which can be selected by the user It is anticipated that MARIO can help increase levels of physical activity and as result also increase functional status	• Interoperability with and use of fitness tracker to capture level of physical activity • Activities of Daily Living Test (ADL)

#	Name	Monitoring Framework Pillar	Framework Indicator	Framework Indicator Type	Mario Mapping / Anticipated Result	Assessment Methodology
MOI-5	Loneliness	Quality of Life	Participation in Society (isolation + volunteering)	Item for consideration + Secondary	MARIO directly targets loneliness via companionship, and customisation features to the person. It is anticipated a smaller percentage and severity of people feeling lonely and isolated.	• Social Dysfunction Rating Scale • Observational Measurement of Engagement (OME) • Project survey targeting older people , caregivers and pilot leaders at appropriate pilots • Qualitative interviewing
MOI-6	Resilience	Quality of Life	Frailty	Specific (A3) + Secondary	Similar to quality of life, MARIO contributes to several aspects of this multi-dimensional indicator (physiological and cognitive) by providing companionship, access to social and care networks, monitoring, and targeted stimulation or customised care applications. It is anticipated a higher proportion of people feeling more resilient.	• Brief Resilience Scale (BRS) • Extracts from other tests (CGA, QOL-AD, CSDD) plus project survey targeting resilience building • Qualitative interviewing
MOI-7	Patient Satisfaction	Quality of Life	Patient Satisfaction	Item for consideration + Secondary	MARIO is intended to allow people to stay at home and/or provide companionship and/or increase their sense of wellbeing. It is anticipated that patient satisfaction will increase along with their capabilities and access to MARIO functionalities.	Surveys/qualitative interviews related to experiences, opinions and satisfaction with the robot and its functionalities
MOI-8	Adherence to Treatment	Quality of Life	Adherence to Treatment	Specific (A1) + Secondary	Via monitoring, reporting and applications customised to individual care plans, MARIO targets increasing this indicator. Tele alarm services for the health care sector and telemedicine thus enhancing the means of communication between the elderly and their carers.	Surveys with older people and care providers. Data from robot monitoring activities.
		Quality of Life	Functional Status	Specific (A3/B3) + Secondary	These indicators appear in the monitoring framework and/or outcome reports. MARIO in	These indicators are largely correlated to the MOI-1 to MOI-8 indicators.

#	Name	Monitoring Framework Pillar	Framework Indicator	Framework Indicator Type	Mario Mapping / Anticipated Result	Assessment Methodology
		Quality of Life	Falls	Specific (A2/C2) + Secondary	some way contributes (or has the potential to contribute) to each one.	If conducted, assessment will draw on extrapolation from the other indicators + reference studies found in the literature).
		Quality of Life	Mortality	Common + Primary		
		Quality of Life	Nutrition	Item for consideration + Secondary		
MOI-9	Health and Care Resource Savings	Sustainability of Health Systems	Health & Care Resource Use	Common	MARIO targets automating part of the CGA (saving time), automating part of patient data recording (saving time) and reducing the monitoring hours required by persons with dementia It is anticipated that the time to conduct the CGA will be decreased, its understanding increased and number of persons/professionals using such an indicator increased	Pilot leader assessment of time savings and extrapolation to broader scale usage of service robots. Linkages to reduction of drug use will be sought to quantify if possible
MOI-10	Health & Care Expenditure Savings	Sustainability of Health Systems	Health & Care Expenditures	Common	MARIO targets keeping people at home longer. Savings associated with time (above) and cost-avoidance are targeted and anticipated.	Monetization (calculation estimates) of time savings on staff and informal care plus cost avoidance related to persons delaying formal care settings.
MOI-11	Management of Health Services	Sustainability of Health Systems	Management of Health Services	Not specified	MARIO connects the health service value chain in new ways for both formal and informal care settings. Synergies, efficiencies and improvements in management are anticipated	Written description of benefits observed in the pilots related to the use of a service robot
MOI-12	Living in Institutions	Sustainability of Health Systems	Living in Institutions	Not specified	MARIO prolongs in-home care reducing living in institutions A reduction of the number of persons living in institutions is anticipated	Quantification and extrapolation of the estimated impact service robots could have on the reduction of persons living in institutions primarily through an estimation resultant of the Stockport pilot of how many persons could potentially be kept at home

#	Name	Monitoring Framework Pillar	Framework Indicator	Framework Indicator Type	Mario Mapping / Anticipated Result	Assessment Methodology
						instead of in community care if MARIO was widely available.
MOI-13	Acceptability	Innovation & Growth	Innovation	Mario Generated	Robot acceptability is critical to the system's innovation potential / uptake.	Surveys with older people and care providers.
MOI-14	Intellectual Property	Innovation & Growth	Innovation	Not specified	MARIO will generate IP related to service robots for the care of persons with dementia, the aging population and hospital care	Written quantification of IP generated within the MARIO project
MOI-15	Product & Service Inventions	Innovation & Growth	Innovation	Not specified	MARIO will result in new products and services by the industrial partners	Summary and quantification of the Exploitable Results related to new products and/or services being offered by project industrials resultant of MARIO
MOI-16	Organizational Innovation	Innovation & Growth	Innovation	Not specified	MARIO may result in organizational innovations adopted at the care facilities. It is anticipated that MARIO and its activities will result in knowledge development and knowledge transfer that drive innovation. These instances will be documented.	Written identification of any organizational innovations resultant of MARIO
MOI-17	Technology Implemented	Innovation & Growth	Innovation	Not specified	MARIO will result in technology implementations at the pilot activities. These instances can be captured and reported.	Quantification of technology implementation aspects (older people interactions, caregiver interactions,
MOI-18	Planned Investment	Innovation & Growth	Growth	Not specified / Mario Generated	MARIO may stimulate continued research and/or product development and/or technology implementation. Indicators include new strategic alliances / collaborations, new research initiatives, planned technology implementation	Quantification of the 5-year planned investment of the partners' resultant of MARIO.
MOI-19	Projected Revenue	Innovation & Growth	Growth	Not specified / Mario Generated	MARIO may result in revenue by its industrials related to new products and services Indicators to justify revenue projection will include clear products and services,	Quantification of the 5-year projected revenue of the project industrials resultant of MARIO.

#	Name	Monitoring Framework Pillar	Framework Indicator	Framework Indicator Type	Mario Mapping / Anticipated Result	Assessment Methodology
					expressions of interest, number of persons in stakeholder groups/attending workshops and potential replication plans by pilots	

3.3. Aspects related to the assessment of persons with dementia/older people, indicators and methods.

In this chapter, aspects related to the assessment of older people/persons with dementia, potential indicators and measurement methods and tools is discussed.

3.3.1 Quality of life

Living well with dementia requires the implementation of interventions that can impact positively on a person’s quality of life, indeed people with dementia live meaningful lives and retain many abilities if a supportive psychosocial environment exists. Spector & Orrell (2010) suggest that there are therefore protective/destructive psychosocial factors at play and that social engagement and sustained connectedness are crucial to improving the outcomes for people with dementia. Older people with dementia also have on average 2-8 co-morbidities (Schubert *et al.* 2006). A common non-age specific one is depression, whose prevalence in older people with dementia is between 8-30% (Enache *et al.* 2011). Higher resilience and regular exercise are correlated with lower depression levels (Pérez-López, *et al.* 2014), while physical activity has been shown to reduce both the symptoms of depression and cognitive decline regardless of the stage of dementia (Yerokhin *et al.* 2012).

