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TECHNOLOGY ASSESSMENT IN HEALTHCARE THROUGH SOCIAL RETURN ON INVESTMENT: THE CASE OF VIRTUAL COACHING FOR HEALTHY AGEING

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Contents

List of Figures

List of Tables

Abstract

English version

Population ageing represents one of the major challenges that contemporary society is going to face in the coming years. This phenomenon is putting high pressure on the healthcare system and makes it necessary to identify specific instruments ensuring to live longer in healthy conditions, concept also referred to as healthy ageing.
Several technological innovations have been proposed and continue to be proposed to successfully move in this direction.

It emerges the need to provide valid guidelines and methodologies to support decision-makers in healthcare in the evaluation process of the proposed innovative technologies. Traditionally, cost-benefit analysis (CBA) is employed. Anyway, it has historically been under discussion. In recent times, social return on investment (SROI) methodology has been promoted as a more 'holistic' approach for demonstrating value-for-money of initiatives.

Given the lack of evidence concerning SROI analysis of technologies, the authors developed and validated a model for performing an SROI analysis when evaluating innovative technologies promoting healthy ageing.
To address the research question, an inductive approach has been employed, selecting as a starting point the real case of a virtual coach for healthy ageing: European NESTORE H2020 project.

NESTORE is a multi-dimensional and personalized virtual coaching technology for the enhancement of people's well-being and quality of life after their 65. SROI for NESTORE (under the assumption of an implementation in the Lombardy Region) has been defined involving as stakeholders the Lombardy Region healthcare system, beneficiaries (senior adults living in the Lombardy Region), the Lombardy Region economic system and beneficiaries' familiar caregivers. SROI ratio (over a time horizon of 10 years) oscillates between 1,36 and 2,23; therefore, the project results to be value-for-money. The result has been validated by NESTORE Consortium itself.

This study contributes to the existing literature on the SROI, confirming that there is room for its application when dealing with healthcare technologies. In addition, it represents a useful aid for NESTORE decision-makers and distributors, supporting them in the definition of a suitable and detailed exploitation strategy for the initiative.

Keywords: CBA; SROI; Virtual coaching; Healthy ageing

Italian version

Il processo di invecchiamento della popolazione rappresenta una delle maggiori sfide per la società contemporanea. Esso pone sotto pressione il sistema sanitario e rende necessaria l'identificazione di strumenti specifici per garantire, con l'avanzare dell'età, il mantenimento di buone condizioni di salute. Questo concetto è anche noto come "healthy ageing" .
Diverse innovazioni tecnologiche sono state e continuano ad essere proposte per procedere con successo in questa direzione.

Emerge dunque la necessità di fornire linee guida e metodologie valide per supportare i decision-makers nel processo di valutazione delle tecnologie proposte. Tradizionalmente, in sanità, viene utilizzata l'analisi costi-benefici (CBA). Tuttavia, tale strumento è stato storicamente oggetto di forti discussioni. Recentemente, la metodologia del Social Return on Investment (SROI) è stata proposta come un approccio più olistico, che consenta di dimostrare il rapporto valore-costo di una data iniziativa.

Data l'assenza, in letteratura, di contributi relativi all'analisi SROI di tecnologie, gli autori hanno sviluppato e validato un modello per applicare lo SROI alla valutazione di tecnologie innovative volte a promuovere l'"healthy ageing".
Per rispondere alla domanda di ricerca, è stato adottato un approccio induttivo, identificando il caso reale di un virtual coach per l'healthy ageing: il progetto europeo H2020 NESTORE.

NESTORE è una tecnologia di coaching virtuale multidimensionale e personalizzata, che mira al miglioramento della salute e della qualità della vita dopo i 65 anni. Il modello SROI per NESTORE (presupponendo l'implementazione nella Regione Lombardia) è stato definito coinvolgendo come stakeholders il Sistema Sanitario della Regione Lombardia, beneficiari (40-79enni che risiedono nella Regione Lombardia), il sistema economico della Regione Lombardia ed i caregiver familiari dei beneficiari. Lo SROI calcolato (considerato un orizzonte temporale di 10 anni) oscilla tra 1,36 e 2,23; di conseguenza, la valutazione finale circa il progetto risulta essere positiva. Il risultato è stato validato dal NESTORE Consortium stesso.

Lo studio in oggetto contribuisce alla letteratura esistente sullo SROI, confermando la sua potenziale applicazione nella valutazione di tecnologie in sanità. Inoltre, esso rappresenta un valido supporto per i decision-makers ed i promotori dell'iniziativa NESTORE, supportandoli nella definizione di una efficace strategia di diffusione.

Keywords: Analisi costi-benefici; Ritorno sociale sull'investimento; Virtual coaching; Healthy ageing

Executive summary

0.1 Problem statement and research objective

Population ageing, defined as the increase in the share of older persons, is occurring throughout the world as a consequence of reductions in fertility and improvements in survival to older ages (European Commission & Economic Policy Committee, 2014). Figures coming from the United Nations show that the number of people aged 80 years or over is projected to increase more than threefold between 2017 and 2050 (United Nations Department of Economic and Social Affairs, 2017). Population ageing implies a reduction in the number of economically active people per pensioner, thus changing the old-age dependency ratio and thereby putting more pressure on the healthcare system. Therefore, for the coming decades, there is a societal goal to maximize the number of people who, experiencing a positive trajectory of ageing, remain healthier and independent for longer (World Health Organization, 2015). This phenomenon is frequently referred to as "healthy ageing". Nowadays, we are assisting in a high-pace proposal for technologies aimed at promoting healthy ageing. These solutions represent an interesting opportunity for the healthcare system; anyhow, budget constraints require to identify proper methods to support decision-makers in assessing the proposed technologies and selecting those to implement (D. Greenberg et al., 2005).
Traditionally, cost-benefit analysis (CBA) is employed to assess the value-for-money of initiatives in healthcare (National Institute for Clinical Excellence, 2004). CBA has historically been under discussion. Critiques can be reduced to two major issues: firstly, CBA merely lists benefits that cannot be easily monetized; secondly, it evaluates costs and benefits from a unique perspective, neglecting comprehensive contributions from the complex network of actors that initiatives in healthcare typically involve (Ackerman (2008), Frank (2000), Sen (2000) and Self et al. (2015)).
In recent times, the social return on investment (SROI) method has been promoted as a more holistic approach for demonstrating value-for-money of healthcare initiatives. SROI measures broader socio-economic outcomes, analyzing and computing views of multiple stakeholders in a singular monetary ratio and employing financial proxies to estimate the monetary value of benefits that cannot be easily monetized. In addition, it accounts for and values potential negative outcomes of a given solution (Banke-Thomas et al. (2015), Nicholls and Lawlor (2012) and Arvidson and McKay (2013)). Even the SROI has been criticized. Actually, it results tough, in the assessment, to establish the counterfactual (what would have happened without the intervention) (Brady, 2011).
Since the application of CBA in the healthcare field has already been widely ex-

plored and given the existence of scarce evidence on the adoption of SROI in the health-related area, the purpose of the current study is to assess whether there is room for the application of SROI methodology in the healthcare field, especially when dealing with technologies for healthy ageing.

0.2 State of the art

Design of the literature review

The State of the art section aims at offering a complete overview of the knowledge that has been developed so far on the topics of healthy ageing, cost-benefit analysis in healthcare and social return on investment in healthcare. It follows a detailed comparison between cost-benefit analysis and social return on investment.

Healthy ageing

The authors conducted a narrative literature search and review on the topic of healthy ageing in order to establish a focus and context for the downstream research. Ageing is associated with an increased risk of a person having more than one disorder at the same time (multimorbidity) (Arokiasamy et al., 2015). Multimorbidity can result in health status in older age that are not captured at all by traditional disease classifications and that are therefore often missing in disease-based assessments of health (Inouye et al., 2007). This complexity of health status implies some difficulty in clarifying the nature of the concept of healthy ageing itself (Lordos et al., 2008). Investigating the literature, it emerges that the definitions of healthy ageing range from the primary biological, such as survival with absence of morbidity, to the comprehensive, such as sustained well-being measured across physical, social and psycho-cognitive functioning. Despite the wide-ranging approaches, the majority of the studies emphasizes the maintenance and development of functional ability and independence in their definition (Ford et al. (2000), Vaillant and Mukamal (2001), Burke et al. (2001), Von Faber et al. (2001), Liotta et al. (2018) and United Nations (2017)).
Healthy ageing can be enhanced by physical activity, proper nutrition, and cognitive and social stimulation. In detail, undermining a healthy ageing path through these initiatives can:

- Reduce senior adults' morbidity of cardiovascular diseases, cancer, type 2 diabetes, fracture, Alzheimer, osteoarthritis, osteoporosis, obesity, and depression (Christie et al. (2017), Sherrington et al. (2019), Heath and Stuart (2002), Scrafford et al. (2019), van Bel et al. (2009), Hsiao et al. (2018) and Merom et al. (2016));
- Reduce senior adults' mortality from cardiovascular diseases, cancer, stroke and diabetes (Rajgopal et al. (2002), Abdullah et al. (2015), van Bel et al. (2009) and Umberson and Karas Montez (2010));
- Increase senior adults' quality of life (Penedo and Dahn (2005), Aranceta et al. (2001), Alessi et al. (1999), Alexander et al. (2013), Merom et al. (2016), Hsiao et al. (2018), Craik et al. (2010), Soga et al. (2017) and M. C. Morris et al. (2015)).

These conditions enable massive cost savings for the healthcare system (Christie et al., 2017).

Cost-benefit analysis of technologies in healthcare

CBA is an economic appraisal tool for the comparison of costs and benefits of a project, with the goal to support decision-making. It translates both, costs and consequences for a unique stakeholder involved in a given initiative (typically the payer) into monetary terms (Brzozowska et al., 2007).

Methodology

Evidence on cost-benefit analysis in healthcare has been detailly explored through a systematic search and narrative review. Being the investigation of technology assessment methods in healthcare the purpose of the current discussion, the authors considered it preferable to perform a systematic search in order to obtain a full overview of the research conducted on cost-benefit analysis until the present date. To guide the analysis, the following main research question has been formulated: "Which is the framework worldwide researchers employ to conduct cost-benefit analysis when dealing with technologies in healthcare?".
To proceed in a structured way, the research question has been restructured in six sub-questions dealing with the following topics: perspective of analysis, cost items involved, benefit items involved (and monetization methods), time horizon adopted, discount rate, uncertainty and sensitivity analysis.

Systematic search

For the development of an effective systematic search strategy, the 12-step framework proposed by Kable et al. (2012) has been applied:

1. Purpose statement: the purpose has been stipulated as discovering which framework worldwide researchers employ to conduct CBA in healthcare when dealing with technologies;
2. Databases, search engines used: the investigated databases were Scopus, PubMed, and Web of Science (WoS);
3. Search limits: the authors limited the search to abstracts and titles of journal articles in the English language, published between January 1, 2009, and August 31, 2019. Further limits, depending on the specific database, were applied to the subject area;
4. Inclusion and exclusion criteria: only journal articles dealing with human medicine and providing a practical example of CBA implementation were included in the search;
5. Search terms: an in-depth exploration of the three selected databases produced the query «Cost-Benefit Analysis AND (Health or Drug*) AND Technolog*»;
6. Exact searches per database, search engine, and the results: the total number of articles resulted from the exploration of the three databases was equal to 851;
7. Relevance assessment of retrieved literature: the elimination of duplicates and the reading of abstracts in the light of inclusion and exclusion criteria produced 43 results. The full-text reading produced 17 results;
8. Table reporting literature included in the review, accompanied by key data such as title, author, citations and quartiles (according to Scimago Journal & Country) (Table 4.4);

9. Document final number of search results: articles requiring a downloading fee were asked directly to the authors through the ResearchGate.com website. All the requests have been satisfied;
10. Quality assessment of retrieved literature: the quotation of each article publishing journal according to Scimago Journal & Country has been included in the aforementioned table;
11. Review;
12. Accurate, complete reference list.

Narrative review and discussion of results

The review revealed that solely 2 out of 17 authors (Harat et al. (2012) and Battistoni et al. (2016)) realize a complete CBA, meeting each of the six research sub-questions.
16 authors declare a perspective (Sommers (2017) is excluded) and detail costs (McKenzie et al. (2010) is excluded).
Contributions decrease as it comes to the identification of benefits and monetization methods (12 authors, excluded Natafgi et al. (2018), Greenspoon et al. (2013), O'Reilly et al. (2011), Roudsari et al. (2016) and Samson et al. (2018)), to the time horizon (10 authors, excluded Roper et al. (2015), Walwyn and Nkolele (2018), Sommers (2017), McKenzie et al. (2010), Tur-Kaspa et al. (2010), Greenspoon et al. (2013), Natafgi et al. (2018)) and to the discount rate (6 authors, Roper et al. (2015), Akiyama and Abraham (2017), Battistoni et al. (2016), Harat et al. (2012), O'Reilly et al. (2011) and Poder et al. (2017)); as well as when performing a sensitivity analysis (9 authors, Roper et al. (2015), Akiyama and Abraham (2017), Harat et al. (2012), Roudsari et al. (2016), Natafgi et al. (2018), Battistoni et al. (2016), Poder et al. (2017), Jeuland and Whittington (2009), and Samson et al. (2018)). This result confirms Banke-Thomas et al. (2015) critique of the CBA: often authors simply list benefits that cannot be easily monetized, escaping their translation into monetary terms.
It follows an analysis of the most relevant results across the different research sub-topics.

Perspective adopted All the articles adopt the perspective of the payer for the initiative. In detail, 14 authors out of 17 adopt the healthcare system perspective; 4 of these also involve a patient perspective (Jeuland and Whittington (2009), Samson et al. (2018), Roudsari et al. (2016) and O'Reilly et al. (2011)).
Authors employ the CBA method for assessing both healthcare technologies and processes: 11 authors (Roper et al. (2015), Akiyama and Abraham (2017), Battistoni et al. (2016), Testa et al. (2015), Vannieuwenborg et al. (2016), Roudsari et al. (2016), Poder et al. (2017), O'Reilly et al. (2011), McKenzie et al. (2010), Greenspoon et al. (2013), Natafgi et al. (2018)) perform a technology evaluation. Only one author (McKenzie et al. (2010)) analyses a technology from the patient perspective (meaning that typically technological initiatives are subsidized by the healthcare system).
Cost items Cost items involved in the assessment change according to the subject under investigation (technology or process) and to the perspective adopted. The cost of initial investment for technologies from the healthcare system perspective is a recurring item: 9 authors out of 11 (Roper et al. (2015), Battistoni et al. (2016),

O'Reilly et al. (2011), Testa et al. (2015), Poder et al. (2017), Greenspoon et al. (2013), Roudsari et al. (2016), Natafgi et al. (2018), Akiyama and Abraham (2017)) in this crossing (technology and healthcare system) mention it.

Benefit items Experts claiming to adopt a certain perspective for the analysis, in reality, often overcome the limits of the single adopted perspective and involve benefits for different actors. Benefit items change according to the potential impact of the solution proposed, independently from the nature of the intervention. Benefit items from the healthcare system perspective include: reduced hospitalization, reduced other medical expenditures, reduced risk/mistake, increased staff productivity. Benefit items from patient perspective include: decreased mortality, decreased morbidity, increased life expectancy, increased productivity, enhanced health consciousness, decreased anxiety of day-to-day life, better quality of care. Benefits monetization seems to be controversial. Excluding benefits represented by cost savings, experts are resistant to proceed towards monetization of potential outcomes of a strategy, favoring, in case, Willingness to Pay or Human Capital method.

Sensitivity analysis The authors perform a sensitivity analysis regarding results, the selected discount rate, and costs and benefits (especially the efficiency of a technology, process).

Social return on investment of technologies in healthcare

SROI compares the net present value of benefits (outcomes) derived from an initiative to the net present value of the resources invested (inputs) (Gargani, 2017). It measures broader socio-economic outcomes, analyzing and computing views of multiple stakeholders in a singular monetary ratio (Banke-Thomas et al., 2015).

Methodology

Evidence on social return on investment in healthcare has been detailly explored through a systematic search and narrative review.

The following main research question has been formulated: "Which is the framework worldwide researchers employ to compute SROI when dealing with technologies in healthcare?".

To proceed in a structured way, the research question has been restructured in six sub-questions dealing with the following topics: stakeholders included, input items involved, outcome items involved (and monetization methods), time horizon adopted, discount rate and analysis of uncertainty (including deadweight[1], drop-off[2], attribution[3], and displacement[4]).

[1]Deadweight is a measure of the amount of outcome that would have happened even if the initiative had not taken place: it is calculated as a percentage and it is assessed referring to comparison groups or benchmarks.

[2]Drop-off is an assessment of the mitigation or decay of the outcomes of the initiatives of the course over time.

[3]Attribution is an assessment of how much of the outcome was caused by the contribution of other organizations or people: attribution is calculated as a percentage.

[4]Displacement is an assessment of how much of the outcome displaced other outcomes (e.g. reducing crime in one area may displace criminal activity to another area).

Systematic search

The 12-step framework proposed by Kable et al. (2012) has been applied.
The purpose has been stipulated as discovering which framework worldwide researchers employ to conduct SROI analysis in healthcare when dealing with technologies.
Databases explored, search limits defined, as well as inclusion and exclusion criteria, correspond to those for the CBA systematic search.
An in-depth exploration of the three selected databases produced the query «Social Return On Investment OR SROI AND (Health or Drug*)». The total number of articles resulted from the exploration of the three databases was equal to 122. The elimination of duplicates and the reading of abstracts in the light of inclusion and exclusion criteria produced 18 results. The full-text reading produced 10 results (3 articles that passed the abstract reading could not be obtained through ResearchGate.com and did not enter the analysis). Table 5.4 reports literature included in the review, accompanied by key data such as title, author, citations and quartiles (according to Scimago Journal & Country).