Dementia is also characterised by progressive physical and sensory functional limitations that negatively impact on quality of life and the activities of daily living. The activities of daily living can be described in two broad classes: (1) Basic Activities of Daily Living or BADL Katz *et al.* 1970; Lawton & Brody 1969; Lawton 1990(and (2) Instrumental Activities of Daily Living or IADL (Lawton & Brody 1969). BADL are physical tasks essential to maintaining one’s independence and include the ability to toilet, feed, dress, groom, bathe, and ambulate. IADL are typically more cognitively demanding than BADL, and include the ability to successfully use the telephone, shop, prepare food, do the housekeeping and laundry, manage medications and finances, and use transportation outside of the home (e.g., driving a car, using public transit, or riding in a taxi).

In the early stage of dementia most people are independent with BADL. Most people with mild dementia will begin to need help with some IADL, especially complex tasks requiring multiple steps or extensive planning. BADL such as eating, dressing, and bathing are likely still to be carried out independently (Wattmo *et al.* 2013). As dementia progresses to the moderate stage, IADL such as work, medication management, remembering appointments and keeping track of personal finances become difficult or impossible. A person may begin to need help with BADL. In the moderate phase, cooking, housework, and shopping require direct assistance, BADL require assistance for set-up and safety, and completing BADL may be disrupted by behavioural and psychological symptoms such as anger, frustration, and difficulty communicating needs (Nowrangi *et al.* 2015). There is variability at this stage, depending on a person’s physical capabilities and the type of dementia, but for some, walking, transferring, bed mobility, and BADL may remain relatively independent. For others, especially those with physical limitations, more help may be required.

As dementia enters the severe stage, independence is gradually lost and caregivers must provide consistent direct care with most if not all BADL. Family members may find it impossible to continue to provide care and may be forced to move their relative to an assisted living or skilled nursing facility. Once a person reaches the severe stage of dementia, the more complex IADL have likely been completely taken over by a family member or caregiver. BADL will require a great deal of assistance to complete, depending on the person's physical capabilities.

Timely access to health care services is important in maintaining quality of life. The evidence to date reveals that access to timely information for people with dementia and their carers is often lacking (Ogain & Mountail 2015). There are key stages where the need for information is higher, in particular when a person progresses to a different stage of the disease (Newbronner *et al.* 2013). Obtaining timely access to this information and resultant changes in health status enables carers and people with dementia to make future health and life plans which may have a positive impact on quality of life.

3.3.2 Potential Indicators for Quality of life

The Potential Indicators that will be used to assess quality of life in this project will be the proportion of persons with dementia who assess the quality of their health to be good or very good and the extent and progression of cognitive, physical, sensory and functional limitations. The instruments used to measure these indicators will include the QoL- AD and the Cornell Scale for Depression in Dementia (CSDD), the Mini Mental State Examination (MMSE) (Folstein *et al.* 1975) and the Activities of Daily Living instrument developed by Katz *et al.* (1963). In addition the potential indicator to measure access of care will be the effectiveness of MARIO to conduct parts of the CGA. In the next section the measurement tools to measure these indicators is presented.

3.3.2.1 Measurements tools

Quality of Life (QOL-AD). (Logsdon *et al.* 1999)

The instrument to be used to assess QoL specifically for people with dementia will be Quality of Life (QOL-AD). It consists of 13 items that give one total score. It measures physical health & condition, energy, mood and memory; living situation; interpersonal relationships with family and friends; ability to participate in meaningful activities; financial situation; life as a whole. It is easy to administer by the interviewer, there is a detailed script to follow and no formal training is needed. On average it takes 10 mins to complete. There also exists a patient rated version for persons with mild to moderate dementia and a proxy caregiver rated version for all stages of dementia. The Internal consistency reliability (Cronbach' alpha) ranges from .84-.88 for patients and caregivers (Logsdon *et al.* 1999; Longsdon *et al.* 2002). Test re-test reliability is deemed acceptable (ICC=.76 for patients and .92 for caregivers - Logsdon *et al.* 1999). Moderate levels of cognitive impairment do not seem to adversely affect internal consistency reliability and patient-caregiver agreement (Logsdon *et al.* 1999; Longsdon *et al.* 2002). It has good internal consistency, validity and reliability (Thorgrimsen *et al.* 2003) and is sensitive to change (Thorgrimsen *et al*. 2003)

Cornell Scale for Depression in Dementia (CSDD) (Alexopoulos *et al.* 1988)

The Cornell Scale for Depression in Dementia (CSDD) was specifically developed to assess signs and symptoms of major depression in patients with dementia. The validity of the CSDD has been investigated and substantiated, including cross-culturally.15, the CSDD uses a comprehensive interviewing approach that derives information from the patient and the caregiver. The interviews focus on depressive symptoms and signs occurring during the week preceding the interview. Many of the items during the patient interview can be filled after direct observation of the patient. The CSDD takes approximately 20 minutes to administer. Each item is rated for severity on a scale of 0-2 (0=absent, 1=mild or intermittent, 2=severe). The item scores are added. Scores above 10 indicate a probable major depression. Scores above 18 indicate a definite major depression. Scores below 6 as a rule are associated with absence of significant depressive symptoms. The scale has high interrater reliability, internal consistency, and sensitivity (Alexopoulos 1988).

Mini Mental State Examination (MMSE) (Folstein, 1975)

The Mini–Mental State Examination (MMSE) or Folstein test (Folstein, 1975) is a 30-point questionnaire that is used extensively in clinical and research settings to measure cognitive impairment (Pangman, 2000). It is commonly used in medicine and allied health to screen for dementia. It is also used to estimate the severity and progression of cognitive impairment and to follow the course of cognitive changes in an individual over time; thus making it an effective way to document an individual's response to treatment interventions (Strauss *et al.* 2006). Administration of the test takes between 5–10 minutes and examines functions including registration, attention and calculation, recall, language, ability to follow simple commands and orientation (Tuijl. 2012). Any score greater than or equal to 27 points (out of 30) indicates a normal cognition. Below this, scores can indicate severe (≤9 points), moderate (10–18 points) or mild (19–24 points) cognitive impairment (Peetoom *et al.* 2014). The raw score may also need to be corrected for educational attainment and age (Crum, 1993). That is, a maximum score of 30 points can never rule out dementia.

Activities of Daily Living (Katz *et al.* 1963)

Activities of Daily living (ADL) consists of self-care tasks including functional mobility, often referred to as transferring (moving from one place to another while performing activities) (Katz, 1970). For most people, functional mobility is measured as the ability to walk, get in and out of bed, and get into and out of a chair; the broader definition above is useful for people with different physical abilities who are still able to get around independently. The items assess a number of daily activities including bathing and showering (washing the body) dressing, self-feeding (not including cooking or chewing and swallowing). Personal hygiene and grooming (including brushing/combing/styling hair), Toilet hygiene (getting to the toilet, cleaning oneself, and getting back up).The total score may range from 0–6. A lower score indicates a higher level of dependence. No formal reliability and validity results have been reported but nonetheless it has consistently demonstrated its utility in evaluating functional status in older people (Shelkey *et al.* 2012).

Comprehensive Geriatric Assessment[8]

The comprehensive geriatric assessment (CGA) is a multidimensional, usually interdisciplinary, diagnostic process intended to determine an older person's medical, psychosocial, and functional capacity and problems with the objective of developing an overall plan for treatment and long-term follow-up. It is particularly useful in dealing with frail older people, since they are likely to have multiple and interacting problems that interfere with daily functioning and complicate treatment, all of which can be better understood and addressed through the comprehensive assessment process. The process of geriatric assessment can range in intensity from a limited assessment by primary care physicians or community health workers focused on identifying an older person's functional problems and disabilities (screening assessment), to a more complete evaluations of these problems usually coupled with therapeutic plans by a multidisciplinary team with geriatric training and experience. Interestingly, there is a large and increasing body of evidence indicating that the prognosis of older patients is strongly related to the presence of concomitant diseases and to the degree of physical, cognitive, biological, and social impairment (Gill *et al.* (2010). The CGA, capable to effectively exploring these multiple domains of health, is indeed the multidimensional and multidisciplinary tool of choice to determine the prognosis of the functionally compromised and frail older subject. (Bagshaw and McDermid (2013). The CGA approach was also effectively evaluated in patients with dementia and it could be effective for preventing disease or complication and for maintaining the health status (Stuck et al. 1993; Riccio et al.2007; Pilotto et al. 2009).

Health status related outcomes will be addressed through the customisation of the comprehensive geriatric assessment (CGA). MARIO Kompai will seek to improve efficiency by completing some of the components of the Comprehensive Geriatric Assessment (CGA) and Multidimensional Prognosis Index (MPI). Efficiency gains should also allow certain components

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[8] Katz S, Downs TD, Cash HR, Grotz RC. Progress in the development of an index of ADL. Gerontologist. 10:20–30, 1970.

Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 9:179-186, 1969.

Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. J Am Geriatr Soc. 23:433-441, 1975.

Parmelee PA, Thuras PD, Katz IR, Lawton MP. Validation of the Cumulative illness rating scale in a geriatric residential population. J Am Geriatr Soc. 43:130-137, 1995.

Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, Albarede JL. The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. Nutrition. 15:116-122, 1999.

Bliss MR, McLaren R, Exton-Smith AN. Mattresses for preventing pressure sores in geriatric patients. Mon Bull Minist Health Public Health Lab Serv. 25:238-268, 1966.

of the CGA to be assessed more frequently and therefore aid effective tracking of the disease progression. This potentially could lead to reductions in costs associated with MARIO Kompai undertaking elements of the CGA.

3.3.3 Participation in society

Social participation is a key contributing factor to successful and healthy aging. Higher levels of social participation have been found to be associated with less cognitive impairment and depression irrespective of physical frailty (Okura *et al.* 2014). However many people with dementia find themselves socially excluded and stigmatised (Forbes *et al.* 2011). This results in reduced social participation (Cantley & Bowes 2004) and isolation (Batsch & Mittelman *et al.* 2012). In the context of long stay care settings many studies have found that residents devote most of their time unconnected and not engaged in any meaningful activity (Cohen Mansfield *et al.* 1992; Burgio *et al.* 1994; Harper-ice 2002). For people with dementia this persistent and continued lack of stimulation and social interaction exacerbates the lethargy, boredom, depression, and loneliness that are often manifest in the progression of dementia (Buettner *et al.* 1996; Cacioppo *et al.* 2006).

Within the literature there is a lack of consensus around the meaning of social participation and many terms are used interchangeable with it including social engagement, social connectedness, social capital, social support, social network, social integration, and community involvement (Levasseur *et al.* 2010). Levasseur *et al.* (2010) following an inventory and analysis of the aging literature acknowledge the multidimensional nature of social participation and define social participation as "…levels of involvement of the Individual with others in social activities". (P2147). They also conclude that there are six levels of involvement governed by the purpose of the interaction. These are doing an activity in readiness for connecting with others; being with others; interacting with people but not undertaking a specific activity; doing an activity with others, assisting others and contributing to society. Activities that promote supportive caring relationships and/or a sense of belonging to social organisations contribute to building resilience (Alaska Division of Behavioural Health 2008). Within the field of dementia such activities may be classified as psychosocial interventions (PSI's).

Psychosocial interventions are non-pharmacological interventions and as outlined by Bates *et al.* (2004) they consist of therapeutic endeavours involving human interactive behaviour between therapist(s) and client(s) (Bates *et al.* 2004). They operate through psychological and social processes and place the person with dementia at the centre of care. PSI interventions are diverse and wide ranging and include behavioural therapies, educational programmes, psychotherapy and social support interventions. The overall aim is to improve and maximise functioning and social connectedness and social performances in people with dementia. Strengthening social connectedness, enhancing autonomy and engaging people with dementia in meaningful activities that promote inclusion and preservation of cognitive functioning help to foster resilience (McFadden & Basting (2010). Resilience, defined as a "dynamic and amendable process" (Luthar *et al.* 2000) encompasses positive adaptation within the context of major adversity. It focuses on modifiable intra-personal skills and protective factors aimed at increasing a person’s ‘hardiness’, i.e. the ability to remain psychologically and physically healthy, or ‘resilient’, in the face of adversity. Resilience building in dementia focuses on strengthening personal attributes and external assets. Windle (2012). Psychosocial interventions that strengthen resilience by focusing on the personal attributes and external assets of people with dementia show strong potential (Dröes *et al.* 2004; Gaugler *et al.* 2007; Martin-Breen & Anderies 2011; van Dijk *et al.* 2012). However, most work on resilience building in dementia is theoretical and preliminary: no empirical psychosocial research involving people with dementia, explicitly using resilient theories to foster social connectedness and inclusion, have been reported. Mario Kompai, given its focus on companionship and fostering relationships and social connectedness, has the potential to impact on the resilience of people with dementia.

The acceptability of a robot companion may also influence social participation. However determining the acceptability of robots is complex and multifaceted (Spiekman, *et al.* 2011). Acceptance is influenced by factors involving individual human-robot interaction, stakeholders and wider society. Acceptance is affected by attitudes (Stafford *et al.* 2013); previous experiences (Stafford *et al.* 2010; Flandorfer 2012); perceived usefulness, (Heerink *et al.* 2010; Stafford 2013; Mitzner *et al.* 2014; Pino, Boulay *et al.* 2015; de Graaf& Allouch *et al.* 2015); how enjoyable (Heerink *et al.*. 2006; Young *et al.* 2009; Heerink *et al.* 2010) ; and easy the robot is to use (Kerssens *et al.* 2015) and the influence of other people (Gelderblom *et al.* 2012).

3.3.4 Potential Indicators for participation in society

The Potential Indicators that will be used to assess social participation in this project will be the proportion of people with dementia who report they feel they are participating or socially connected, perceive they have social support and feel resilient. In addition the engagement of the person with dementia will be captured through direct observations as they interact with MARIO. In addition the acceptability of the Mario Kompai robot will also be assessed.