Narrative review and discussion of results

The review revealed that 4 out of 10 authors (Bellucci et al. (2019), Tanaree et al. (2019), Goudet et al. (2018), Bosco et al. (2019)) realize a complete SROI analysis, meeting each of the six research sub-questions. 10 authors declare who the stakeholders involved are and detail the time horizon. Contributions slightly decrease as it comes to the identification of outcomes and monetization methods (9 authors out of 10, excluded Banke-Thomas et al. (2015)), to the input items (8 authors, excluded Banke-Thomas et al. (2015) and Muyambi et al. (2017)) and to the discount rate (7 authors, excluded Akingbola et al. (2015), Muyambi et al. (2017), and Arvidson and McKay (2013)). Only 4 authors (Bellucci et al. (2019), Tanaree et al. (2019), Goudet et al. (2018), Bosco et al. (2019)) deal with uncertainty. This result confirms Banke-Thomas et al. (2015) praise to the SROI: the percentage of authors involving and monetizing outcomes increases respect to the CBA, as the identification of proper financial proxies enables a streamlined monetization. Analogously, also Brady (2011) critique of the SROI is confirmed: in the assessment, it results difficult to deal with uncertainty; particularly with displacement, attribution, deadweight and drop-off.
In addition, it resulted that no article refers to the evaluation of a technology; they all concern a health process.
It follows an analysis of the most relevant results across the different research sub-topics.

Stakeholders involved Papers can be categorized into three groups, corresponding to the level of involvement of stakeholders. Some papers (2 out of 10, Akingbola et al. (2015) and Ricciuti and Bufali (2019)) include in the analysis only beneficiaries, while other papers (5 out of 10, Muyambi et al. (2017), Goudet et al. (2018), Banke-Thomas et al. (2015), Bosco et al. (2019) and Arvidson and McKay (2013)) consider also the role of promoters and implementers; in the end, other papers (3 out of 10, Ramon et al. (2018), Bellucci et al. (2019) and Tanaree et al. (2019)) take into account a broader plethora of stakeholders that can be directly or indirectly

touched by the health initiative.
Input items When assessing a healthcare process, the most recurring input item (8 authors out of 10, excluded Banke-Thomas et al. (2015)and Muyambi et al. (2017)) is the staff cost.
Outcome items When assessing a healthcare process, the most recurring outcome item (8 authors, excluded Banke-Thomas et al. (2015) and Ramon et al. (2018)) is the increased Quality of Life. They follow increased social inclusion and staff satisfaction. The heavy involvement of social inclusion confirms Nicholls and Lawlor (2012) praise to the SROI: it includes broader social implications derived from a given initiative. Focusing on monetization, it emerges a predominant use of financial proxies, along with Cost Savings, Human Capital and Willingness to Pay.
Uncertainty Referring to the SROI, uncertainty involves both the estimation of the counterfactual and a sensitivity analysis. The counterfactual refers to the definition of attribution, drop-off, displacement, and deadweight. Merely 4 authors (Bellucci et al. (2019), Tanaree et al. (2019), Goudet et al. (2018) and Bosco et al. (2019)) mention them, providing poor justification for their value.

Conclusions and gaps

Evidence confirms how part of CBA limits (especially the adoption of a single perspective and the resistance to the monetization of the most complex benefits (Ackerman (2008), Sen (2000)), in healthcare, are being overcome through an SROI-oriented approach. Anyway, SROI itself, as observed by Brady (2011), is not free from complexities: dealing with several stakeholders introduces some ambiguities in the analysis that often the concepts of deadweight, drop-off, attribution, and displacement fail in solving.

0.3 Empirical research

Objectives and methods

Starting from the awareness that their systematic literature search did not produce any evidence in terms of SROI for technology in healthcare, the authors aimed at developing and validating a model for performing an SROI analysis when evaluating technologies in healthcare. In detail, stated the urgent social and economic implications deriving from population ageing (World Health Organization, 2017), the authors decided to focus on technologies fostering healthy ageing.
To offer a consistent, solid and validated model of SROI, the authors proceeded through an inductive method: starting from a real case and then generalizing the model developed. The adoption of a real case is a research approach used to generate an in-depth, multifaceted understanding of a complex issue in its real-life context (Crowe et al., 2011). The authors selected the case study of NESTORE H2020 program (Non-intrusive Empowering Solutions and Technologies for Older people to Retain Everyday life activity) since it represents one of the most innovative eHealth solutions available nowadays in Europe leveraging technological advancements in order to support population ageing. As an H2020 project, NESTORE can guarantee the availability of public, valuable and trustworthy information on the project strictly necessary to set the analysis. Another crucial factor that drove the choice towards NESTORE is represented by the synergies between the purpose of

the SROI methodology and that of an H2020 project: the former allows to capture and monetize the social implications that the latter fixes it as its own primary objectives.

The case study of NESTORE

NESTORE, a project funded by the European Union Horizon 2020 Research and Innovation Programme, is a multi-dimensional and personalized virtual coaching technology for the enhancement of people's well-being and quality of life after their 65. It aims at supporting healthy ageing by leveraging on five different levers through personalized suggestions: physical activity, nutrition, social, cognitive and psychological stimulation. NESTORE system operates through tangible objects and sensors, as well as software and apps, enabling monitoring and coaching. NESTORE Consortium seems inclined to propose NESTORE as a medical device, subsidized and distributed to senior adults by the healthcare system itself through General Practitioners.

Towards the model

Methodology and design of the model

It is important to highlight that NESTORE project is still in a development phase and has not been implemented yet. Therefore, the authors performed a prospective SROI analysis aiming at the best possible estimation of outcomes and inputs. In detail, they explored the potential impact that NESTORE could generate if implemented in the Lombardy Region.
The prospective SROI analysis for NESTORE has been developed following six main stages (Nicholls and Lawlor, 2012):

1. Establishing scope (setting the boundaries for the analysis) and identifying key stakeholders.
Stakeholders have been identified by combining both stakeholders involved by NESTORE project (as declared by NESTORE Consortium itself) and actors typically interacting with or economically bound to senior adults. Under the hypothesis to implement the project in the Lombardy Region, a complete list includes beneficiaries (40-79 in health individuals in the region), Lombardy Region healthcare system, beneficiaries' familiar caregivers, Lombardy Region economic system (including professional caregivers), NPOs and NGOs, Municipalities, pharmaceutical, and biomedical companies. NPOs, NGOs, and Municipalities have been excluded in order to avoid double-counting issues in the analysis. Pharma and BioMed companies have been excluded due to relevant complexities in estimating their contribution to the final result.
Although NESTORE was designed to address 65+ individuals, the World Health Organization (2015) has underlined how the most coherent strategy to reduce the burden of morbidity in older age is to promote healthy behaviors and to control risk factors earlier in life. Therefore, the authors found it reasonable to include 40+ beneficiaries in their analysis.
2. Mapping outcomes, concerned with identifying inputs (what stakeholders are contributing in order to make the activity possible), valuing inputs (to give a value to non-monetised inputs), and describing outcomes (positive and negative consequences of the initiative).

Input value has been estimated together with representatives from the NESTORE Consortium (in particular, Fondazione Politecnico di Milano, that plays the role of coordinator for the project). The list of outcomes derives from an in-depth exploration of the literature on the potential benefits of healthy ageing (Chapter 3) in the light of the Lombardy Region current features and conditions.
3. Evidencing outcomes and giving them a value, concerned with collecting outcomes data and monetizing outcomes (eventually recurring to proper financial proxies).
Outcomes quantification and monetization has been estimated employing data coming from ISTAT databases and Lombardy Region healthcare system official website.
4. Establishing impact ("corrected" impact), concerned with correcting outcome in the light of deadweight, displacement, attribution, and drop-off.
Displacement has been assumed equal to 0%: the undermining of a prevention path for individuals in the Lombardy Region cannot result in worse health conditions for those excluded from the project. Drop-off has been assumed equal to 0%: time effects (e.g. obsolescence of the proposed technology) have been dealt with through the selection of a proper time horizon. Deadweight has been assumed equal to 0%: given the prospective nature of the study, it results impossible to create a control group for its exact estimation. Attribution has been assumed equal to 95% (5% outcome loss): the authors assumed that only 5% of beneficiaries' morbidity reduction comes from prevention interventions different from NESTORE.
5. Calculating the SROI, having defined the time horizon for the analysis and the discount rate. They follow the conduction of a sensitivity analysis and the computation of the payback period.
10 years represent the maximum time horizon allowing a complete overview of the benefits that NESTORE can offer, without the risk of obsolescence of the technology. The cost of capital has been assumed equal to 3,5% as HM Treasury (2003) Green Book for public authorities recommends.
6. Reporting, using and embedding

Table 1 details the developed model.

Identifying stakeholders	**Mapping and valuing outcomes**			**Establishing impact**	**Calculating the SROI**
	Input (NPV on 10 years with a discount rate of 3,5%) (€)	**Outcomes**	**Outcomes** (NPV on 10 years with a discount rate of 3,5%) (€)	Attribution=95%	$\sum_{n=1}^{10} \frac{\frac{Impact(n)}{(1+k)^n}}{\frac{Input(n)}{(1+k)^n}}$
Lombardy Region healthcare system	€8.551.160.116 (cost to acquire and distribute NESTORE)	Reduced beneficiaries' morbidity	€1.182.345.936 (Monetization method: cost saving)	€1.123.228.639	
		Reduced familiar caregivers' morbidity	€1.328.803 (Monetization method: cost saving)	€1.262.363	
Beneficiaries (40-79 living in the Lombardy Region, in health and willing to use a virtual coach - 2.669.271 individuals)		Reduced beneficiary's morbidity	€18.028.695.911 (Monetization method: Willingness to Pay)	€17.127.261.116	
		Reduced need for full-time professional caregivers	€24.740.580* (Monetization method: cost saving)	€23.503.551*	
Familiar caregivers (full-time employed beneficiaries' familiar caregivers - 2.464.571 individuals)		Reduced need for full-time familiar caregivers	€252.064.766 (Monetization method: financial proxy - income increase)	€239.461.527	
Lombardy Region economic system (including full-time professional caregivers)		Reduced need for full-time professional caregivers	- €24.740.580* (Monetization method: economic loss)	- €23.503.551*	
		Reduced beneficiaries' work absence due to illness	€567.002.272 (Monetization method: cost saving)	€538.652.158	
Total	**€8.551.160.116**		**€20.031.437.687**	**€19.029.865.803**	**2,23**

Table 1: SROI model. * Value annihilate themselves

Discussion of the results

In terms of sensitivity analysis, by varying the effectiveness of NESTORE in reducing the beneficiary's morbidity and its cost, SROI ratio oscillates between 1,36 and 2,23. The project is, in any circumstance, value-for-money. In addition, looking

at the payback period, it results that NESTORE is value-for-money since year 1. Analyzing stakeholders and impact items' contribution to the total impact, it results that beneficiaries are the actors that benefit the most from the implementation of the project. In detail, beneficiary's reduced morbidity (measured through Willingness to Pay) plays the most relevant role. This means that a traditional CBA, performed involving merely the healthcare system (that finances the project), would have labeled NESTORE as not-value-for-money. As a matter of fact, CBA on NESTORE provides a result equal to 0,13.
Analyzing age groups' contribution to the total impact, it results that 50% of the result is attributable to 65-79 beneficiaries and 50% to 40-64 beneficiaries. Therefore, the authors' initiative to involve 40+ in the project finds validity in the analysis results.
Analyzing genders' contribution to the total impact, it results that 59% of the result is attributable to females and 41% to males. This evidence can become particularly relevant when driving a marketing strategy for NESTORE.

Validation

The authors' analysis has been presented to NESTORE Consortium and international reviewers during the "NESTORE review meeting", held on the 12th of November 2019. These actors deeply appreciated the attempt to monetize the social implications of NESTORE and considered of high value the possibility to estimate how impact is spread among different stakeholders.

0.4 Conclusions and limitations

Theoretical contribution

In terms of theory, the current study offers original results to the existing literature on impact assessment through the SROI method on two different levels.
On one level, it contributes to the literature as an in-depth systematic analysis on the topics of SROI and CBA in healthcare.
On a second level, given the lack of evidence on the adoption of the SROI method for assessing technologies, it represents a first attempt to adopt the SROI model for evaluating technologies in healthcare.

Focusing on the first level, the systematic exploration of the CBA literature confirms that authors, in the wake of tradition, tend to adopt a single perspective of analysis (as declared by Sen (2000)). In detail, solely 4 articles out of 17 adopt multiple points of view when balancing costs and benefits. Even the CBA resistance to monetize (or simply to list) the most complex benefits (as declared by Ackerman (2008)) finds validity in the authors' search: 5 out of 17 authors do not even mention benefits in their analysis.
In contrast, the systematic exploration of the SROI literature confirms that the method enables the involvement of the point of view of multiple stakeholders (as declared by Banke-Thomas et al. (2015) and Arvidson and McKay (2013)). As aforementioned, retrieved papers can be categorized into three groups, corresponding to the level of involvement of stakeholders: beneficiaries (2 authors out of 10), beneficiaries and implementers (5 authors out of 10), broader group of actors (3

authors out of 10). As for the ability of the SROI to capture social implications (declared by Nicholls and Lawlor (2012) and Banke-Thomas et al. (2015)), evidence on the method involves benefits, such as lower criminality and savings for the State, that a traditional CBA would have completely neglected. Focusing on monetization, 9 authors out of 10 proceed towards a conversion of outcomes into monetary terms. In particular, it emerges a predominant use of financial proxies (7 authors out of 10). This result confirms Banke-Thomas et al. (2015) praise to the SROI: the use of proper financial proxies enables a streamlined monetization. Reinforcing critiques of the SROI, only 4 out of 10 authors involves deadweight, drop-off, attribution and displacement.

Focusing on the second level, the model developed by the authors is aligned with available evidence on SROI in healthcare as it embraces a broad plethora of stakeholders (quite analogous to those involved by Tanaree et al. (2019)) to guarantee their engagement in the initiative and the completeness of the study (Banke-Thomas et al., 2015). In addition, it includes outcomes with a social nature (Nicholls and Lawlor, 2012), such as beneficiaries' Willingness to Pay for reduced morbidity (as Muyambi et al. (2017) and Ricciuti and Bufali (2019)) and familiar caregivers' reduced morbidity, moving beyond traditional economic implications. In detail, involving health-related implications for familiar caregivers among the outcomes represents a novelty in the literature.
Arvidson and McKay (2013) mentioned as an SROI advantage the inclusion of negative outcomes in the assessment. Anyway, no evidence exists strengthening this statement. As a further novelty, the model developed by the authors cites and monetizes negative outcomes (loss for the Regional economic system).

Moreover, the study contributes to the literature on virtual coaches for healthy ageing, offering an economic evaluation of these preventive initiatives.

Managerial contribution

SROI analysis is a strategic tool to support promoters of a given initiative (e.g. NESTORE Consortium) in ensuring that the initiative they are promoting is managing the most economic and social implications and risks. In addition, this method allows to manage unexpected outcomes, both positive and negative and to demonstrate to public services financing the initiative (e.g. Lombardy Region healthcare system) that the business is securing social value. SROI plays a fundamental role in facilitating strategic discussions, creating a formal dialogue with stakeholders and in identifying common ground between what promoters want to achieve and what their stakeholders want to achieve (Social Value, UK, 2012).

Limitations and further developments

The authors invite future researchers to enrich their analysis by enlarging the list of stakeholders involved (e.g. involving BioMed and pharmaceutical companies); by employing data on costs and outcomes directly collected on the field about NESTORE project (moving beyond the prospective nature of the current discussion); by defining control groups and involving ex-post and proven-in-the-field values for deadweight; by surpassing the current weak validation that the model has obtained so far, employing the model for assessing other technologies operating in the healthcare field.

Part I

Introduction

Chapter 1

Problem statement and research objective

1.1 World population ageing

World population is ageing: **older people are increasing in number** and make up a growing share of the population in every country, with implications for nearly all sectors of society, including labour and financial markets, the demand for goods and services such as housing, transportation, and social protection, as well as family structures and inter-generational ties (Bloom et al., 2015).

Figures coming from the United Nations Department of Economic and Social Affairs (2017) show that population ageing [1] is occurring throughout the world: each of the 201 countries or areas with at least 90,000 inhabitants in 2017 is projected to see an increase in the proportion of persons aged +60 between 2017 and 2050.
More in-depth, the global population aged +60 numbered 962 million in 2017, more than twice as large as in 1980 when there were 382 million older people worldwide; the number is expected to double again by 2050 when it is projected to reach nearly 2.1 billion.
Globally, **the number of people aged 80 years or over is projected to increase more than threefold between 2017 and 2050**, rising from 137 million to 425 million. In addition, in 2030, older people are expected to outnumber children under age 10 (1.41 billion versus 1.35 billion); in 2050, projections indicate that there will be more older people aged +60 than adolescents and youth at ages 10-24 (2.1 billion versus 2.0 billion). The Figure 1.1 shows global population by broad age group in 1980, 2030 and 2050.

As reported by the European Commission & Economic Policy Committee (2014), population ageing is driven by reductions in fertility and improvements in survival that occur during the demographic transition [2].

[1] The inevitable increase in the share of older persons that results from the decline in fertility and improvement in survival that characterize the demographic transition (United Nations, 2017).