The instruments that will be used to measure these indicators include the Social Dysfunction Rating Scale (SDRS) (Linn *et al.* 1969), the Multidimensional Scale of Perceived Social Support, and the Brief resilience Scale (BRS) (Smith 2008). In addition the Observational Measurement of Engagement (OME) tool will be used (Cohen Mansfield *et al.* 2009) to measure interactions with MARIO. Furthermore the perspective of people with dementia on engagement with MARIO, impact on loneliness, resilience and satisfaction will also be explored through the use of semi-structured interviews. Finally the potential indicators for acceptability will include older people’s attitude, satisfaction and likelihood to use the MARIO system. Caregivers and community homes, community managers and hospital staff will also be surveyed.

3.3.4.1 Measurement Tools

Social Dysfunction Rating Scale (SDRS) (Linn *et al.* 1969)

This scale was developed to assess negative aspects of a person’s social adjustment e.g. symptoms of low morale and reduced social participation (Linn 1988, McDowell 2006; Johnson

2010). The SDRS includes 21 social and emotional symptoms grouped into three classes i.e. respondent's self-image, interpersonal relationships, and concern lack of success and dissatisfaction in social situations. It was developed for use with adults and in particular older people (Dale 2010). Semi-structured questions are judged on a six-point severity scale namely not present, very mild, mild, moderate, severe and very severe. Items are not weighted differentially. Higher scores on the scale mean greater dysfunction. The SDRS is applied by an interviewer (e.g. therapists) familiar with the patient and the interview is completed in 30 minutes (McDowell 2006).

In terms of reliability, intra-class correlations of items between two interviewers were measured between 0.54 and 0.86 (Linn 1969, McDowell 2006; Johnson 2010). Kendall's coefficient of concordance was calculated as 0.91 between seven interviewers who assessed ten schizophrenic patients. As a result, reliability between interviewers can be high for complete score, but there is a wide range between individual scales (Linn 1969, McDowell 2006; Johnson 2010). There is little evidence of the validity of this scale and its use with people with dementia has not been reported. Therefore in this study the feasibility of using the SDRS scale with people with dementia will be tested.

The Multidimensional Scale of Perceived Social Support-(MPSS) (Zimet *et al.* 1988)

This scale developed by Zimet *et al.* (1988) measures the adequacy of social support provided by three different sources i.e. family, friends and significant others. The scale has been used with healthy people and those with a broad range of diseases including cancer, diabetes, addiction treatment, major depression, schizophrenia, haemodialysis, neuromotor and cognitive disorders, etc. to assess the perceived burden and social support of patients, caregivers and family members (Dale 2010) . The MSPSS scale includes three subscales i.e. family, friends and significant others (special person) subscales, and each subclass contains four items. The responses use a seven-point Likert scale between “1=Very strongly disagree” and “7= Very strongly agree”. MSPSS is an easy-to-use scale. Completion of scale approximately takes five minutes. To calculate subscale and total values, individual scores are added and then divided by the number of items. Lower values mean lower perceived support. The support levels can be interpreted as low, middle and high, if mean scale scores are between 1 and 2.9, 3 and 5 or 5.1 and 7, respectively (Zimet 1988; Dale 2010; Corcoran & Fischer 2013).

Internal reliability of the MSPSS measured using Cronbach's coefficient alpha for subscales of family, friends and other significant, and total scale were calculated as 0.87, 0.85, 0.91 and 0.88 respectively (Zimet 1988; Dale 2010). Test-retest reliabilities of these categories were measured as 0.65, 0.75, 0.72, and 0.85 (Zimet 1988; Dale 2010). In another study, high reliability (between 0.83 and 0.89) was found (Zimet 1988; Dale 2010). In terms of validity the correlation between MSPSS and Beck Depression Inventory was measured as -0.41 and -0.55 (Zimet 1988; Dale 2010). Similar to the SDRS the feasibility of using the MMPS scale with people with dementia will be tested.

Brief Resilience Scale (Smith 2008)

Windle *et al.* (2011) reviewed 19 scales that have been used to measure resilience. However none of these scales have been used or tested with people with dementia. In this study resilience will be measured by the use of semi structured questionnaires and in addition the feasibility of using the Brief Resilient Scale (BRS) (Smith 2008) with people with dementia will be tested. The Brief resilience Scale is a six item questionnaire designed to assess the ability to bounce back or recover from stress. Items 1, 3 and 5 are positively worded and items 2, 4, and 6 are negatively worded. Participants are asked to answer each question by indicating their agreement with each statement using the following scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The scale has good internal constancy with a Cronbach's alpha ranging from 0.80 to 0.91 (Smith *et al.* 2008). However as mentioned earlier there are no reports on its use with people with dementia.

The Observational Measurement of Engagement (OME) (Cohen Mansfield 2009).

This direct observational tool measures the interactions between people with cognitive impairment and environmental stimuli. This tool measures a number of dimensions including: engagement time, attention, attitude, and manipulation (Cohen Mansfield 2009). Each participant's attitude is measured on a 7–point scale, which ranges from very negative (1) to very positive (7). This scale has good inter–rater agreement rate and intra-class correlation (Cohen Mansfield 2009).

Almere Model (Modified Unified theory of Acceptance and use of Technology) Heerink *et al.* 2010

A number of measurement tools have been used to assess the acceptability of robotics. The Technology Acceptance Model (TAM) has been widely used, as has the Unified theory of Acceptance and use of Technology (UTAUT). However UTAUT has been found inadequate in the context of social robots and older people (Heerink *et al.* 2010). In addition others suggest that TAM and UTAUT are not able to provide a means of measuring acceptance of social robots for people with dementia in the context of care old people settings (Nestorov, Stone *et al.* 2014; McGlynn; Kemple *et al.*. 2014).

The Almere model which develops and expands the UTAUT to accommodate issues relating to older people and their acceptance of assistive social robotic agents (Heerink *et al.* 2010) will be used in this study. This model was tested using controlled experiments and longitudinal data with 3 different social robots, at elderly care facilities and in the homes of older adults without dementia. The modified UTAUT questionnaire include questions to measure anxiety, trust and attitude toward using the technology, perceived enjoyment in doing so, and perceptions of social presence, perceived sociability and perceived adaptability.

4. Chapter 4: Business model approach and supporting business cases

The indicators in Chapter 3 provide a mechanism to communicate impact and their derivation from, and mapping to the EIP-AHA monitoring framework provides a level of credibility and standardisation to the approach. The realization of innovation and growth, however, requires a business model and its communication / implementation to the appropriate customer segments.

4.1. Total Benefit

Not all of the MARIO assessment indicators relate to financial terms and any direct attempt to place value on those terms (such as quality of life) will likely be more disruptive than helpful to early adopters of MARIO systems. As such, a good way is to provide a business model framework that is intuitive and lets various stakeholders customise that business model for their own purposes guided by business cases.