[2] The phenomenon and theory of the demographic transition refers to the historical shift in demographics from high birth rates and high infant death rates in societies with minimal technology, education (especially of women) and economic development, to demographic of low birth rates and low death rates in societies with advanced technology, education and economic

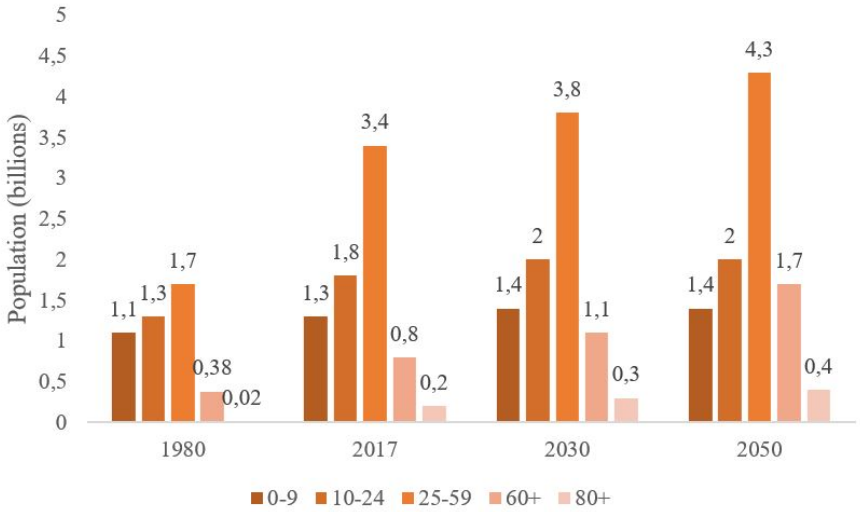

Figure 1.1: United Nations (2017). World Population Prospects: the 2017 Revision

Europe was the first region to enter the transition, having begun the shift to lower fertility and increased longevity by the late nineteenth or early twentieth centuries in almost all areas. Consequently, many of the countries in the region are among the world most aged. The demographic transition began later in Asia and in Latin America and the Caribbean; as a result, their populations are youthful compared to those in Europe and in Northern America. Many countries in Africa remain in the early stages of the demographic transition: some have begun to see reductions in fertility only recently, while others have yet to see a significant decline in fertility. Thus, while the number of older people has grown, their share of the overall population has remained small.

Although **fertility has been the most influential factor in shaping trends in the number and proportion of elders in the world population** over the long term, **improvements in survival to older ages have contributed to population ageing as well** (Lee and Mason, 2010; Preston et al., 2001).
Since 1950-1955, life expectancy at birth has risen by more than 10 years in Northern America, Europe, and Oceania, and by close to 25 years in Latin America and the Caribbean. In each of these regions, life expectancy is projected to surpass 80 years in the coming decades. Asia has achieved the largest gains in survival, adding nearly 30 years to life expectancy at birth from 1950-1955. The region is projected to continue to make improvements, with life expectancy projected to increase from 72 years in 2010-2015 to 78 years in 2045-2050 (United Nations, 2017). Figure 1.2 shows life expectancy at birth by region, both sexes combined, form 1950 to 2050.

Population ageing, even if following different asynchronous development paths around the world, represents one of the major challenges that the contemporary society is going to face in the coming years, making it necessary to identify specific instruments to prevent its negative impacts (World Health Organization, 2015).
More in detail, increasing life expectancy together with decreasing fertility rates will reduce the number of economically active people per pensioner in the years

development, as well as the stages between these two scenarios (WHO, 2015).

to come, thus changing the old-age dependency ratio and thereby putting more pressure on the healthcare system (United Nations, 2017).
Therefore, for the coming decades, **there is a societal goal to maximize the number of people who experience the positive trajectory of ageing (healthy ageing)**, thus lightening the burden on the healthcare system. This fact necessitates a shift from treatment towards prevention of age-related diseases and a need to develop innovative solutions that 1) enable the ageing generation to stay healthy and independent longer and 2) empower the elders to take care of their own health and function (World Health Organization, 2015).

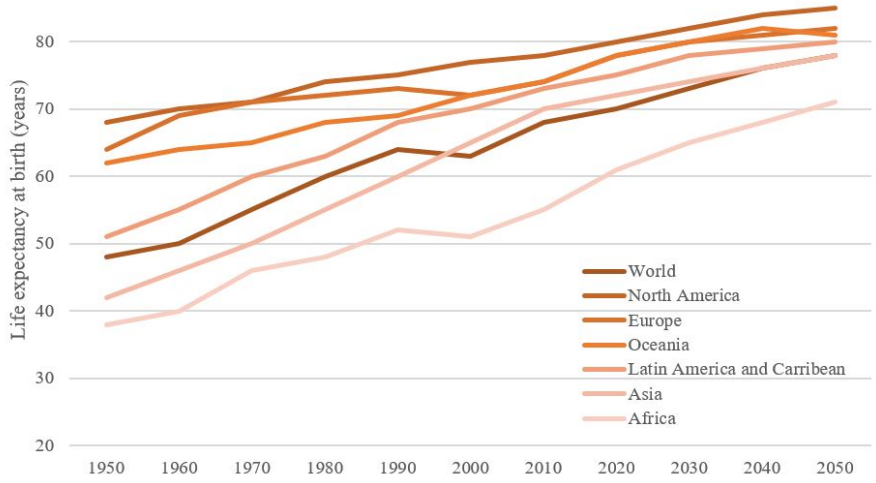

Figure 1.2: United Nations (2017). World Population Prospects: the 2017 Revision

1.2 The concept of healthy ageing

World Health Organization (2015), in its report on ageing and health, affirms that the ageing process is extremely complex to be described since it varies among individuals. As the organization points out, by age 60, the physical and mental functionalities of the person can start to decline, but their deterioration can have different consequences for elders' lives: indeed, a disease can be easily controlled for one person while it can lead to severe consequences for another.
Furthermore, the WHO affirms that, with ageing, the risk of contracting more than one disease at the same time, a phenomenon called multi-morbidity, is significantly higher. This makes even more difficult to identify the effects of the different diseases when describing the ageing process.
Moreover, the pathologies that can hit a person can evolve in many different ways. For example, old people who experienced heart failure can follow different trajectories of illness, and their needs may vary considerably.

Healthy ageing is an umbrella term that, in its broadest sense, embodies the idea of an ageing process that allows an individual to still enjoy overall satisfaction with their life (Liotta et al., 2018).

The WHO (2015) defines healthy ageing as "the process of developing and maintaining the functional ability that enables well-being in older age."
In this context, functional ability entails the capability that persons have to meet their basic needs, to learn, grow, and make decisions, to be mobile, to build and maintain relationships, and to contribute to society. This encompasses both capabilities on the individual level, such as the intrinsic abilities to walk, think, see, hear, and remember, as well as external factors in the environment such as societal relationships, attitudes and values, and health and social policies (World Health Organization, 2015).

However, **there is an ongoing debate about how to exactly define healthy ageing**, and how to apply the WHO framework to real-world scenarios. The WHO (2015) itself acknowledges that healthy ageing cannot be uniformly defined since ageing is a highly personal process with diverse outcomes differing significantly from person to person.
To overcome these issues, it has been proposed to decompose the concept of ageing in several dimensions. For example, EuroHealthNet (2012) , a European partnership that promotes health, equity, and well-being, subdivided healthy ageing into subcategories spanning nutrition, exercise, social aspects, as well as environmental aspects to capture the scope of measures that are in use across the projects they support. WHO (2015) guidelines, instead, suggest the following health constituting dimensions: physical health, mental health (defined by psychological and cognitive well-being) and social well-being. An individual undermines a healthy ageing path once none of them is compromised by their behaviours and attitudes.

1.3 Research objective

Having taken note of the threat deriving from the rapid ageing of the population, **it is necessary to promote healthy ageing practices for the elders. Several technological innovations have been proposed and continue to be proposed to successfully move in this direction**.

The continuous and high-pace proposal of innovative solutions to promote every field of health, alongside healthy ageing, represents a double-edged sword for the healthcare system.
On the one hand, it can benefit from the availability of innovative solutions aiming at lightening its burden and promoting citizens' health; on the other hand, the presence of numerous valuable options and the limitation in terms of investment budgets lead to the necessity to select and implement only some of the innovative solutions available on the market.
Therefore, **it emerges the need to provide valid guidelines and methodologies to support decision-makers in the evaluation process of the proposed innovative technologies**. In particular, decision-makers must be provided with all the essential elements, as all the implications, costs, consequences and results achievable through the technology, to evaluate and compare different solutions.

Traditionally, cost-benefit analysis (CBA) is employed to support decision-making in healthcare and value-for-money of health interventions (National Institute

for Clinical Excellence, 2004).
CBA measures both, costs and consequences, in terms of money. Anyway, it **has historically been under discussion** as it results to be extremely difficult to translate consequences, as clinical results, into monetary terms. Given this difficulty, frequently practitioners resist its adoption. To this, ethical issues add, such as the reluctance in providing a monetary value to human life (Ackerman, 2008).
Frank (2000) claims that CBA is a flawed procedure, which should not be central to public policy decisions on human health or other issues. In practice, CBA exhibits numerous problems, ranging from deep ethical and logical contradictions to a persistent tendency towards forecasting errors and partisan abuse. Some of these flaws could, in theory, be corrected; others are inherent in the methodology and underscore the need for alternatives. More in detail, CBA, at first, wrongly aims at pricing the priceless as the costs and benefits of health policies are not normally expressed in comparable units. In addition, CBA requires definite numbers on each side of the balance sheet, to allow the comparison of costs and benefits. Anyway, many important questions of health policy involve inescapably uncertain outcomes. According to Sen (2000), it also has to be noticed that the costs and benefits of public policies do not always occur simultaneously. While both can occur over a period of years, the benefits of health protection often extend much farther into the future than the costs and this can lead to misleading results for the analysis.
To conclude, CBA follows standard economic practice in discounting future amounts, converting them to their equivalent value today. However, discounting is a perfectly sensible practice when evaluating financial transactions that occur within a single lifetime, but it becomes problematic and controversial when extended beyond its domain of validity.

Even moving beyond the healthcare field, there have been several critiques against the use of CBA to assess projects and technologies.
The critiques of CBA can be reduced to one statement according to which "numbers don't tell everything". The implication from the critiques of CBA is that these evoke cautiousness or wariness against an economized calculation in the environment, health, and natural resources policy in which inherent incommensurability exists (Hwang, 2016).
Going more in detail, a first criticism is that CBA cannot deal with the non-commensurable dimensions of a policy or project evaluation, particularly those dimensions that cannot (or, for ethical reasons, should not) be given a monetary valuation (Frank, 2000).
A second criticism is that CBA treats a dollar as a dollar, regardless of who it is removed from, or accrues to. This gives a greater weight to higher-income consumers, who have a lower marginal utility of income and hence can 'pay more' to secure a benefit or avoid a loss. In that sense, aggregating willingness to pay involves an information loss, relative to a 'perfect' utility measure, due to differences in the marginal utility of income (Self et al., 2015).
The third and final criticism of CBA is that it is based on complex assumptions, and hence likely to be inaccurate (Sen, 2000).

In recent times, **social return on investment (SROI) methodology has been promoted as a more 'holistic' approach for demonstrating value-**

for-money and, thus, as an alternative respect to the traditional CBA.
The social return on investment (SROI) methodology has the capacity to measure broader socio-economic outcomes, analysing and computing views of multiple stakeholders in a singular monetary ratio (Banke-Thomas et al., 2015).
In the most recent SROI methodology guidance, SROI is defined as "a framework for measuring and accounting for the much broader concept of value. It seeks to reduce inequality and environmental degradation and improve wellbeing by incorporating social, environmental and economic costs and benefits" (Nicholls and Lawlor, 2012).
SROI has been described as an extension of the CBA that additionally incorporates the broader socio-economic and environmental outcomes (Arvidson and McKay, 2013).
Anyway, also the SROI has been criticized, highlighting both its strengths (including capacity to generate a singular ratio that captures both positive and negative outcomes, provision of platform for meaningful engagement of multiple stakeholders and its representation of stakeholder benefits in ways that are unique to the stakeholders themselves) and weaknesses (difficulty of attaching financial values to "soft outcomes" and establishing what would have happened without the intervention (the counterfactual) as well as poor comparability of SROI ratios across interventions) (Brady, 2011).

Banke-Thomas et al. (2015) offer a comprehensive resume and comparison of the two evaluation methods when applied to the healthcare field (Table 1.1):

	CBA	**SROI**
Main objective	To assess if an initiative is worth the investment	To assess if an initiative is worth the investment
Costs	Monetary value	Monetary value
Benefits	Captures health and non-health impacts. Reported as monetary value or welfare benefit. Lists benefits that cannot be easily monetized and explains why they cannot be monetized.	Captures health and non-health impacts, underpinned by the "triple bottom line" approach (social, economic and environmental). In addition, seeks to account for and value potential negative effect of interventions. Reported as monetary value or welfare benefit. Uses financial proxies to estimate monetary value of benefits that cannot be easily monetized.
Timeline of analysis	Retrospective or Prospective	Retrospective or Prospective
Discounting of future value	Yes	Yes
Stakeholder engagement	No	Yes
Interpretation of main output of analysis	Benefit-Cost ratio > 1	SROI ratio > 1
Relevance	Priority setting and resource allocation	Priority setting and resource allocation. Stakeholder relationship building. Accountability framework, Management tool.

Table 1.1: Comparison between CBA and SROI

Starting from the awareness that new health-related technologies are a leading cause of increasing health-care expenditures and that the adoption of a new technology is one of the most important decisions for the healthcare system (D. Greenberg et al.,

2005), the purpose of this thesis is to lay down and develop a proper methodology to support decision-makers in the burden of evaluating health-related technologies. In particular, due to the relevance of the phenomenon of population ageing and its impact on the healthcare system, the focus of the discussion is on the definition of a proper methodology for evaluating health-related technologies supporting and promoting healthy ageing.
CBA and SROI represent the evaluation methods subjected to in-depth analysis. In particular, since the application of CBA in the healthcare field has already been widely explored, evaluated and even criticized by some, and given that few studies from the literture investigated the adoption of SROI in the health-related area, **the purpose of the thesis is to assess whether there is room for the application of SROI methodology in the healthcare field**.

1.4 Thesis organization

The authors' thesis is organized into eleven chapters.

The first chapter deals with the definition of the research problem and the consequent research objectives.
Having observed that population ageing represents a major challenge nowadays, and having deepened the concepts of healthy ageing, the authors identify their objective in developing a model for social return on investment when assessing technologies promoting a healthy ageing path.

Chapters number two, three, four, five and six are dedicated to the definition of the state of the art for the concept of healthy ageing, for cost-benefit analysis (CBA) and for social return on investment (SROI).
In particular, healthy ageing has been explored in order to investigate its meaning, its domains and the strategies to pursue it. It follows a detailed comparison of the two evaluation methods (CBA and SROI), detecting their respective strengths and weaknesses and aimed at assessing whether social return on investment represents a suitable methodology for dealing with innovative technologies in healthcare.

Chapters number seven, eight and nine are devoted to the so-called "empirical research".
In detail, the seventh chapter outlines thesis objectives and methods: the authors aim at developing a model for performing an SROI analysis when evaluating technologies for health promotion. They adopt an inductive approach, by starting from the European virtual coaching NESTORE H2020 project in pursuing their objective.
Chapter eight explores NESTORE universe, with its purpose and features, as well as the main characteristics of virtual coaching systems.
Chapter nine is dedicated to the SROI analysis of NESTORE, to be then inducted for building an SROI model for virtual coaches for healthy ageing. It is included a description of the analysis validation obtained.

To conclude, chapters ten and eleven concern the presentation of the model, with the discussion of results. To conclude they are presented the model limitations and suggestions for potential future developments and improvement.

Part II

State of the art

Chapter 2

Design of the literature review

The State of the art section aims at offering a complete overview of the past knowledge that has been developed so far and that will inform the empirical research. In particular, **the state of the art exploration is conceived considering four main chapters: "Healthy ageing", "Cost-benefit analysis", "Social return on investment" and "Conclusions and comparison" between cost-benefit analysis and social return on investment**.

Chapter three ("Healthy ageing") intends to explore the concept of healthy ageing and has the scope to establish a focus and context for the downstream research.
A narrative literature search and a narrative review have been conducted to obtain a critical and objective analysis of the current knowledge on the topic. In particular, it is provided a range of definitions, on which no univocal consensus exists, as well as a detailed discussion on the dimensions that constitute the concept of healthy ageing.

Chapters four and five ("Cost-benefit analysis", "Social return on investment") review two methods of assessment for innovative technologies in healthcare.
The focus is on the study and comparison of the traditional cost-benefit analysis (CBA) method and the social return on investment (SROI), a cost-benefit analysis tool that emerged in the field of social initiatives (Nicholls and Lawlor, 2009). **Since the design and validation of an evaluation tool is the core objective of the thesis, both the methods have been investigated through a systematic literature search and a narrative review** in order to provide a complete and exhaustive summary of current evidence relevant to the research question.
In the fourth chapter ("Cost-benefit analysis"), it has been conducted a review on the adoption of the CBA for evaluating innovative technologies in healthcare. At first, a general overview of the method is provided, followed by a focus on its application in the healthcare field, particularly when dealing with an innovative technology. The core of the chapter consists in a systematic search of data and information on the topic and a narrative review of the retrieved results.
The same approach has been employed to conduct the literature search and review on the adoption of the SROI method when dealing with innovative technologies in

healthcare (chapter five).
The authors decided to perform a systematic search when dealing with the two assessment methods (differently from the narrative search conducted for the concept of healthy ageing) in order to be sure not to miss any potential literature contribution, as the comparison and exploration of these two tools represents the real objective of the whole discussion.
Systematic literature searches differ fundamentally from traditional ones. Rousseau et al. (2008) state that the main difference lies in their representativeness: while traditional searches tend to be a cherry-picking studies, systematic ones aim at providing a full overview of research conducted on a specific field until the present date. All research procedures have to be made explicit before the actual conduct of the search to make the process objective and replicable.
According to Tranfield et al. (2003), traditional narrative searches frequently lack thoroughness, and in many cases are not undertaken as genuine pieces of investigatory science. Consequently, they can lack a mean for making sense of what the collection of studies is saying. This is why over the last fifteen years, medical science has attempted to improve the review process by synthesizing research in a systematic, transparent, and reproducible manner with the twin aims of enhancing the knowledge base and informing policy-making and practice.