The business model will be constructed around the total system benefit which can be expressed as:

$$Total\ Benefit = Qualitative\ Benefit + Quantitative\ Benefit \tag{1}$$

Where the qualitative benefit can be non-numerical linked to indicators that are not well suited for cost quantification and quantitative benefit can be a numerical calculation of savings. Placing qualitative benefits “upfront” or as “clearly visible” immediately communicates that the system delivers more than which is communicated by financial terms. One result of this equation could be:

$$\begin{aligned} Total\ Benefit = {} & 0.2\ reduction\ on\ the\ Cornell\ Scale\ for\ Depression\ in\ Dementia + \\ & 5000€\ savings\ per\ annum\ in\ staff\ monitoring\ costs \end{aligned} \tag{2}$$

In working with such an equation, it then becomes a matter of educating users about appropriate likely qualitative costs and quantitative costs. One technique is a table which can be placed in communication literature such as that shown in Table 13.

Table 13: Initial proposal for qualitative and quantitative benefit terms

Qualitative Benefits	Quantitative Benefits
Improvement to Quality of Life Improvement to Sustainability of Health Care Systems Improvement to Innovation & Growth	Reduced Direct Costs • Institutional care costs • Care and Diagnosis Costs • Monitoring/Surveillance Costs • Drug Costs Reduced Indirect Costs • Informal care costs

	• Lost opportunity costs of family members not working to provide care Cost Avoidance – any quantifiable benefits not captured in direct or indirect costs such as cost savings related to fall avoidance or physical activity improvement or other indicators.

4.2. MARIO Business Cases

Business cases can be coupled to user cases to provide instances of a MARIO business model and typically align with the targeted customer segments. In MARIO, we investigate three User Case / Business Case couplings as shown in Table 14.

Table 14: MARIO User Case / Business Case Pairings

User Case / Business Case	Description	Associated Pilot
UC/BC1	In home one robot-one individual care subsidised by a community care program	Stockport
UC/BC2	Long-stay care facilities: one robot-one individual	NUIG
UC/BC3	Hospital care settings: one robot -one individual with the focus on CGA assessment, surveillance activities, and process management improvement	IRCCS

The end result of each UC/BC is an example of the total benefit various stakeholders can anticipate from using MARIO. For exploitation oriented literature, these business cases will be supported by the activities of each pilot and notably by the expertise of the professionals at each pilot who are qualified to make sound estimates of the direct and indirect costs for at least their institution and scenario.

5. Chapter 5: Conclusions

This document has presented the motivation, development and realization of the MARIO Assessment Methodology. It is underpinned by and aligned to the EIP on AHA Monitoring Framework so that the project can report its commitments to the EIP on AHA and so that the project is immediately recognised as following an approach that is being widely adopted in Europe and one that is focused on realising innovation potential. Contact to the EIP-AHA has been made and if the EIP on AHA is open to receiving data from the MARIO project, we are prepared and now well aligned to provide those data.

The assessment methodology consists of four process indicators and nineteen outcome indicators. In addition, the planned assessment methodologies to evaluate those indicators are provided to include aspects related to the assessment of dementia as appropriate.

The assessment methodology is linked to a business model approach and the use of business case / use case couplings that are relevant to project activities and in specific the three pilots which represent unique and targeted customer segments. To begin to understand potential costs and benefits, an analysis of the prevalence and costs of dementia in Europe has been conducted and is included in this report.

6. ANNEXES

Annex 1: EIP AHA Outcome Questionnaire

Outcome questionnaire

Part 0: Privacy statement
I have read and accepted the privacy statement (see attachment) Yes/No

Part 1: General part: Questionnaire outcome indicators
Name of the organisation………..
Name of the commitment……….
Acronym of the commitment……
The commitment is submitted to the following Action Groups……………………………………………………

1. Short description of the intervention
Example: After a fall incident, the physiotherapist and the dietician make an integrated health plan. In this health plan there is an emphasis on the self-management of the patient. Each day the patient should count the calories and move at least 30 minutes. The patient has a device to send this information to the physiotherapist and the dietician. The technology used is an open platform. (±300 words)
………
………
………
………

2. Please give a description of your target group and main characteristics (e.g. sex, age, cardiac disease, frail problems, balance problems, polypharmacy)
Example: all **female** patients above **70** visiting physiotherapy in the city of Madrid having a **balance problem** after a **fall incident**. (±150 words)
………
………

3. Does your commitment affect (or impact) the delivery of care and do/did you use a business model? If yes, please describe this influence and /or the business model.
Example: As a result of the intervention, the regular hospital visits went down; there were less hospital admissions and less 'new' fall incidents. We didn't use a business model. (±150 words)
………
………
………
………

4. Evidence: are you registering any evidence? If yes, please give a brief description of the followed methodology.
Example: The methodology of this study is to **compare** the visits (hospital and general practioner), hospitalisation and 'new' fall incidents **with and without treatment by physiotherapist and a dietician** after a fall incident. (±200 words)
………
………
………
………

5. Indicators you are registering
5.1 Which indicators do you register in your commitment?

Please fill in the table if you are registering or planning to register information regarding the following issues. If you are registering or planning to register information we would also like to ask you to fill in the attached excel-file with more specific information regarding the indicators you are registering (or planning to register).

	Do you register, or are you planning to register information about	**Yes**	**No**	**Planned**
Nutrition	the (mal)nutrition, vitamin D consumption or other nutrition information of your target group?			
Physical activity	the physical activity of your target group, e.g. physical activity in the last 7 days, lifestyle, muscle strength, gait balance, Activities of Daily Living (ADL), self-sufficiency?			
Prevention and identification: risk and preventative factors	the adherence level of your target group?			
	the blood pressure of your target group?			
	the cholesterol level of your target group?			
	the glucose level of your target group?			
	the Body Mass Index (BMI) of your target group?			
	other risk factors and preventative factors of your target group e.g. abnormal lipid metabolism, persistence level (length of time between first and last dose of medication)?			
Health status	(self-assessed) health status of your target group?			
	the Quality of Life, mental well-being, … of your target group?			
	frailty index within your target group?			
	cognitive function within your target group?			
	functional capacity within your target group?			
Participation in society	voluntary work, social isolation, supportive relationships, social contacts, lack of participation due to physical barriers,…?			
Mortality and injuries	the number of people in your target group that died because of a chronic disease?			
	the number of people in your target group that had a fall incident or died because of a fall incident or…?			
Use of health and care services, such as information regarding hospitalisation	the hospital (re-)admissions of your target group?			
	the average length of stay in your target group, the bed days?			
	the number of hospital visits			
	other type of consumption of health and care services?			
Management of health and care services	the costs of health and care expenditures of your target group?			
	the costs of the drug use of your target group			
	the costs of hospitalisation			
	other costs /resource use (e.g. costs of home visits, costs of general practitioner visits)			
	patient satisfaction within your target group?			
	appropriateness of prescription?			
	adverse effects of prescription?			
	the use of drugs by patients?			
	training and education of health and care professionals or informal carers, patients and their family : e.g. number of training courses, number of participants?			
Care at home and institutionalisation	Proportion of your target group living at home, avoided institutionalisation, level of institutionalisation,…?			
Innovation	the implemented technology and devices, e.g. number of users; number of implemented apps, games, number of patients/older citizens receiving telehealth/telecare,…?			
Employment and growth	employment, e.g. the number of jobs created, number of companies created, growth of companies, …			

5.2 Are you registering other outcome indicators? If yes, please mention them below.

………

………

……

……

Annex 2: Activity Based Costing Framework in Healthcare

A.2.1. Activity Based Costing General Principles

Activity Based Costing (ABC) is a costing framework, mainly derived from the management accounting practices adopted by manufacturing industries, based on the assumption that in the production cycle resources (salaries, materials, etc.) are consumed by activities performed by the various departments of the industry and activities are consumed by cost objects (products and services). The method improves the accuracy of cost attribution as it goes beyond the traditional approach based on the simplistic assumption that products or services consume resources. It focuses on the segregation of fixed vs. variable vs. overhead costs. While direct labour and materials are rather easy to link to products, allocating indirect costs is more difficult and one needs some kind of weighting. In this framework, a cost driver is a weighting factor that drives the cost of the activity. For example, the exact or estimated time spent to perform a given activity could be in some case considered as a viable cost driver to weight indirect costs.

The method allows the organizations adopting it to improve the allocation of resources answering to simple questions that are nevertheless essential for the management of complex organizations: what is the cost to produce a single product? Why a given product/service has that cost? If one changes the way in which products/services are executed, how are costs affected?

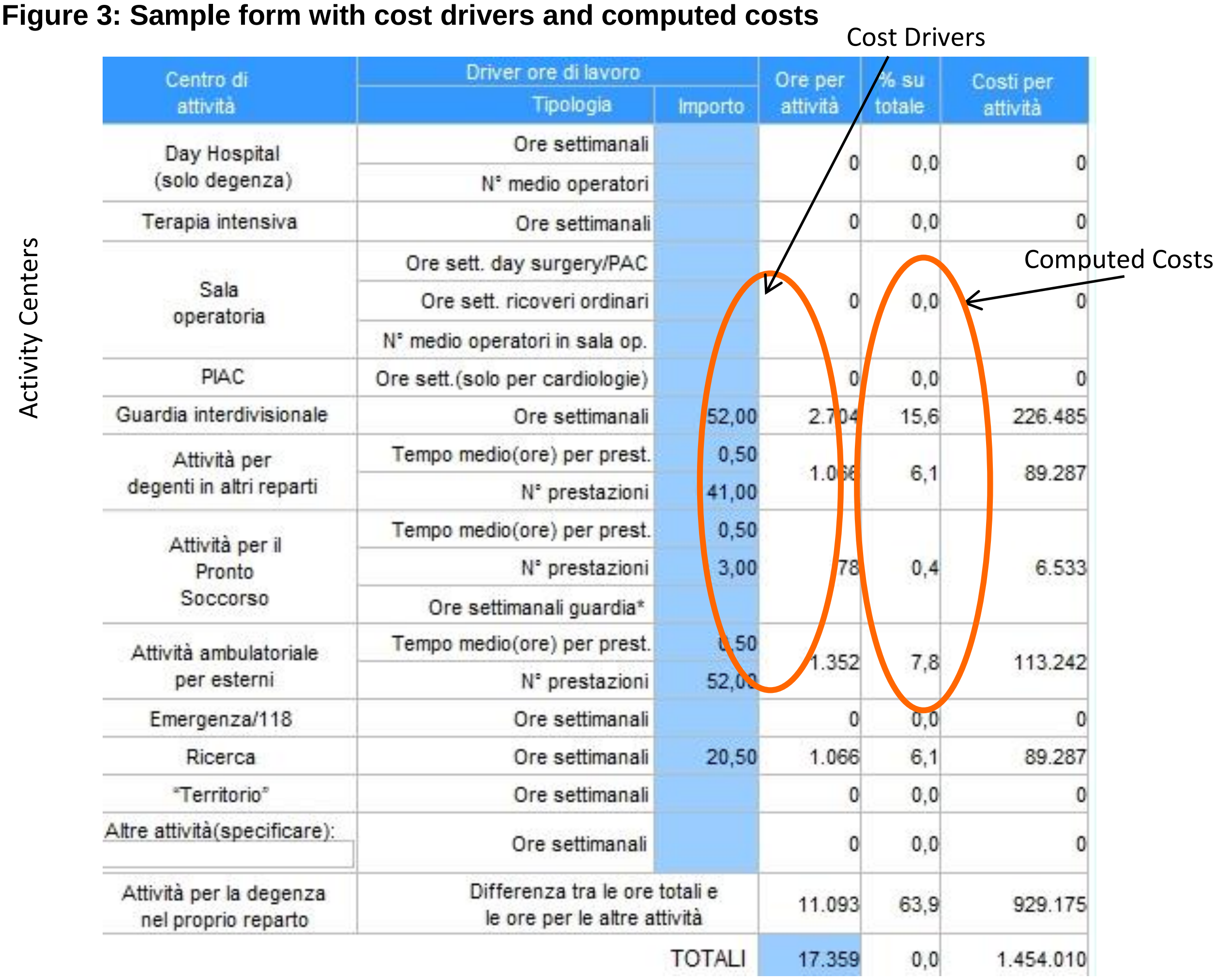
A.2.2. ABC implementation in Healthcare

IRCCS Casa Sollievo della Sofferenza adopts a Hospital ABC approach to know how the resources it provides contribute to give its patients all they need. This methodology allows computing the cost for a single hospitalization event split for each employed resource (medical staff, nursing staff, drugs, etc.). Since 2009 IRCCS is also the founder of the N.I.San., the Italian Health Network for the sharing of Standard Costs. This association is made of healthcare providers sharing the same ABC methods and tools to compute the cost of what they produce. For a given product, in this case for each type of hospitalization event (identified by the proper DRG code), each node belonging to the network can compare its own costs with the mean cost (also called “standard cost”) obtained considering the mean of the costs of the nodes of the network for that particular type of hospitalization event.

A.2.3. The fundamentals of the method

Since in a single hospitalization case the patient usually requires health services from many clinical units, the starting point is the identification of the “activity centres” (operating rooms, clinical ward, outpatient clinic, resuscitation unit, intensive care, other services, etc.). To correctly allocate costs to each activity centre the IRCCS uses a form in which each head of the clinical unity declares an estimate of the time spent by the personnel of his unit for each activity. A sample form with cost drivers and computed costs is presented in Figure 3.