The sixth chapter ("Conclusions and comparison") compares both methodologies and investigates their respective strengths and weaknesses, with the final purpose of defining whether there is room for the application of SROI methodology in the healthcare field. Moreover, the chapter intends to highlight the major gaps in the literature for both methodologies in order to set the proper research questions.

Chapter 3

Healthy ageing

3.1 Introduction

It follows an overview on the concept of healthy ageing and its domains. The aim is to set the boundaries for a proper analysis and application of technology evaluation methods in this field.

Today most people can expect to live into their 60s and beyond (UN-DESA, n.d.).
In less developed countries, this longevity is largely the result of much reduced mortality at younger ages. In high-income countries, continuing increases in longevity are now mainly due to rising life expectancy among those who are 60 years or older. **When combined with falling fertility rates, these increases in life expectancy are leading to the rapid ageing of populations around the world** (Christensen et al., 2009).
More in depth, the increases in life expectancy observed globally during the past 50 years have been accompanied by substantial changes in cause of death. To explore which of these causes of death, nowadays, results in the greatest burden on senior adults, Figure 3.1 shows years of life lost in +60 using data from the WHO Global Health Estimates (GHE). Globally, the disorders that dominate mortality in this age group are ischaemic heart disease, stroke and chronic obstructive pulmonary disease (WHO Global Health Estimates, 2013). The burden from all these diseases is far greater in low-income and middle-income countries than in high-income OECD countries.
WHO Global Health Estimates (2013) also identifies the greatest causes of disability in people +60. In order of decreasing burden, these are: sensory impairments, back and neck pain, chronic obstructive respiratory disease, depressive disorders, falls, diabetes, dementia, and osteoarthritis.

The extent of the opportunities that arise from these extra years of life will be very heavily dependent on one key factor: health. If these added years are dominated by decreases in physical or mental capacity, the implications for senior adults and for society are much more negative (Beard et al., 2016).
Although increasing longevity is often assumed to be accompanied by an extended period of good health, little evidence exists that senior adults, nowadays, are experiencing better health than their parents did at the

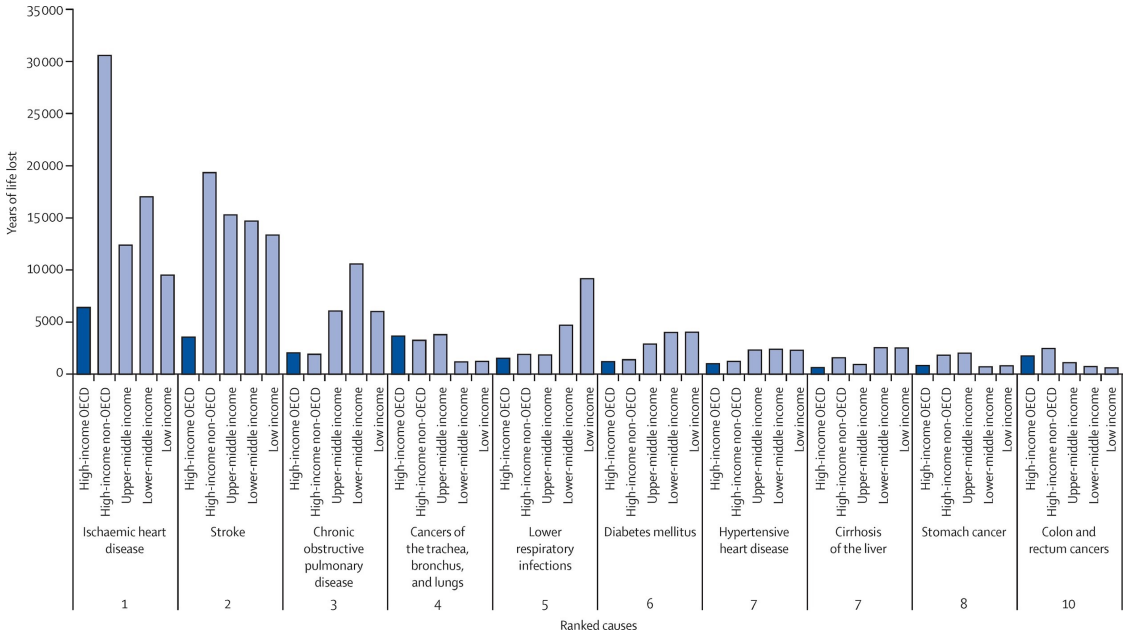

Figure 3.1: Top ten causes of years of life lost for 100.000 people, WHO Global Health Estimates (2013)

same age (Crimmins and Beltran-Sanchez, 2010). A research reported in 2014 by WHO suggests that, although severe disability in senior adults (that necessitate help from another person for basic activities such as eating and washing) might be decreasing slightly, no substantial change in less severe disability has been noted in the past 30 years (Chatterji et al., 2015).

The path towards healthy ageing requires a coherent and focused response across multiple sectors and stakeholders. To date, this response has largely been lacking (Lloyd-Sherlock et al., 2012). To provide a public health framework for action, World Health Organization (2015) has released the first "World report on ageing and health". The report considers ageing from a life-course perspective, but focuses on the second half of life (Beard et al., 2016).

3.2 A definition for healthy ageing

Ageing is associated with an increased risk of a person having more than one disorder at the same time (multimorbidity). Although no consensus exists about which disorders should be considered, more than half of senior adults are likely to experience multimorbidity, even in low-income and middle-income countries (Arokiasamy et al., 2015).
Multimorbidity can lead to interactions between disorders; between one disorder and treatment recommendations for another; and between drugs prescribed for different disorders. As a result, the effect of multimorbidity on functioning, quality of life (QOL), and mortality risk might be much greater than the individual effects that might be expected from these disorders. predictably, multimorbidity is also associated with increased rates of health-care use and increased costs (Marengoni et al., 2011).

The multifaceted dynamics between underlying physiological change, chronic disease, and multimorbidity can also result in health states in older age that are not captured at all by traditional disease classifications and that are therefore often missing in disease-based assessments of health. These are commonly known as geriatric syndromes, although there is still some debate as to what disorders these include (Inouye et al., 2007).

This complexity of health states in older age implies a huge complexity in drafting a definition for healthy ageing and means that disease-based conceptualisations are inadequate proxies for health in a senior adult. Rather than the presence or absence of disease, the most important consideration for a senior adult is likely to be their functioning. Comprehensive assessments of functioning in older age are also much better predictors of survival than the presence of diseases or even the extent of co-morbidities (Lordos et al., 2008).
In sum, **there is some difficulty in clarifying the nature of the concept of healthy ageing itself**.
An example of the confusion related to the concept of healthy ageing is that, despite policy documents conceiving healthy ageing in positive terms, empirical research has largely been based on negative aspects; mortality, morbidity and disability (Strawbridge et al., 1996). Many studies of the aged population have examined functional status decline or restricted assessment to individual disease's specific outcomes, such as dementia (Hogan et al., 1999). Descriptive and evaluative research based on such "pathology " models neglects the vast heterogeneity in health status among older adults, and cannot adequately address the issue of healthy ageing (Grundy and Bowling, 1999).

From the literature, several different definitions for healthy ageing can be drafted.
The definitions of healthy ageing range from the primary biological, such as survival with absence of morbidity, to the comprehensive, such as sustained well-being using a biopsychosocial model. Despite the wide-ranging approaches to the study of healthy ageing, the majority of the studies emphasise the maintenance of functional independence in their definition.

In 2000, Ford et al. (2000) defined healthy ageing as sustained personal autonomy in domains of activities of daily living, ability to participate in valued activities and not having entered a nursing home during the period of observation.
Vaillant and Mukamal (2001), defined healthy ageing as survival to age 75 with a high level of well-being in six domains of functioning (objective and subjective physical health, mental health, active life, life satisfaction and social supports).
In the same year, Burke et al. (2001) defined it as remaining alive and free of chronic disease and symptoms in later life and Von Faber et al. (2001) as the optimal state of overall functioning and well-being measured across physical, social and psycho-cognitive functioning and on feelings of well-being.
One year later, *Workshop on Healthy Aging (Online)* (2001) defined healthy ageing as a lifelong process optimising opportunities for improving and preserving health and physical, social and mental wellness, independence, quality of life and enhancing successful life-course transitions.

The World Health Organization (2015) defines healthy aging as the process of developing and maintaining the functional ability that enables well-being in older age. In this context, functional ability entails the capability that a person has to meet their basic needs, to learn, grow, and make decisions, to be mobile, to build and maintain relationships, and to contribute to society. This encompasses both capabilities on the individual level, such as the intrinsic abilities to walk, think, see, hear, and remember, as well as external factors in the environment such as societal relationships, attitudes and values, and health and social policies.
Three years later, in 2018, Liotta et al. (2018) defined healthy ageing as an umbrella term that, in its broadest sense, embodies the idea of an aging process that allows an individual to still enjoy overall satisfaction with their life.

3.3 Domains and measures for healthy ageing

As mentioned, **the majority of studies on healthy ageing includes the domains of physical, mental and social functioning.**

WHO (World Health Organization, 2015) guidelines suggest the following health constituting dimensions: physical health, mental health (defined by psychological and cognitive well-being) and social well-being. An individual undermines a healthy aging path once none of them is compromised by their behaviours and attitudes.
EuroHealthNet (2012), a European partnership that promotes health, equity, and well-being, in 2012, subdivided healthy aging into subcategories spanning nutrition, exercise, social aspects, as well as environmental aspects to capture the scope of measures that are in use across the projects they support.

Shifting towards the measures employed for each domain, in line with conventional measures of health status, most studies on healthy ageing include criteria in the key domain of physical health and functioning. Absence of disability is often ascertained using activities of daily living (ADL) and/or physical performance scales as an indicator of healthy ageing. Also included as a measure of physical health in some studies is the absence of disease or impairments, and/or the absence of mortality (Peel et al., 2004). While often categorised as a measure of physical functioning, the ability to perform both basic self-care ADL (e.g. bathing, dressing, eating) and instrumental ADL (e.g. shopping, managing transport and money) entails preservation of both cognitive and physical abilities and is also a measure of the ability to function in the social environment (Stewart and King, 1994).
In addition to ADL measures, some studies include measures of mental health, most frequently a measure of cognitive functioning. Other measures of mental well-being include absence of psychiatric morbidity, positive perceived health, life satisfaction, and personality resources such as sense of control (Peel et al., 2004).
Social functioning indicators are often included as measures of social contact or participation, and environmental security. Another indicator used as a measure of ability to function independently in the community was limited use of home care services, formal or informal (Peel et al., 2004).

3.3.1 Benefits of preventive initiatives for healthy ageing

According to the WHO, there is a societal goal to maximize the number of people who experience the positive trajectory of aging (healthy aging), thus lightening the burden on the healthcare system. This fact necessitates a shift from treatment towards prevention of age-related diseases and the development of innovative solutions that 1) enable the ageing generation to stay healthy and independent longer and 2) empower the senior adults to take care of their own health and function (World Health Organization, 2015).
It follows a deeper focus on potential benefits that initiatives regarding each healthy ageing domain (physical well-being has been subdivided into physical activity and nutrition in order to provide a deeper and more complete focus on this complex and heterogeneous dimension) could generate on different nature stakeholders.

Physical activity

Even if it is well known that regular physical exercise is an important part of a healthy lifestyle in all age groups, as people age, they become less and less active: rates of physical activity are lowest in those aged 60+ (Kruger et al., 2005).
Although about one half of the overall population reports doing some routine exercise activities, only 30% of those aged 60+ report any regular exercise. This inactivity is in stark contrast to current recommendations of 30 minutes of activity on most days of the week (Heath and Stuart, 2002).

People who are physically active tend to be healthier than those who are not: exercise improves one or more aspects of physical health, including cardiovascular endurance, muscular strength, flexibility, balance, and fine motor control (Christie et al., 2017). It has been proved that regular exercise confers several benefits not only on physical fitness, but also on mental state and psychological well-being, including better health-related quality of life, better functional capacity and better mood state (Penedo and Dahn, 2005). Another key benefit of performing physical activity is that it can foster social relationships when practised in a social setting, thus contributing to physical, psychological and social well-being (Aranceta et al., 2001).

Coming to the monetization of benefits, Katzmarzyk and Janssen (2004), discussing the economic burden of physical inactivity in Canada, state that about $2.1 billion, or 2.5% of the total direct health care costs in Canada, were attributable to physical inactivity in 1999. About 21000 lives were lost prematurely in 1995 because of inactivity. A 10% reduction in the prevalence of physical inactivity has the potential to reduce direct health care expenditures by $150 million a year.
Colditz (1992) estimates that 2.4 per cent of the direct costs of health expenditure in US are attributable to physical inactivity.
Jones and Eaton (1994) identify that walking is a cost-beneficial population strategy, with savings of up to $4.3 billion if the entire sedentary population became active. This level of physical activity participation is most efficient for those aged 45-54, where a benefit would accrue even if the time spent walking were costed at the average hourly wage rate.

In 1987, the Commonwealth released a report on the Economic benefits of participation in regular physical activity (A. Roberts et al., 1987). This report includes confining physical activity to "vigorous"levels of participation, including general practitioners' visits, therapy for hypertension and other risk factors, and above all, includes indirect cost estimates. They report indirect costs, for example for coronary heart disease as 2-3 times greater than direct costs. In terms of encouraging physical activity, they propose (in 1988 dollars) a $1 million economic benefit (direct cost savings only) for each 1% increase in vigorous physical activity participation. They propose a total saving of around $273.6 million if direct and indirect costs are considered (in 1988 dollars).

Looking specifically at the senior adults, in addition to its potential for improving general measures of health, exercise can be a specific therapeutic intervention for the many accumulated chronic illness of frail senior adults. These diseases include osteoarthritis, diabetes, peripheral vascular diseases, coronary heart disease and congestive heart failure, obesity, and depression (Heath and Stuart, 2002).
It has been proved that routine physical activity can prevent loss of bone mineral density and osteoporosis, common in postmenopausal women and elderly, and, as consequence, can prevent elderly from falling reducing the hospitalization costs (Heath and Stuart, 2002). A study conducted by Sherrington et al. (2019) estimated that exercise reduces the rate of falls by 23%. A more specific study (Lin et al., 2006) investigated the impact of the implementation of Tai chi as a falling prevention exercise program and reported that after 15 weeks of Tai Chi, the frequency of falls was reduced by 47.5%. Other beneficial effects of practising a discipline like Tai Chi are improvements in psychological well-being including reduced stress, anxiety, depression and mood disturbance, and increased self-esteem (Wang et al., 2010).
One major intervention study, conducted by Alessi et al. (1999), uses daytime arm and leg exercises, conducted in a supervised group setting, as a means to improve the sleep of nursing home residents. The investigators find that participants' quality and quantity of sleep improved by about 40% during subsequent nighttime observations.
Another institutionally based study examines the effect of weight-training on strength and stair climbing in a selected group of very old (mean age 87 years) nursing home residents. Participants assigned to the intervention group had enhanced overall mobility compared with the control group, for whom only a socialization intervention was provided. This study provides the best evidence that exercise can produce short-term, highly relevant improvements for even the oldest frail elder (Fiatarone et al., 1994).
Conducting a literature review regarding the sports that suit the elderly the most, it has been highlighted, alongside with walking or Tai Chi, practising yoga: according to a study conducted on a sample of 42 older adults, it has been proved that practicing yoga reduces stress/anxiety, enhances calmness and enriches the quality of sleep. Consequently, yoga shows benefits in terms of improved physical function and enhanced mental and emotional state (Alexander et al., 2013).

Nutrition

The dietary and nutrition choices that individuals make over their lives have significant links to their overall health and their chances of experiencing later diseases (EuroHealthNet, 2012).
The adoption of a proper diet can have a positive impact on physical health all along an individual's lifespan.
In particular, increased consumption of fruits, vegetables, and other healthy foods could prevent millions of deaths from cardiovascular diseases, hundreds of thousands of diabetes cases, and save billions of dollars in healthcare costs.
As a matter of fact, the Expanded Food and Nutrition Education program (EFNEp) conducted in the US in 2002 shows that a proper diet would help to reduce at least 20% of the annual deaths from heart disease, cancer, stroke, and diabetes (Rajgopal et al., 2002).