Figure 3: Sample form with cost drivers and computed costs



Cost Drivers

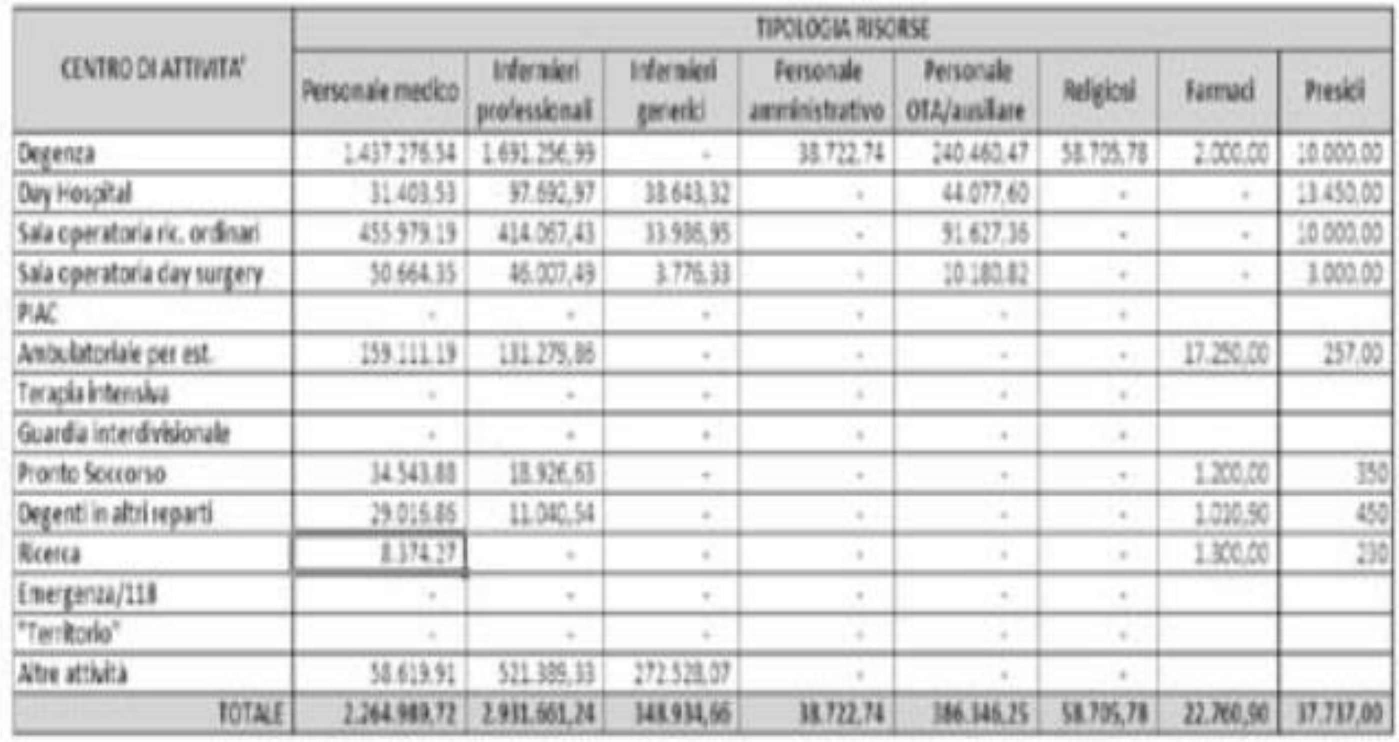
Computed Costs

Activity Centers

Centro di attività	Driver ore di lavoro		Ore per attività	% su totale	Costi per attività
	Tipologia	Importo			
Day Hospital (solo degenza)	Ore settimanali		0	0,0	0
	N° medio operatori				
Terapia intensiva	Ore settimanali		0	0,0	0
Sala operatoria	Ore sett. day surgery/PAC		0	0,0	0
	Ore sett. ricoveri ordinari				
	N° medio operatori in sala op.				
PIAC	Ore sett.(solo per cardiologie)		0	0,0	0
Guardia interdivisionale	Ore settimanali	52,00	2.704	15,6	226.485
Attività per degenti in altri reparti	Tempo medio(ore) per prest.	0,50	1.066	6,1	89.287
	N° prestazioni	41,00			
Attività per il Pronto Soccorso	Tempo medio(ore) per prest.	0,50	78	0,4	6.533
	N° prestazioni	3,00			
	Ore settimanali guardia*				
Attività ambulatoriale per esterni	Tempo medio(ore) per prest.	0,50	1.352	7,8	113.242
	N° prestazioni	52,00			
Emergenza/118	Ore settimanali		0	0,0	0
Ricerca	Ore settimanali	20,50	1.066	6,1	89.287
"Territorio"	Ore settimanali		0	0,0	0
Altre attività(specificare):	Ore settimanali		0	0,0	0
Attività per la degenza nel proprio reparto	Differenza tra le ore totali e le ore per le altre attività		11.093	63,9	929.175
	TOTALI		17.359	0,0	1.454.010

Using various cost drivers (for example the time spent on each activity) this step allows to coherently allocating the expenditures for the staff and the consumption goods for each organizational unit to the right activity centre. The result of this activity is shown in the Kaplan West matrix in Figure 4.

Figure 4: An example of expenditure for the employed results



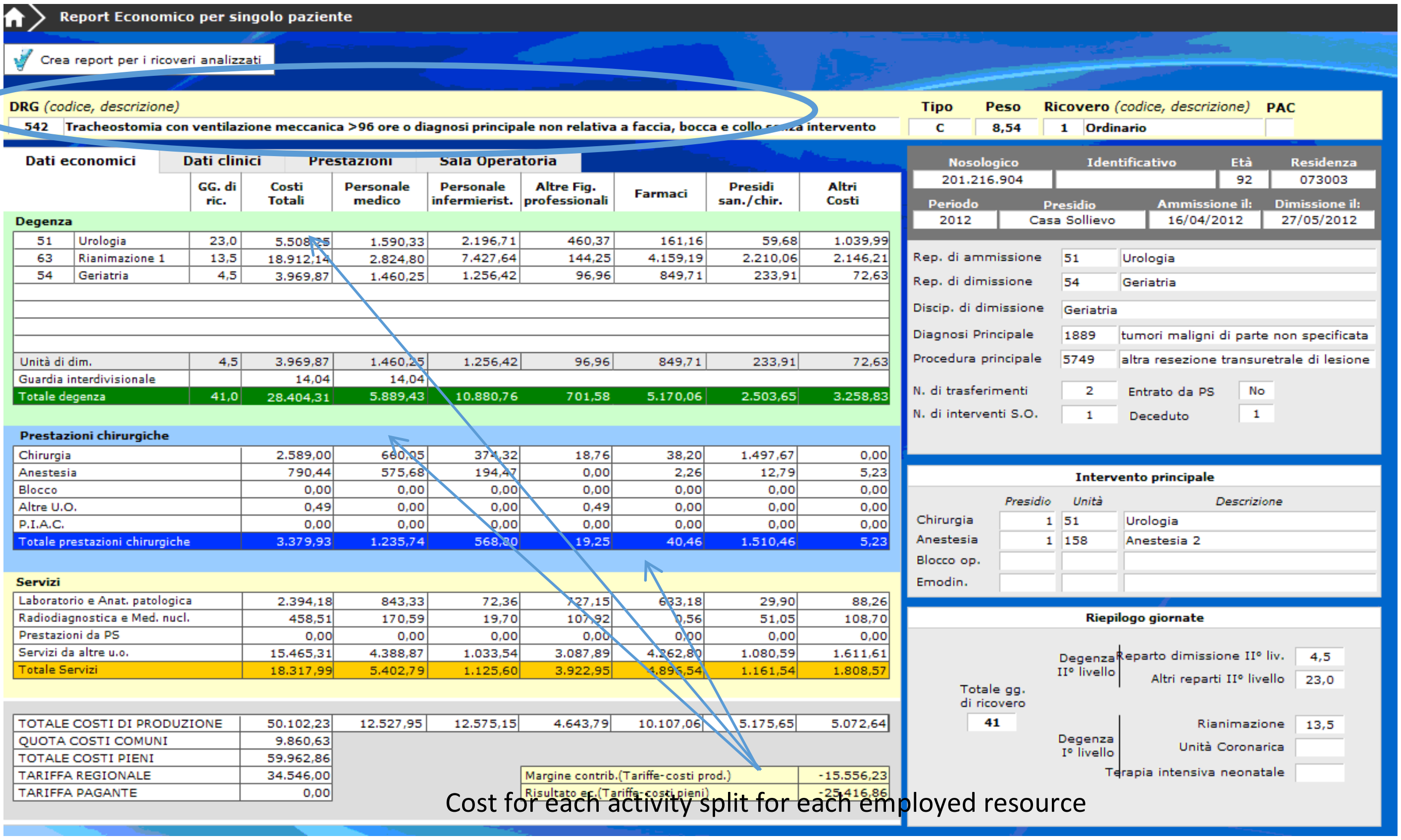
Activity Centre's

CENTRO DI ATTIVITA'	TIPOLOGIA RISORSE							
	Personale medico	Infermieri professionali	Infermieri generici	Personale amministrativo	Personale OTA/ausiliare	Religiosi	Farmaci	Presidi
Degenza	1.437.276,34	1.691.256,99	-	38.722,74	240.460,47	58.705,78	2.000,00	10.000,00
Day Hospital	31.403,53	97.692,97	38.643,32	-	44.077,60	-	-	13.450,00
Sala operatoria ric. ordinari	455.979,19	414.067,43	33.986,95	-	91.627,36	-	-	10.000,00
Sala operatoria day surgery	50.664,35	46.007,49	3.776,33	-	10.180,82	-	-	3.000,00
PIAC	-	-	-	-	-	-		
Ambulatoriale per est.	159.111,19	131.279,86	-	-	-	-	17.250,00	257,00
Terapia Intensiva	-	-	-	-	-	-		
Guardia interdivisionale	-	-	-	-	-	-		
Pronto Soccorso	34.543,88	18.926,63	-	-	-	-	1.200,00	350
Degenti in altri reparti	29.016,86	11.040,54	-	-	-	-	1.010,90	450
Ricerca	8.374,27	-	-	-	-	-	1.300,00	230
Emergenza/118	-	-	-	-	-	-		
"Territorio"	-	-	-	-	-	-		
Altre attività	58.619,91	521.389,33	272.528,07	-	-	-		
TOTALE	2.264.989,72	2.931.661,24	348.934,66	38.722,74	386.346,25	58.705,78	22.760,90	37.737,00

Once the costs are allocated to each activity centre, they are assigned to the single hospitalization cases and consequently to their aggregation, namely the single DRG (Diagnosis Related Group). To obtain this result, for each hospitalization episode the method considers the episode type (long stay care, day hospital, day surgery), the diagnosis, the principal operating procedures and then assigns, according to a system of predetermined weights, the cost to that episode.

Once attributed overhead costs we obtain, for each DRG, the final matrix that contains the full cost split for the type of activity (operating rooms, clinical ward, outpatient clinic, resuscitation unit, other services, etc.) and for resource type (medical staff, nursing staff, drugs, etc.). A sample matrix is presented in Figure 5

Figure 5: Sample Matrix



Report Economico per singolo paziente

Crea report per i ricoveri analizzati

DRG *(codice, descrizione)*		Tipo	Peso	Ricovero *(codice, descrizione)*		PAC
542	Tracheostomia con ventilazione meccanica >96 ore o diagnosi principale non relativa a faccia, bocca e collo senza intervento	C	8,54	1	Ordinario	

		GG. di ric.	Costi Totali	Personale medico	Personale infermierist.	Altre Fig. professionali	Farmaci	Presidi san./chir.	Altri Costi
Degenza									
51	Urologia	23,0	5.508,25	1.590,33	2.196,71	460,37	161,16	59,68	1.039,99
63	Rianimazione 1	13,5	18.912,14	2.824,80	7.427,64	144,25	4.159,19	2.210,06	2.146,21
54	Geriatria	4,5	3.969,87	1.460,25	1.256,42	96,96	849,71	233,91	72,63
Unità di dim.		4,5	3.969,87	1.460,25	1.256,42	96,96	849,71	233,91	72,63
Guardia interdivisionale			14,04	14,04					
Totale degenza		41,0	28.404,31	5.889,43	10.880,76	701,58	5.170,06	2.503,65	3.258,83
Prestazioni chirurgiche									
Chirurgia			2.589,00	660,05	374,32	18,76	38,20	1.497,67	0,00
Anestesia			790,44	575,68	194,47	0,00	2,26	12,79	5,23
Blocco			0,00	0,00	0,00	0,00	0,00	0,00	0,00
Altre U.O.			0,49	0,00	0,00	0,49	0,00	0,00	0,00
P.I.A.C.			0,00	0,00	0,00	0,00	0,00	0,00	0,00
Totale prestazioni chirurgiche			3.379,93	1.235,74	568,80	19,25	40,46	1.510,46	5,23
Servizi									
Laboratorio e Anat. patologica			2.394,18	843,33	72,36	727,15	633,18	29,90	88,26
Radiodiagnostica e Med. nucl.			458,51	170,59	19,70	107,92	0,56	51,05	108,70
Prestazioni da PS			0,00	0,00	0,00	0,00	0,00	0,00	0,00
Servizi da altre u.o.			15.465,31	4.388,87	1.033,54	3.087,89	4.262,80	1.080,59	1.611,61
Totale Servizi			18.317,99	5.402,79	1.125,60	3.922,95	4.896,54	1.161,54	1.808,57
TOTALE COSTI DI PRODUZIONE			50.102,23	12.527,95	12.575,15	4.643,79	10.107,06	5.175,65	5.072,64
QUOTA COSTI COMUNI			9.860,63						
TOTALE COSTI PIENI			59.962,86						
TARIFFA REGIONALE			34.546,00						
TARIFFA PAGANTE			0,00						

Margine contrib.(Tariffe-costi prod.)	-15.556,23
Risultato ec.(Tariffe-costi pieni)	-25.416,86

Nosologico	Identificativo	Età	Residenza
201.216.904		92	073003

Periodo	Presidio	Ammissione il:	Dimissione il:
2012	Casa Sollievo	16/04/2012	27/05/2012

Rep. di ammissione	51	Urologia
Rep. di dimissione	54	Geriatria
Discip. di dimissione	Geriatria	
Diagnosi Principale	1889	tumori maligni di parte non specificata
Procedura principale	5749	altra resezione transuretrale di lesione

N. di trasferimenti	2	Entrato da PS	No
N. di interventi S.O.	1	Deceduto	1

Intervento principale

	Presidio	*Unità*	*Descrizione*
Chirurgia	1	51	Urologia
Anestesia	1	158	Anestesia 2
Blocco op.			
Emodin.			

Riepilogo giornate

Totale gg. di ricovero: 41

Degenza II° livello	Reparto dimissione II° liv.	4,5
	Altri reparti II° livello	23,0
Degenza I° livello	Rianimazione	13,5
	Unità Coronarica	
	Terapia intensiva neonatale	

Cost for each activity split for each employed resource

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