Scrafford et al. (2019) attempt to estimate the impact on healthcare costs associated with increased conformance with the three healthy patterns recommended in the 2015-2020 Dietary Guidelines for Americans, including the Healthy US-Style, the Healthy Mediterranean-Style, and the Healthy Vegetarian eating patterns. Overall modeled cost savings are $16.7 billion (range=$6.7 billion to $25.4 billion) to $31.5 billion (range=$23.9 billion to $38.9 billion) resulting from reductions in cardiovascular disease, cancer, type 2 diabetes and Alzheimer's disease.
Abdullah et al. (2015) identify that type 2 diabetes (T2D) and cardiovascular disease (CVD) are leading causes of mortality in Canada and two of the most costly diet-related ailments worldwide. Consumption of fiber-rich diets has been repeatedly associated with favorable impacts on these co-epidemics. Non-trivial healthcare and related savings of CAD$35.9-$718.8 million in T2D costs and CAD$64.8 million–$1.3 billion in CVD costs are calculated under a scenario where cereal fiber is used to increase current intakes of dietary fiber to the recommended levels of 38 g per day for men and 25 g per day for women. Each 1 g per day increase in fiber consumption results in annual CAD$2.6 to $51.1 million savings for T2D and $4.6 to $92.1 million savings for CVD.
In 2009, Doll et al. (2009), referring to US, estimate that permanent 100-kcal reductions in daily intake would eliminate approximately 71.2 million cases of overweight/obesity and save $58 billion annually. Long-term sodium intake reductions of 400 mg/d in those with uncontrolled hypertension would eliminate about 1.5 million cases, saving $2.3 billion annually. Decreasing 5 g/d of saturated fat intake in those with elevated cholesterol would eliminate 3.9 million cases, saving $2.0 billion annually.

The costs of obesity have been assessed in numerous studies. The World Health Organisation report suggests it might contribute to 2–7% of total healthcare costs (WHO, 2015). The WHO report cites US studies estimating the direct costs of obesity to be $45 billion, much of which is attributed to the costs of treating obesity-related hypertension.
Other studies reach different conclusions for obesity: a US study reported total costs of $17.2 billion, of which most of the costs were for the moderate to severe obesity category. This study mainly focuses on indirect costs (Thompson and Fahrenbach,

1994).

Looking specifically at the senior adults, another study, investigating the benefits that adopting certain nutritional habits may have on health, states that citrus fruits, high in flavonoids, are useful in the management of most diffused cancerous tumours among 60+ (Yao et al., 2004). In fact, there is a positive correlation between flavonoids-rich diet (from vegetables and fruits) and lower risk of colon, prostate and breast cancers. The consequences of the risk reduction are relevant for people, society and hospitals, since cancer is a major public health concern in both developed and developing countries (Batra and Sharma, 2013).
As regards cognitive dimension, some studies have proved that high consumption of vegetables, especially leafy greens, allows to slow down cognitive decline (M. C. Morris et al., 2015). The benefits resulting from a richer vegetable diet are relevant not only for the person that can count on a higher quality of life due to the absence or delay of cognitive disabilities, but also in terms of savings for the healthcare system: in the USA, where dementia is the sixth leading cause of death, it is estimated that delaying disease onset by 5 years will reduce the cost and prevalence by half (M. C. Morris et al., 2015).

Social sphere

It is worldwide accepted the assumption according to which social relationships, both quantity and quality, affect mental health, health behaviour, physical health, and mortality risk (van Bel et al., 2009). Of course stimulating social connections enhances social well-being.

The most important benefits related to social-connection come from prospective studies of mortality: these studies consistently show that individuals with the lowest level of involvement in social relationships are more likely to die than those with greater involvement (Umberson and Karas Montez, 2010). In particular, it has been shown a consistent linking between low quantity or quality of social ties, such as the marital history, and a host of conditions, including development and progression of cardiovascular disease, recurrent myocardial infarction, atherosclerosis, autonomic dysregulation, high blood pressure, cancer and delayed cancer recovery, and slower wound healing (Umberson and Karas Montez, 2010). Looking specifically at the senior adults, alongside with reducing risk of morbidity and mortality, accumulating evidence also suggests that humans have a higher risk of developing Alzheimer's disease if they are lonely or living isolated (Hsiao et al., 2018).

Cognitive ability

Cognitive abilities are strictly related to the concept of self-expression.
Self-expression can be defined as the expression of one's personality, feelings or opinions. The analysis of the benefits that can be generated stimulating this dimension is not trivial, because of the existence of different forms of expression. Among them, here they are analysed the ones considered most significant.

Social dancing can: improve heart and lungs' condition and weight management; increase muscular strength; reduce risk of osteoporosis due to stronger bones, better

coordination, agility and flexibility; increase physical confidence, mental functioning and psychological well-being thanks to a greater self-confidence and social skills (Merom et al., 2016). particularly for senior adults, dancing can improve mobility in people affected by parkinson's disease and slow down related physical declines (Hackney et al., 2007).
Volunteering experiences lead to an increase in physical and mental health (Yeung et al., 2018). Learning a new language can: support brain development and improves creativity and decision making (Maartensson et al., 2012); prevent dementia; delay the onset of Alzheimer of 5 years; lengthen attention span and improve memory (Craik et al., 2010).
Reading books and expressive writing are amongst the most brain-stimulating activities: they can slow down the decline of memory in comparison to those who are not persistent readers/writers (Koren, 2013).
Musical activity such as playing an instrument or periodically listening to music, enhances memory, especially when music is able to generate a certain emotional status (Diaz Abrahan et al., 2019).
Gardening can improve physical, psychological, and social health, which can, from a long-term perspective, alleviate and prevent various health issues facing today's society, such as anxiety, stress, fatigue and depression (Soga et al., 2017).
Owning a pet leads to a decrease in depressive symptoms, improved perception of quality of life, and better cognitive functioning in elderly patients with dementia, depression, or psychosis (Moretti et al., 2011).

3.4 Conclusions

In conclusion, the literature shows that **undermining a healthy ageing path can lead to benefits such as reduced healthcare system-related costs, reduced morbidity, reduced mortality and better quality of life**.
In particular, improvements in physical activity and nutrition play a fundamental role in reducing the incidence of negative consequences mainly of cardiovascular diseases and diabetes (two of the main chronic diseases that currently affect senior adults). Their role in delaying cognitive disabilities is also fundamental for improving senior adults' quality of life.
Studies concerning the potential benefits for the senior adults deriving from social and cognitive well-being are much more difficult to find. However, most authors report and remark their contribution in reducing cognitive disabilities and improving quality of life.
An overview on how physical activity, nutrition, social and cognitive stimulaton can enhance senior adults' health is provided in Table 3.1.

	Benefits for the elders			
Domain	**Reduced healthcare system-related costs**	**Reduced morbidity**	**Reduced mortality**	**Better quality of life**
Physical activity	Due to reduced incidence of cardiovascular diseases, coronary heart disease, osteoarthritis, osteoporosis, diabetes, congestive heart failure, obesity, and depression, and reduced falling episodes (Christie et al. (2017),Sherrington et al. (2019), Heath and Stuart (2002))	Of cardiovascular diseases, coronary heart disease, osteoarthritis, osteoporosis, diabetes, congestive heart failure, obesity, and depression (Christie et al. (2017), Sherrington et al. (2019), Heath and Stuart (2002))		Due to improved mental state, psychological well-being, social well-being and better sleep (Penedo and Dahn (2005), Aranceta et al. (2001), Alessi et al. (1999), Alexander et al. (2013))
Nutrition	Batra and Sharma (2013) and Rajgopal et al. (2002)	Of cardiovascular disease, cancer, type 2 diabetes and Alzheimer's disease (Scrafford et al. (2019))	From cardiovascular diseases, cancer, stroke, and diabetes (Rajgopal et al. (2002), Abdullah et al. (2015))	Due to absence or delay of cognitive disabilities (M. C. Morris et al. (2015))

Social sphere		Of cardiovascular disease, recurrent myocardial infarction, atherosclerosis, autonomic dysregulation, high blood pressure, and cancer (van Bel et al. (2009), Hsiao et al. (2018))	From cardiovascular disease, recurrent myocardial infarction, atherosclerosis, autonomic dysregulation, high blood pressure, and cancer (van Bel et al. (2009), Umberson and Karas Montez (2010))	Due to lower risk of developing Alzheimer (Hsiao et al. (2018))
Cognitive ability		Of fracture (Merom et al. (2016))		Due to improved mental functioning and psychological well-being and lower risk of developing Alzheimer (Merom et al. (2016), Craik et al. (2010), Soga et al. (2017))

Table 3.1: Benefits per domain

Chapter 4

Cost-benefit analysis of technologies in healthcare

4.1 Introduction

This section is dedicated to a review through systematic search on the use of the CBA in healthcare for evaluating innovative technologies.
Traditionally, CBA has been defined and employed as the supporting tool for decision-making in healthcare (National Institute for Clinical Excellence, 2004). As a consequence, it has been considered necessary to devote a section of the thesis to a deeper and structured understanding of this method.

CBA is an economic appraisal tool for the comparison of costs and benefits of a project, with the goal to support decision-making.
It is typically used by governments to evaluate the desirability of a given intervention in markets (Brzozowska et al., 2007).
In particular, CBA allows policy-makers to compare alternative project proposals to a baseline scenario, or status quo, under which no investments are made. Simply put by Snell (1997), "having formulated a project, we assess the cost it will incur and the benefits it will bring, balance the one against the other, perhaps consider other influences, and then decide: is the benefit worth the cost?". CBA is employed to select which proposal is the most valuable investment. Ideally, the project that maximizes benefits while minimizing costs should be chosen.
Generally, CBA applies to policies, programs, projects, regulations, demonstrations, and other interventions dependent on the decisions of government, that is basically responsible for roads, bridges, airports, parks, amenity land, new urban areas and housing (Harvey, 1996).
Alongside with the public application of CBA, in the private sector, CBA is used to justify equipment and technology investment, measure life cycle costs, meet regulations cost-effectively and quantify hidden costs and intangible benefits. It is also useful, for example, to demonstrate how quality improvements can affect returns (Audouin and Govender, 2004).

One of the most controversial examples of application of CBA in the Italian field regards the construction of the new railway line between Turin and Lyon (TAV). The CBA, carried out by a team charged by the Ministry of Infrastructure and

Transport and coordinated by Marco Ponti, has reported its conclusion at the beginning of 2019: TAV would be an inconvenient investment.
To this conclusion, they have been raised many objections of highly technical nature concerning, for example, the monetization method for the reduction of the times of mileage or for that of harmful emissions. What emerges from this practical example of CBA is that the results of the analysis are not incontestable.
However, despite the widespread awareness of the limits related to risk and uncertainty, **analysts and economists argue that CBA remains a valuable tool to support decision-makers** (Rose-Ackerman, 2016).

Traditionally, CBA covers a wide range of applications, such as water resource management, motorways, nationalized industries, airport locations, forestry, recreational facilities, and urban investment projects. However, Quah and Edward Joshua Mishan (2007) report that its techniques are particularly prominent in fields where there is some kind of ethical dimension (i.e. the healthcare field).

4.2 Cost-benefit analysis in healthcare

One of the main problems for the public and private healthcare systems of industrialized countries regards the retrieval and allocation of the resources necessary for the prevention and treatment of pathologies of the assisted population.
In the coming decades, this phenomenon will become increasingly important for health decision-makers given the continued ageing of the population, the increase in patient expectations and the rapid development of available technology.
These phenomena have led to increasing global feeling that proper economic measures to guide policy-makers in the healthcare field are deeply needed (Frew, 2010).

Joglekar (1984) recommends to use CBA as a mechanism to evaluate innovative health programs, since it can enable health practitioners to cost-justify their innovative services to the government and other third-party payers.
However, according to the York Health Economics Consortium (2016), CBA is not commonly used in health technology assessment (HTA[1]) due to difficulty of associating monetary values with health outcomes such as (increased) survival. Most commonly, CBA has been used to assess large capital development projects (e.g.new hospital facilities) or interventions that improve waiting times or location/access to services.

Monetization remains controversial. While the cost side of the equation consists of the expenditure for a program, there are different theories about how benefits of a healthcare program should be estimated.
Some scholars have evaluated the benefits of a program as direct, indirect and intangible benefits (Bootman et al., 1979).
Direct benefits are the portion of medical expenditures saved because of prevention

[1]Health Technology Assessment (HTA) is a multidisciplinary process that synthesizes information on clinical, economic, social and ethical issues related to the use of a health technology, in a systematic, transparent, impartial and solid manner.

or treatment of the disease or illness.
Indirect benefits are the potential increased earning or productivity gains.
Intangible benefits are associated to the lack of pain and discomfort, and improvement of quality of life, that can accrue in part to the patients and in part to their families, friends, and society at large.
However, some of the consequences are difficult to predict and some are difficult to measure. Among the most difficult to measure there are the intangible aspects of human life and experience, including the sheer value of human life or that of good health (Klarman, 1967). Moreover, when CBA is applied in the context of healthcare, alongside with the conceptual and practical issues and difficulties, there are also ethical ones associated with valuing benefits such as health improvement into monetary terms (McIntosh et al., 1999).

4.3 Methodology

The purpose of this section is to provide an overview of the most influential scientific literature published on the topic of CBA in healthcare when dealing with innovative technologies.
CBA represents one of the reference methodologies for economic evaluation in healthcare and it is traditionally employed to support decision-making for health interventions (National Institute for Clinical Excellence, 2004).

Given that the purpose of the thesis project is represented by the construction of a method for the assessment of healthy ageing technologies, it has been decided to conduct a deep and detailed analysis of CBA by performing a systematic literature search.
Systematic literature searches differ fundamentally from traditional ones.
Rousseau et al. (2008) state that the main difference lies in their representativeness: while traditional searches tend to be "cherry-picking studies", systematic ones aim at providing a full overview of research conducted on a specific field until the present date. All research procedures have to be made explicit before the actual conduct of the review to make the process objective and replicable.
According to Tranfield et al. (2003), traditional narrative searches frequently lack thoroughness, and in many cases are not undertaken as genuine pieces of investigatory science. Consequently, they can lack a mean for making sense of what the collection of studies is saying. This is why over the last fifteen years, medical science has attempted to improve the review process by synthesizing research in a systematic, transparent, and reproducible manner with the twin aims of enhancing the knowledge base and informing policy-making and practice.

To guide the systematic analysis, the following main research question has been formulated: "Which is the framework worldwide researchers employ to conduct cost-benefit analysis when dealing with innovative technologies in healthcare?".
This major statement firstly suggests limiting the boundaries of the search to practical applications of CBA in healthcare for evaluating innovative technologies.
To manage the research and the analysis in a structured way, the re-

search question has been restructured in 6 sub-questions:

1. "Typically, which is the perspective adopted when conducting a cost-benefit analysis?"

2. "Which are the main costs taken into account by researchers when dealing with a cost-benefit analysis?"

3. "Which are the main benefits taken into account by researchers when dealing with a cost-benefit analysis?"
   More in detail, the analysis focused on the extrapolation of cost items and/or benefits included in the articles and the methodology of monetization thereof, if present and described.

4. "Which is the time horizon selected for the analysis?"

5. "Which is the value assumed for the discount rate when computing the final result of the analysis?"
   Since the evaluation of a technology is always prospective and oriented towards the future, it is likely to think that each article reports the time horizon for the evaluation of costs/benefits and the applied discount rate for their actualization.

6. "How is the uncertainty of the analysis managed?"
   The perspective nature of CBA, with benefits occurring in the distant future, pushes analysts towards evaluating a certain degree of uncertainty of the analysis conducted.

In sum, the aim of the systematic literature search and narrative review consists in drafting an answer to these questions through an in-depth analysis of practical applications of CBA in the aforementioned field.

Upstream of a solid literature review, a systematic search phase is crucial to provide transparent report of studies identification, clarifying what has been done to identify papers, and how the findings of the review are situated in the relevant evidence (Cooper et al., 2018).
Alongside with a systematic search, the results and findings have also to be discussed. For this reason, it is suggested to adopt a narrative approach when reporting a literature review (Ferrari, 2015).
In detail, Ferrari (2015) recommends using the systematic search and narrative review methodology in a parallel way, since that the quality of a narrative review may be improved by borrowing methodologies from the systematic search.

The following paragraphs present a systematic search along with a narrative review of the adoption of CBA in healthcare for evaluating innovative technologies.

4.3.1 Systematic search

For the development of an effective systematic search strategy, the 12-step framework proposed by Kable et al. (2012) has been applied. The

framework presents a valuable tool for documenting a systematic search strategy while also guiding researchers to consider all aspects required for locating relevant literature, ensuring that no important aspects are left out. Therefore, the framework is viewed to be an especially valuable tool for inexperienced researchers.
Steps to be followed are:

1. Purpose statement;
2. Databases, search engines used;
3. Search limits;
4. Inclusion and exclusion criteria;
5. Search terms;
6. Exact searches per database, search engine and the results;
7. Relevance assessment of retrieved literature;
8. Table reporting literature included in the review, accompanied with key data such as title, author, but also research subject and findings;
9. Document final number of search results;
10. Quality assessment of retrieved literature;
11. Review;
12. Accurate, complete reference list.

To enhance readability and enable readers to quickly find certain steps, this section presents each of the twelve steps consecutively.

The purpose The purpose has been stipulated as discovering which framework worldwide researchers employ to conduct CBA in healthcare when dealing with innovative technologies.
The purpose statement was formulated together with the principal and project supervisor.

Databases The investigated databases were Scopus, PubMed and Web of Science (WoS). The three databases are well-established, multi-disciplinary research platforms, holding a wide variety of peer-reviewed journals, and they are being kept up to date. The authors chose for three databases to ensure all relevant papers are included, since it is possible that one database omits relevant research (Crossan and Apaydin, 2010).

When conducting systematic search, it is generally considered important to include grey literature in the review to develop a more complete overview (Tranfield et al., 2003).

Grey literature refers to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing. The major online source of grey literature is represented by Google Scholar.
Due to its nature, grey literature is difficult to locate and can be abundant. Therefore, despite its relevance, Google Scholar has been explored only as a starting point of the analysis in order to obtain a broad overview on the magnitude of the topic and understand the main diffused considerations.
It has not been included in the systematic search.
Anyway, among the aforementioned databases, Scopus involves grey literature. Therefore, contributions coming from grey literature have not been completely neglected in the search. Analogously, two books dealing with the CBA topic have been preliminarily explored to have a first evidence regarding the world of CBA, as suggested by the supervisor, but not included in the systematic analysis: Handbooks in Health Economic Evaluation (Clarke et al., 2010), Cost-Benefit Analysis: Concepts and Practice (Boardman et al., 2017).

Search limits The following search limits have been applied to the searches:

- *Journal articles* Books and books chapters have been excluded from the review in line with the objective of mainly exploring practical applications of CBA in healthcare. In fact, explored books tend to mainly focus on providing theoretical frameworks for the methodology.

- *English language* For journal articles, it has been assumed that high impact research about CBA in healthcare had been translated into English. Therefore, even if they may exist relevant papers in other languages too, it is believed that the articles in English give a sufficiently complete overview of the documentation available.

- *Published between January 1, 2009 and August 31, 2019 (end of the search)* From the database analysis, it emerged that the last 10 years publications have devoted a growing interest towards evaluation tools in the health field. This reason, together with the fact that the research aims at finding out innovation related articles, led to the choice of conducting the search within the last 10 year. The time frame, as a matter of fact, was supposed to be sufficiently broad to collect all relevant documentation. The final year of consideration, 2019, was the most current research year when this review was initiated and was thus chosen to represent the most current developments in the searched field.

- *Search within* For the databases PubMed and Scopus, the research for the search terms were restricted to title and abstract of the article. For the Web of Science database, searches were restricted to the topic subject and title.

- *Subject area* For the PubMed database, pre-selected filters applied by default by the database were not modified (the authors identified them as suitable for their peculiar analysis): article type (clinical trial, journal article, review,

review) and type of journals. Being PubMed, a database referring both to humans and to animals, it was necessary to apply an additional filter on species. For Scopus and Web of Science, no filters on type of subject area and document type were applied. Given that in the articles selection phase the authors had still little knowledge about the CBA topic, it has been considered too high the risk of reducing sensitivity and specificity of the search from the aprioristic exclusion for subject area or document type.

Relevance assessment Criteria for in- or excluding specific literature manifest the research focus and also point to its limits. With respect to assessing the relevance of retrieved literature at the end of the search process, Bettany-Saltikov (2012) proposes to conduct a first, quick assessment by means of reading only the titles and abstracts and compare them against the criteria for in- and exclusion. Only those papers classified as relevant or likely to be relevant after this first assessment should then be read in full during a second assessment stage. The benefit of this approach is that potentially large bulks of literature can be assessed rather quickly. These criteria for in- or excluding retrieved articles have been formulated in conjunction with the project supervisor.
The main rationale was that the authors only wanted to include articles that were strictly on the topic of practical application of CBA for evaluating technologies in the healthcare field.
A first exclusion criteria, was:

1. Articles form Web of Science and Scopus providing contribution in Agromedicine, Environment Protection, Animal and Fishery, Hydrology, Governance, Energy, Aerospace research fields, Environmental science, Social science, Computer science, Agricultural Science, Energy, Nursing, Material science, Chemistry, Mathematics, Physics and Astronomy, Psychology, Veterinary, Arts and humanities, Chemical engineering and Neuroscience were excluded in the abstract and full-article selection phase.

Moreover, practitioners publishing the papers, very often claim to clearly know the distinction between CBA, cost-utility analysis and cost-effectiveness analysis, but, in practice, this proves not to be true. For this reason, an exclusion criterion applied to the research was:

2. Studies that only recommend a future CBA and studies concerning cost-effectiveness analysis or cost-utility analysis instead of CBA were excluded in the abstract and full-article selection phase.

Search terms For formulating suitable search terms, the guideline provided in 2009 by the Centre for Reviews and Dissemination (CRD) on reviews suggests consulting the main research question (University of York. Centre for Reviews and Dissemination and Akers, Jo, 2009). For searching electronic databases, the guideline recommends to also consider "synonyms, abbreviations and spelling variants". In particular, several queries were searched using different databases and the number of results provided by each query was finally compared to get those search

terms that could embrace all the evidence on the topic. At first, potential synonyms for the phrase «Cost-Benefit Analysis» were searched. In particular, queries investigated were: «cost-benefit Analysis», «cost-benefit Application», «cost-benefit Approach, «cost-benefit Assessment», «cost-benefit Calculation», «cost-benefit Calculus», «cost-benefit Concept» , «cost-benefit Considerations», «cost-benefit Criteria», «cost-benefit Estimation», «cost-benefit Evaluation», «cost-benefit Example», «cost-benefit Framework», «cost-benefit Infrastructure», «cost-benefit Judgement», «cost-benefit Literature», «cost-benefit Logic», «cost-benefit Measurement», «cost-benefit Measure», «cost-benefit Method», «cost-benefit Model», «cost-benefit Paradigm», «cost-benefit Perspective», «cost-benefit Practice», «cost-benefit Principle», «cost-benefit Reasoning», «cost-benefit Relation», «cost-benefit Research», «cost-benefit Review», «cost-benefit Rules», «cost-benefit State», «cost-benefit Structure», «cost-benefit Study», «cost-benefit Techniques», «cost-benefit Test», «cost-benefit Theory», «cost-benefit Valuation», «cost-benefit View», «cost-benefit Viewpoint».

The investigation of the single aforementioned queries produced the results shown in Table 4.1.

Due to the substantial gaps that different queries reported, they were included in further analyses only bold terms reported in the table. As a following step, the authors investigated possible synonyms of «Healthcare» in order to add this further component to the query. Identified synonyms were «Medicine», «Health», «Cure» and «Drug». All the above mentioned queries were combined with each one of these key words and the resulting queries were investigated on Scopus, Web of Science and Pubmed producing the results shown in Table 4.2.

Given the huge differences in terms of number of results among the queries involving the word “Analysis” and the other synonyms of analysis, the authors found it reasonable to include in further investigation only the following queries: «cost-benefit Analysis AND Healthcare», «cost-benefit Analysis AND Health», «cost-benefit Analysis AND Medicine», «cost-benefit Analysis AND Cure» and «cost-benefit Analysis AND Drug». Because of the topic of the analysis, the key word «technolog*» was added to each one of the kept queries, producing the results shown in Table 4.3.

At this level of the analysis, the authors observed that the number of results in all the three explored databases was much higher for the query «cost-benefit Analysis AND (Health or Drug*) AND Technolog*». As a result, the authors decided to limit the investigation to this specific query for all the three databases.

Table 4.1: Investigated Cost-Benefit-x queries

Cost Benefit				
Searched terms	Scopus	WoS	Pubmed	Total
Analysis	172329	12203	511	**1655043**
Application	10	2	0	113
Approach	331	184	6	**16921**
Assessment	402	190	9	**12101**
Calculation	336	78	5	**21319**
Calculus	69	43 0	6	8542
Concept	15	5	0	299
Considerations	331	174	20	**11825**
Criteria	9	21	1	2612
Estimation	32	13	3	806
Evaluation	419	183	15	**10207**
Example	2	1	0	94
Framework	228	148	0	**7006**
Infrastructure	1	0	0	29
Judgement	7	0	0	123
Literature	4	3	0	436
Logic	14	7	0	877
Measurement	4	0	0	241
Measure	27	7	0	865
Method	150	34	2	1536
Model	529	301	4	**10374**
paradigm	16	8	0	821
perspective	137	87	2	6736
practice	4	2	0	100
principle	38	9	0	1029
Reasoning	14	9	0	886
Relation	576	75	21	**4812**
Research	20	10	1	877
Review	13	4	0	613
Rules	23	11	0	803
State	10	9	0	1059
Structure	31	15	0	1556
Study	527	111	15	**10013**
Techniques	47	12	1	1420
Test	68	40	0	4898
Theory	38	25	0	1223
Valuation	15	5	0	606
View	31	4	0	531
Viewpoint	15	3	0	487

Table 4.2: Investigated Cost-Benefit-x AND Healthcare synonyms queries

		Cost Benefit									
		Analysis	App.	Assess.	Calcul.	Cons.	Eval.	Frame.	Model	Relation.	Study
Scopus		7797	3	8	4	9	14	2	8	5	13
WoS	Healthcare	353	2	4	0	5	5	0	5	1	3
PubMed		24	0	1	1	3	0	0	0	0	0
Scopus		71024	147	100	53	80	104	30	68	47	179
Wos	Health	2562	23	45	12	25	36	15	33	11	25
PubMed		212	2	3	3	7	3	0	2	4	4
Scopus		12717	8	15	10	23	21	1	6	12	31
WoS	Medicine	286	5	6	2	8	8	1	1	4	0
PubMed		28	0	1	1	0	0	0	1	1	0
Scopus		820	1	0	2	0	0	0	0	0	0
WoS	Cure	54	1	0	1	0	0	0	0	0	0
PubMed		4	0	0	0	0	0	0	0	0	0
Scopus		32133	14	43	15	46	42	3	26	25	84
WoS	Drug	560	7	12	1	10	19	3	9	3	9
PubMed		36	0	0	0	3	0	0	0	3	0

Table 4.3: Investigated Cost-Benefit-x AND Healthcare synonyms AND Technolog* queries

	Scopus	WoS	PubMed	S	Wos	PM	S	WoS	PM	S	WoS	PM	S	WoS	PM
Cost Benefit	Healthcare				**Health**			Medicine*			Cure*			**Drug***	
Analysis	47	45	33	298	317	169	31	45	33	7	2	2	36	51	19
	Technolog*														

Documentation of search process The total number of articles resulted from the exploration of the three databases for the query «cost-benefit Analysis AND (Health or Drug) AND Technolog*» was equal to 851. More in detail:
For Scopus, the specific query explored was (TITLE-ABS ("cost-benefit analysis") AND TITLE-ABS (health OR drug) AND TITLE-ABS (technolog*)) and it produced 306 results. Anyway, once applied the filter on language (the authors decided to involve in the analysis only articles written or translated in English), the number of results was reduced to 273 articles. Subsequently, the filter on years (the authors decided to consider only articles of the last 10 years- therefore written between 2009 - 2019) was applied, providing a final number of 138 results. No filters on type of subject area and document type were applied.
For Web of Science, the specific query explored was (TOPIC ("cost-benefit analysis") AND TOPIC (health OR drug) AND TOPIC (technolog*)) and it produced 328 results. Anyway, once applied the filter on language the number of results was reduced to 219 articles. Subsequently, the filter on years was applied, providing a final number of 181 results. No filters on type of subject area and document type were applied.
For PubMed, pre-selected filters applied by default by the database were not modified (the authors identified them as suitable for their peculiar analysis): article type (clinical trial, journal article, review, review) and type of journals (nursing and dentistry journals were excluded). The specific query explored was (TITLE-ABS ("cost-benefit analysis") AND TITLE-ABS (health OR drug) AND TITLE-ABS (technolog*)) and it produced 217 results. Anyway, once applied the filter on language the number of results was reduced to 203 articles. Subsequently, the filter on years was applied, providing a final number of 132 results. Being PubMed, a database referring both to humans and to animals, it was necessary to apply an additional filter on species, leading to a final number of 50 articles human-related. Figure 4.1 displays results for this step:

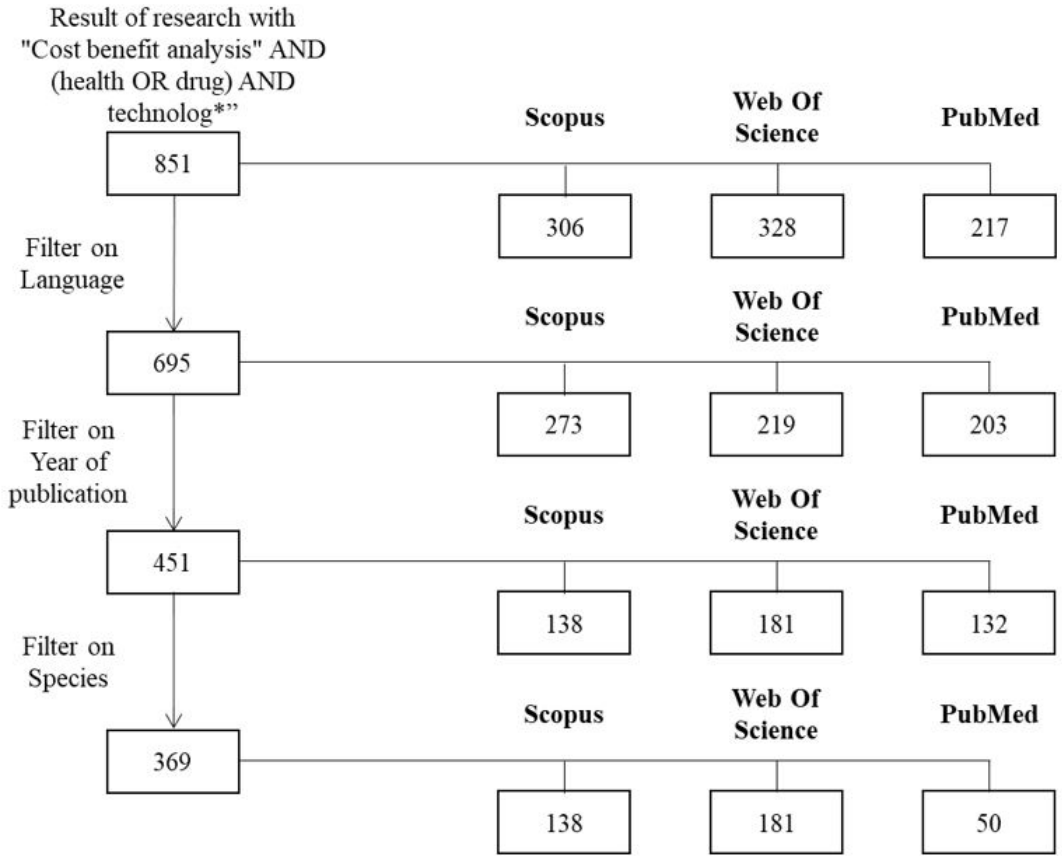

Figure 4.1: CBA Funnel Diagram 1

Test relevance of retrieved articles At first, articles' duplications were eliminated (85 duplications were found), leading to a final number of 284 articles to submit to the abstracts reading phase.
So, articles' abstracts were read and assessed against the criteria for in- and exclusion. Full articles with less informative abstracts were included. This skimming phase produced 43 results.
More in detail, 111 abstracts were eliminated for reason 1 (Articles form Web of Science and Scopus providing contribution in Agromedicine, Environment Protection, Animal and Fishery, Hydrology, Governance, Energy, Aerospace research fields, Environmental science, Social science, Computer science, Agricultural Science, Energy, Nursing, Material science, Chemistry, Mathematics, Physics and Astronomy, Psychology, Veterinary, Arts and humanities, Chemical engineering and Neuroscience were excluded in the abstract and full-article selection phase) and 130 abstracts for reason 2 (Studies that only recommend a future cost-benefit Analysis and studies concerning Cost Effectiveness Analysis instead of cost-benefit Analysis were excluded in the abstract and full-article selection phase).

The full-text reading step led to consider valuable and eligible for the literature analysis only 17 articles. The flow through the different phases of the review has been visually reported if the following funnel (Figure 4.2).

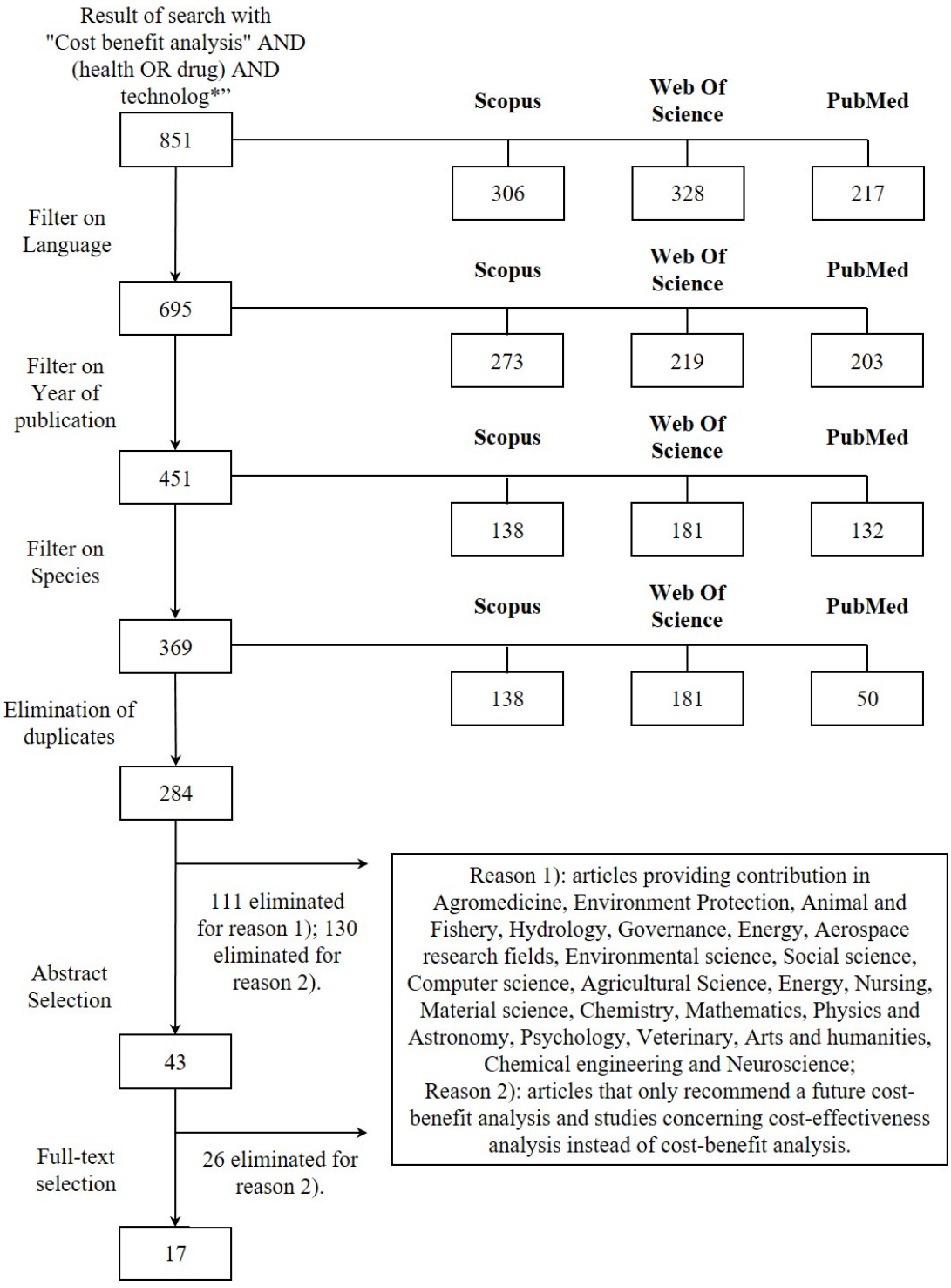

Figure 4.2: CBA Funnel Diagram 2

Summary table of included articles Table 4.4 reports the 17 selected articles for the CBA literature review with the corresponding year of publication, authors, journal of publication, the most recent quartiles of the publishing journal according to Scimago Journal & Country and citations per document (average citations over 4 years - most recent).

Title	Year	Authors	Journal	Quartiles	Citations
A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	2015	Roper, K.O.; Sedehi, A.; Ashuri, B.	Facilities	Q2 (2017)	1.526 (2017)
An evaluation of South Africa's public-private partnership for the localisation of vaccine research, manufacture and distribution	2018	Walwyn, D.R.; Nkolele, A.T.	Health research policy and Systems	Q1 (2018)	2.888 (2017)
Assessment of economic effectiveness in treatment of neuropathic pain and refractory angina pectoris using spinal cord stimulation	2017	Harat, A.; Sokal, P.; Zieliński, P.; (...), Rusicka, T.; Herbowski, L.	Advances in Clinical and Experimental Medicine	Q2 (2017)	1.385 (2017)
Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	2016	Akiyama, M; Abraham, C.	International Journal of Medical Informatics	Q1 (2017)	4.175 (2017)
Cost-benefit analysis of applied research infrastructure. Evidence from health care	2009	Battistoni, G.; Genco, M.; Marsilio, M.; Pancotti, C.; Rossi, S.; Vignetti, S.	Technological Forecasting and Social Change	Q1 (2017)	4.852 (2017)
Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	2012	Jeuland, M; Whittington, D.	Vaccine	Q1 (2015)	3.385 (2017)
Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	2015	Testa, A.; Francesconi, A.; Giannuzzi, R.; Berardi, S.; Sbraccia, P.	Internal and Emergency Medicine	Q1 (2017)	2.072 (2017)

Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	2016	Vannieuwenborg, F.; Van der Auwermeulen, T.; Van Ooteghem, J.; Jacobs, A.; Verbrugge, S.; Colle, D.	JMIR Medical Informatics	-	-
Fairness in cost-benefit analysis: A methodology for health technology assessment	2018	Samson, A.L.; Schokkaert, E.; Thebaut, C.; Dormont, B.; Fleurbaey, M.; Luchini, S.; Van de Voorde, C.	Health Economics	Q1 (2017)	2.44 (2017)
Hand sanitisers for reducing illness absences in primary school children in New Zealand: a cluster randomised controlled trial study protocol	2016	McKenzie J.E.; Priest, P.; Audas, R.; Poore, M.R.; Brunton, C.R.; Reeves L.M.	Trials	Q1 (2017)	2.285 (2018)
Introduction to Cost Analysis in IR: Challenges and Opportunities	2017	Roudsari, B.; McWilliams, J.; Bresnahan, B.; Padia, S.A.	Journal of Vascular and Interventional Radiology	Q2 (2017)	2.695 (2017)
Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	2017	Poder, T.G.; Erraji, J.; Coulibaly, L.P.; Koffi, K.	pLoS ONE	Q1 (2016)	3.337 (2018)
PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis	2011	Tur-Kaspa, I.; Aljadeff, G.; Rechitsky, S.; Grotjan, H.E.; Verlinsky, Y.	Reproductive BioMedicine Online	Q1 (2017)	3.704 (2018)

Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	2010	Greenspoon, J.N.; Whitton, A.; Whelan, T.; Sharieff, W.; Wright, J.; Sussman, J.; Gafni, A.	Technology in Cancer Research & Treatment	Q3 (2017)	1.579 (2018)
State medicaid expansions and mortality, revisited: A cost-benefit analysis	2010	Sommers, Benjamin D.	American Journal of Health Economics	Q1 (2018)	1.841 (2018)
The economics of health information technology in medication management: A systematic review of economic evaluations	2013	O'Reilly, D.;Tarride, J.E.; Goeree, R.; Lokker, C.; McKibbon, K.A.	Journal of the American Medical Informatics Association	Q1 (2017)	4.691 (2018)
Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits	2018	Natafgi, N.; Shane, D.M.; Ullrich, F.; MacKinney, A.C.; Bell, A.; Ward, M.M.	Journal of Telemedicine and Telecare	Q1 (2017)	2.579 (2017)

Table 4.4: CBA summary table of reviewed articles

Retrieved articles at the end of the search process Articles that required a downloading fee were asked directly to authors through ResearchGate.com website. All the requests have been satisfied and the missing reports have been shared by their authors.

Quality appraisal of retrieved articles Quality assessment is crucial to ensure that findings of papers are correct (Popay et al., 2006). For this reason, the quotation of the publishing journal according to Scimago Journal & Country has been included in the aforementioned summary tables.
Even if some journal had not explicit quotation, the paper they published were kept for the analysis due to the perceived relevance of their contributions. However, the lack of certified quotation has been taken into account when analysing and comparing the papers' results.

Critical review The critical review entails the three processes of data extraction, analysis and synthesis. To extract relevant data from included literature, a data extraction form was developed in collaboration with the project supervisor.

Data extraction The sum of selected articles is structured as follows:

1. Introduction to the topic;
2. Perspective adopted for the analysis;
3. Benefit (identification of benefits, quantification of benefits and monetization of benefits);
4. Costs (list of costs and valuation of costs);
5. Time horizon for the measurement;
6. Cost of capital.
7. Sensitivity analysis

Data analysis The retrieved data were then analysed to answer the main research questions and sub-questions. The collected information for each paper has been summarized in order to allow to report a review of the results.

Synthesis Finally, the findings were discussed in a narrative synthesis. The synthesis is presented in the following section (4.4).

4.4 Narrative review

A first relevant consideration that emerged from the reading phase of the articles is that, **although most of the 17 reports included in the CBA review shows a clear aim of running a CBA, not all the authors offer a complete CBA** (see Table 4.5), focusing only on a part of the 6 research sub-questions aforementioned, as graphically represented in Figure 4.3:

1. "Typically, which is the perspective adopted when conducting a cost-benefit analysis?"
2. "Which are the main costs taken into account by researchers when dealing with a cost-benefit analysis?"
3. "Which are the main benefits taken into account by researchers when dealing with a cost-benefit analysis?"
4. "Which is the time horizon selected for the analysis?"
5. "Which is the value assumed for the discount rate when computing the final result of the analysis?"
6. "How is the uncertainty of the analysis managed?"

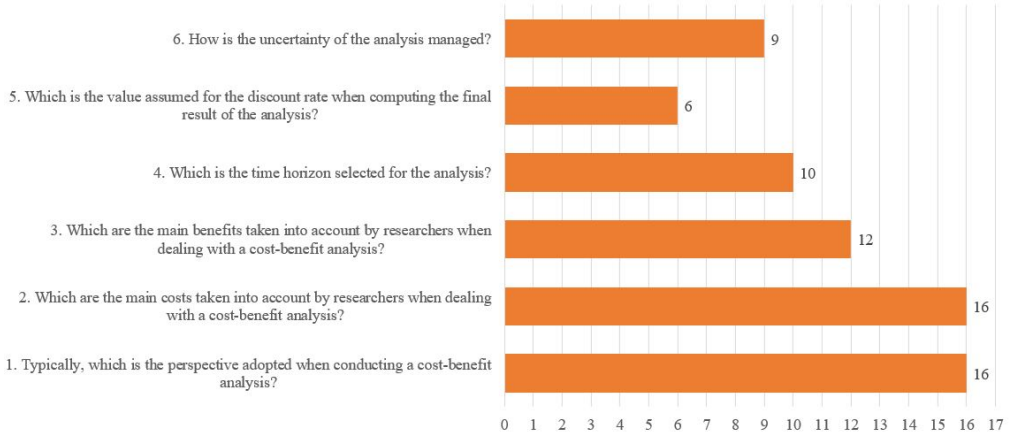

Figure 4.3: Number of articles replying to the research sub-questions

Article title	Author	Questions					
		Q1	Q2	Q3	Q4	Q5	Q6
A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)	X	X	X	NO	X	X
An evaluation of South Africa's public-private partnership for the localisation of vaccine research,manufacture and distribution	Walwyn and Nkolele (2018)	X	X	X	NO	NO	NO
Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	Akiyama and Abraham (2017)	X	X	X	X	X	X

Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)	X	X	X	X	X	X
Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)	X	X	X	X	NO	X
Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)	X	X	X	X	X	X
Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)	X	X	X	X	NO	NO
Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	Vannieuwenborg et al. (2016)	X	X	X	X	NO	NO

Fairness in cost-benefit analysis: A methodology for health technology assessment	Samson et al. (2018)	X	X	NO	X	NO	X
Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)	X	X	NO	X	NO	X
Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)	X	X	X	X	X	X
State Medicaid Expansions and Mortality reviseted: a cost-benefit analysis	Sommers (2017)	NO	X	X	NO	NO	NO
The economics of health information technology in medication management: a systematic review of economic evaluations	O'Reilly et al. (2011)	X	X	NO	X	X	NO

Hand sanitisers for reducing illness absences in primary school children in New Zealand: a cluster randomised controlled trial study protocol	McKenzie et al. (2010)	X	NO	X	NO	NO	NO
PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis	Tur-Kaspa et al. (2010)	X	X	X	NO	NO	NO
Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)	X	X	NO	NO	NO	NO
Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits	Natafgi et al. (2018)	X	X	NO	NO	NO	X

Table 4.5: Articles replying to the research sub-questions

As shown, within the papers that entered the analysis, there is one contribution, that of Sommers (2017), that does not state the adoption of any perspective while running the CBA.
The issue of costs identification and evaluation is not covered uniquely by McKenzie et al. (2010), that provide only a benefit analysis.
Some reports, instead, avoid the listing and monetization phase of benefits. This is the case of the contributions from Natafgi et al. (2018), Greenspoon et al. (2013),

O'Reilly et al. (2011), Roudsari et al. (2016) and Samson et al. (2018). The reason behind this lack of results may lay in the difficulties that occur when evaluating benefits: it seems particularly clear when running a prospective estimation for which no clear evidence regarding the generated benefits is available.
As regards the definition of a time horizon, Roper et al. (2015), Walwyn and Nkolele (2018), Sommers (2017), McKenzie et al. (2010), Tur-Kaspa et al. (2010), Greenspoon et al. (2013) and Natafgi et al. (2018) did not offer, within their contributions, a time horizon of analysis. As for the discount rate, the majority of authors (11 papers) did not declare the adopted discount rate.
According to the guidelines for the economic evaluation of health interventions in Italy (Fattore, 2009), the uncertainties related to the indicator resulting from the CBA require to be managed through the development of a sensitivity analysis, that aims to determine the "robustness" of the estimated indicator. However, some authors (8 papers) did not perform a sensitivity analysis within their CBA. This is the case of Walwyn and Nkolele (2018), Testa et al. (2015), Vannieuwenborg et al. (2016), Sommers (2017), O'Reilly et al. (2011), McKenzie et al. (2010), Tur-Kaspa et al. (2010) and Greenspoon et al. (2013).
Deeper investigation of each sub-question is provided in the following paragraphs.

4.4.1 Perspective of analysis

Reviewing the selected papers, it has been noticed that the identification of costs and benefits and the applied monetization methods vary according to the point of view taken by the authors to perform the analysis.
As a matter of fact, O'Reilly et al. (2011) state that the CBA of a technology in healthcare can be performed considering different perspectives that not only require a different time horizon and discount rate but can also lead to different results and evaluations.
In particular, from the reading it emerged that **it is possible to classify papers according to two different perspectives of analysis: customer/patient perspective and provider (generally identified with the healthcare system) perspective**.
This classification finds validity in the paper by (Davalos et al., 2009). In fact, the authors propose the aforementioned perspectives to estimate economic costs and economic benefits when running a CBA in healthcare. As shown by Figure 4.4, some articles perform a more complete analysis by combining both perspectives.
Moreover, form the review, it emerged the analysis varies also according to another classification criteria: the subject under investigation.
Papers can be distinguished between technology evaluations, when the accomplished CBA is devoted to the estimation of a technology, and process evaluations, when the goal of the CBA is to estimate the impact of a new health process or intervention (Figure 4.5).

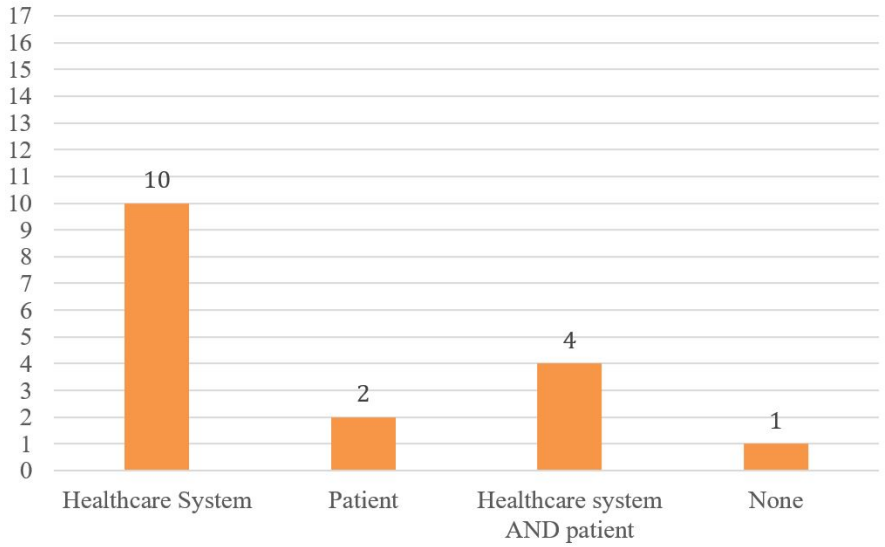

Figure 4.4: Number of articles according to perspective under analysis

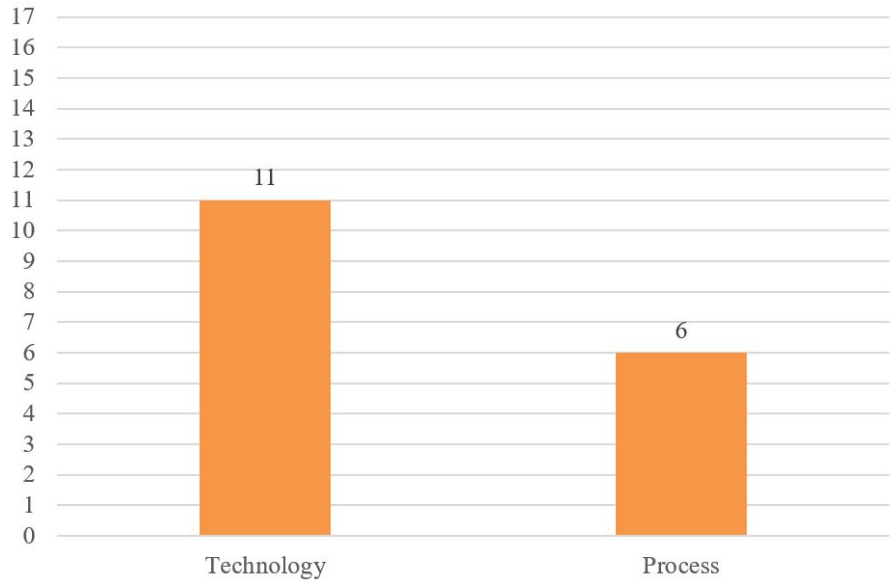

Figure 4.5: Number of articles according to subject under analysis

The two classification criteria, perspective and subject under investigation, have been combined (Figure 4.6) and employed as papers categorization criteria, as shown in Table 4.6 .

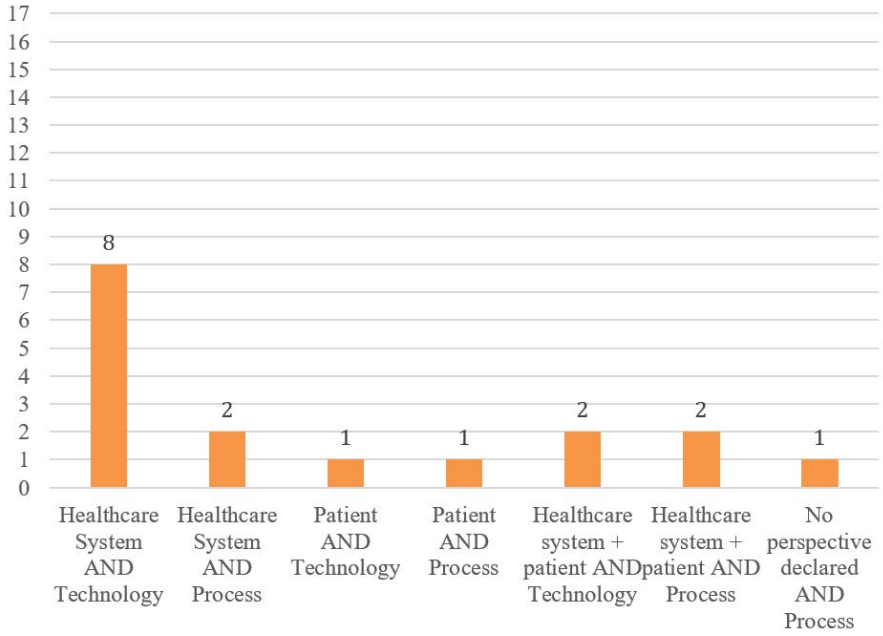

Figure 4.6: Number of articles according to perspective AND subject under analysis

Article Title	Authors	**Perspective**	**Subject**
A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)	Healthcare System	Technology
An evaluation of South Africa's public-private partnership for the localisation of vaccine research, manufacture and distribution	Walwyn and Nkolele (2018)	Healthcare System	Process

Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	Akiyama and Abraham (2017)	Healthcare System	Technology
Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)	Healthcare System	Technology
Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)	Healthcare system AND patient	Process
Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)	Payer (patient)	Process
Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)	Healthcare System	Technology

Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	Vannieuwenborg et al. (2016)	Homecare Organization	Technology
Fairness in cost-benefit analysis: A methodology for health technology assessment	Samson et al. (2018)	Healthcare system AND patient	Process
Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)	Patient AND Healthcare provider AND Insurance Companies AND Society	Technology
Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)	Public Healthcare System	Technology
State Medicaid Expansions and Mortality reviseted: a cost-benefit analysis	Sommers (2017)	None	Process

The economics of health information technology in medication management: a systematic review of economic evaluations	O'Reilly et al. (2011)	Healthcare System AND patient	Technology
Hand sanitisers for reducing illness absences in primary school children in New Zealand: a cluster randomised controlled trial study protocol	McKenzie et al. (2010)	Patient	Technology
PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis	Tur-Kaspa et al. (2010)	Healthcare System	Process
Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)	Healthcare System	Technology
Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits	Natafgi et al. (2018)	Healthcare System	Technology

Table 4.6: Articles per perspective and subject under investigation

Dealing with the valuation of a technology, form the analysis it emerges that the majority of the authors, 8, adopt the healthcare system perspective.
In particular, Roper et al. (2015) investigate the costs and benefits of a radio frequency identification system (RFID) for asset tracking in healthcare facilities; Akiyama and Abraham (2017) of a tele-homecare system for community-dwelling elderly patients in Japan; Battistoni et al. (2016) of an accelerator (CNAO) specifically designed to provide oncological medical treatment; Testa et al. (2015) and colleagues (2015) evaluate the bedside ultrasonography technology to carry out quick and reliable examination; Vannieuwenborg et al. (2016) study the impact of smart care platforms for care-dependent people; Roudsari et al. (2016) estimate the adoption of interventional radiology (IR) clinic visits;Poder et al. (2017) of the drug-eluting stents to eradicate retentions and promote revascularization; Greenspoon et al. (2013) of the robotic radiosurgery of treatment of brain metastases; Natafgi et al. (2018), instead, assess the development of tele-emergency in rural areas.

There are some peculiar reviews, such as that of Roudsari et al. (2016), that, while estimating the adoption of a new technology (IR clinic visits), do not only assume the healthcare system perspective or the patient perspective, but analyse and compare them both together with those of insurance companies and the whole society as well. The choice of the authors is based on the awareness that their study could be potentially relevant for policy development and, therefore, it becomes essential to offer a complete overview of the expected impact of the IR technology. The same reasoning is proposed by O'Reilly et al. (2011), whose review takes into account the perspective of the healthcare system, of the payer, of the healthcare practice and of the institutions involved.

The other possible core subject for a CBA is a process/intervention. Two authors adopt the mere healthcare system perspective. Walwyn and Nkolele (2018) analyse the impact of a public-private partnership for the vaccine research and development, manufacturing and supply; Sommers (2017) evaluates the impact of the local launch of the Medicaid program on the population.

Jeuland and Whittington (2009) observe that, in some cases, the healthcare system perspective may be not enough to stand alone and offer a complete overview of the impact generated by a certain process. The authors, in fact, estimate the impact of a vaccination program form both the healthcare system and the patient perspective. Similarly, in their analysis of the delivery program of a specific treatment for essential hypertension, Samson et al. (2018) involve costs for both, the healthcare system and the patient.

Other authors consider the healthcare system perspective not to be valuable and worthy of analysis to evaluate certain processes or intervention and, as consequence, decide to run the CBA taking the point of view of the patient. This is the case of Harat et al. (2012) that estimate the impact that the process of spinal cord stimulation (SCS) intervention may have on patients' lives; similarly, also McKenzie et al. (2010) assess the role of installed hand sanitisers in schools to avoid infectious disease between children.

4.4.2 Costs analysis

Form the review, it emerged that **the list of costs involved and corresponding monetization methods change when dealing with a technology or a process and when adopting the healthcare system or the patient perspective**.
As a consequence, it follows a detailed analysis of the cost items involved in each of the four combinations we get when crossing the two aforementioned classification criteria.

The first analysed combination refers to articles that adopt the perspective of the healthcare system and that concern a technology. It has to be noticed that also articles combining different perspectives have been involved, reporting anyway only those cost items that they explicitly refer to the healthcare system. As a result, 10 articles belong to this category.
The following Figure 4.7 displays the major cost items involved in the category and the Table 4.7 shows the articles involving them.

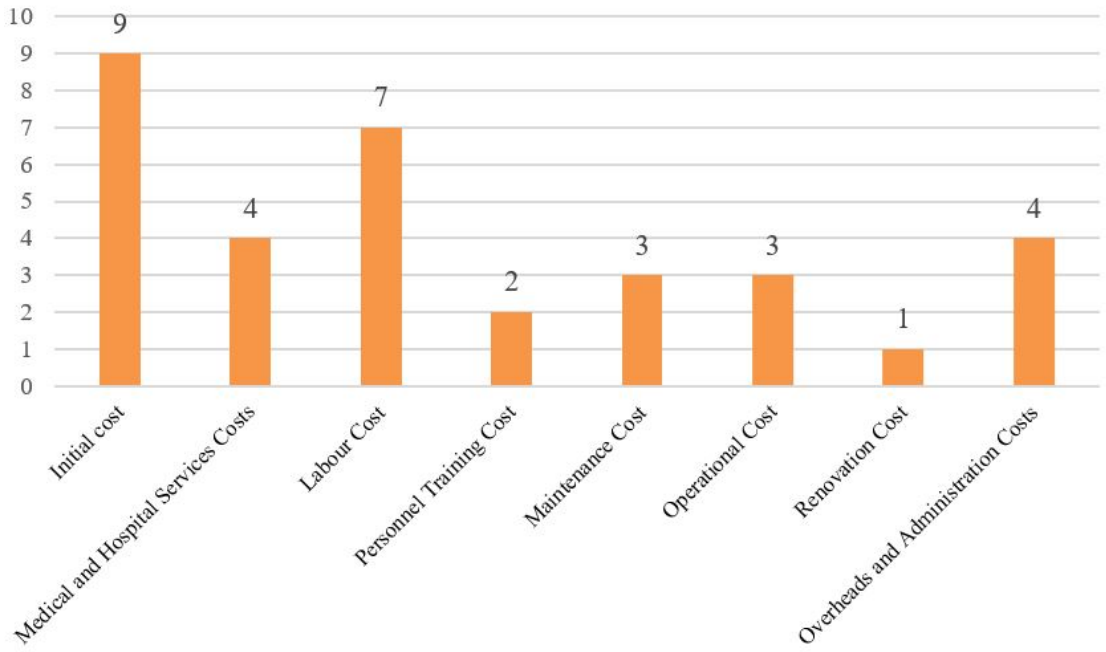

Figure 4.7: Cost items for healthcare system AND technology (number of articles mentioning the item)

Cost items in Healthcare system perspective AND Technology	Article Title	Authors
Initial cost (fixed assets purchase, non-fixed assets for planning and project management, system integration)	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
	The economics of health information technology in medication management: a systematic review of economic evaluations	O'Reilly et al. (2011)

	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
	Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)
	Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)
	Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)
	Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits	Natafgi et al. (2018)
	Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	Akiyama and Abraham (2017)

Medical and hospital services costs	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
	Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)
	Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)
	Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)
Labour cost	Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	Akiyama and Abraham (2017)
	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)

	The economics of health information technology in medication management: a systematic review of economic evaluations	O'Reilly et al. (2011)
	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
	Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)
	Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)
	Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)
Personnel training cost	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015).

	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
Maintenance cost	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
	Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)
Operational cost	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
	Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)

Renovation cost	Robotic Radiosurgery for the Treatment of 1-3 Brain Metastases: A pragmatic Application of Cost-Benefit Analysis Using Willingness-to-pay	Greenspoon et al. (2013)
Overheads and administration cost	Introduction to Cost Analysis in IR: Challenges and Opportunities	Roudsari et al. (2016)
	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
	The economics of health information technology in medication management: a systematic review of economic evaluations	O'Reilly et al. (2011)
	Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	Vannieuwenborg et al. (2016)

Table 4.7: Cost items in articles with healthcare system perspective AND technology

Considering articles that refer to medical informatics or technology in healthcare, Akiyama and Abraham (2017) identify as main cost categories the initial costs, referring both to the purchase of the devices and to the system integration, and the labour costs; in the same way, Battistoni et al. (2016) include in their analysis the investment costs, considering both the fixed assets of machinery and the non-fixed assets of planning and project management, and the labour cost of personnel, but they also consider the required maintenance costs for running the technology, the future costs of investment for constant upgrading of technological instruments and overhead costs, such as administration and energy. Initial investment costs and labour costs are considered also by O'Reilly et al. (2011), together with administration and research costs. Instead, the analysis of Natafgi et al. (2018) considers only

the equipment purchase costs. Vannieuwenborg et al. (2016) contribution, which appears to be a less authoritative source (no information is given on the quality of the journal), focuses only on administration costs.
Articles referring to journals of medicine or diagnosis consider slightly different costs: Testa et al. (2015), Poder et al. (2017), Roudsari et al. (2016) and Greenspoon et al. (2013) consider the initial investment and labour costs but their articles also list the medical and hospital services expenditures as the costs for treatment planning and delivering.
Testa et al. (2015) insert in their CBA also the training costs for personnel, while Greenspoon et al. (2013) extend their analysis also to overheads, annual operations costs for running the technology and renovation costs. Roudsari et al. (2016)consider overheads and maintenance costs.
Despite the paper written by Roper et al. (2015) belongs to a journal concerning facilities and does not present any quotation, in their analysis it is possible to find some similarities with the other articles: they list fixed costs of investments, maintenance cost, training cost and annual operational costs for running technologies.
As regards the monetization methods, the various articles present different solutions. Roper et al. (2015) obtain all numerical values from published journal papers, hospital cases and available reports, while Akiyama and Abraham (2017) exploit other studies of CBA and medical expenditure save. Battistoni et al. (2016) estimate the costs basing on historical data and Testa et al. (2015) apply a retrospective study. Vannieuwenborg et al. (2016) combine two methodologies: information is extracted both from interviews, focus groups or workshops and from realistic data provided by service providers and experts from health care organizations. Poder et al. (2017), instead, state that their study relied on clinical data yielded by the systematic literature review combined with their institution's cost data. O'Reilly et al. (2011) utilize peer-reviewed electronic databases and grey literature to gather data to evaluate costs. Greenspoon et al. (2013), Roudsari et al. (2016) nd Natafgi et al. (2018) do not report any methodology for estimating costs.

The second category of papers refers to health interventions assuming the perspective of the healthcare system. It has to be noticed that also articles combining different perspectives (or assuming no perspective) have been involved, reporting anyway only those cost items that they explicitly refer to the healthcare system. As a result, 5 articles belong to this category and they are reported in Table 4.8

Cost items in Healthcare system perspective AND process	Article Title	Authors
Initial investment in medical intervention (production, procurement and delivery)	An evaluation of South Africa's public-private partnership for the localisation of vaccine research, manufacture and distribution	Walwyn and Nkolele (2018)
	Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)
Medical services cost (medication, specialist treatment, hospitalization, rehabilitation, drug treatment, follow-up and therapy)	PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis	Tur-Kaspa et al. (2010)
	Fairness in cost-benefit analysis: A methodology for health technology assessment	Samson et al. (2018)
	State Medicaid Expansions and Mortality reviseted: a cost-benefit analysis	Sommers (2017)

Table 4.8: Cost items in articles with Healthcare system perspective AND process

Walwyn and Nkolele (2018) and Jeuland and Whittington (2009) deal with the same subject (delivery of vaccines) and both consider only the cost for the initial investment in the medical intervention although with a small difference: while the former includes in the cost of investment the procurement and the delivery of vaccines, the latter considers also the costs related to the production.
Samson et al. (2018), Tur-Kaspa et al. (2010) and Sommers (2017) include in their analysis the costs of medical services; particularly, for Samson et al. (2018) the costs are referred to drugs treatment, hospitalization and follow-up of the treatment; Tur-Kaspa et al. (2010) consider only costs of therapy. Finally, Sommers (2017) refers to the costs of medical service, intended as the healthcare spending to deliver the treatment, talking about cost per life saved.
Regarding the methodologies for the estimation of costs, all articles exploit different sources: Tur-Kaspa et al. (2010) gather information through interviews, Jeuland and Whittington (2009) extract economic estimations from trials, Walwyn and Nkolele (2018) obtain economic evaluations from secondary data sources as financial statements.
Samson et al. (2018) and Sommers (2017) do not provide any information about the methodologies for the estimation of economic data.

Articles adopting the perspective of the patient and analysing a new process or intervention provide few information regarding the cost items to consider (Table 4.9).

Cost items in patient perspective AND process	Article Title	Authors
Medical services cost (medication, treatment, hospitalization, rehabilitation, follow-up and therapy)	Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)
	Fairness in cost-benefit analysis: A methodology for health technology assessment	Samson et al. (2018)
Private time spent for travelling and queueing	Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)

Table 4.9: Cost items in articles with patient perspective AND process

Jeuland and Whittington (2009) include in their CBA the private costs associated with vaccination. In particular, they refer to the monetary value of the time that households spend acquiring the required doses of the vaccine, so travelling and queuing; Harat et al. (2012) consider the out of pocket for medical services such as medication, specialist treatment, hospitalization and rehabilitation; Samson et al. (2018) insert in the cost items drugs treatment, hospitalization and follow-up of the treatment. Finally, even if McKenzie et al. (2010) represent the only authors that adopt exclusively the perspective of the patient for evaluating a technology, they limit their analysis to the benefits, without giving any information about the costs.

4.4.3 Benefits analysis

From the review, it emerged that the list of benefit items involved and the corresponding monetization methods change according to the perspective of analysis.
Anyway, it was noticed that the declared perspective of analysis (patient or healthcare system) is not always strictly respected by authors when dealing with benefits. As a matter of fact, independently from the perspective of analysis taken, many authors include both benefits strictly related to the healthcare system, such as revenues and costs savings, and benefits valuable from a patient point of view, such as reduction of mortality.
In this section, the subdivision of articles for type of subject, technology or process, has been neglected since it was noticed that this variable does

not influence the categorization of measured benefits.
Figure 4.8 and 4.9 represents the main benefit items for, respectively, the healthcare system and the patient and the number of articles involving them in their analysis. Table 4.10, insted, illustrates the contibution of each article.

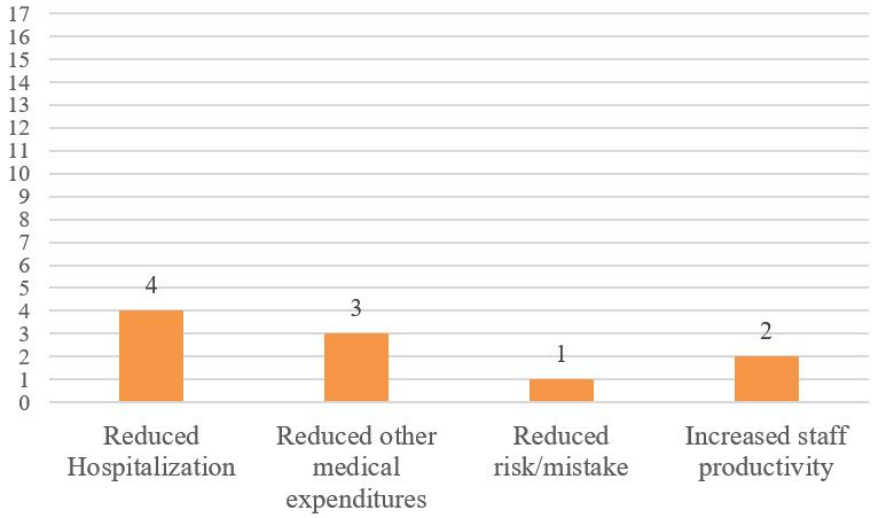

Figure 4.8: Benefit items from healthcare system perspective (number of articles mentioning the item)

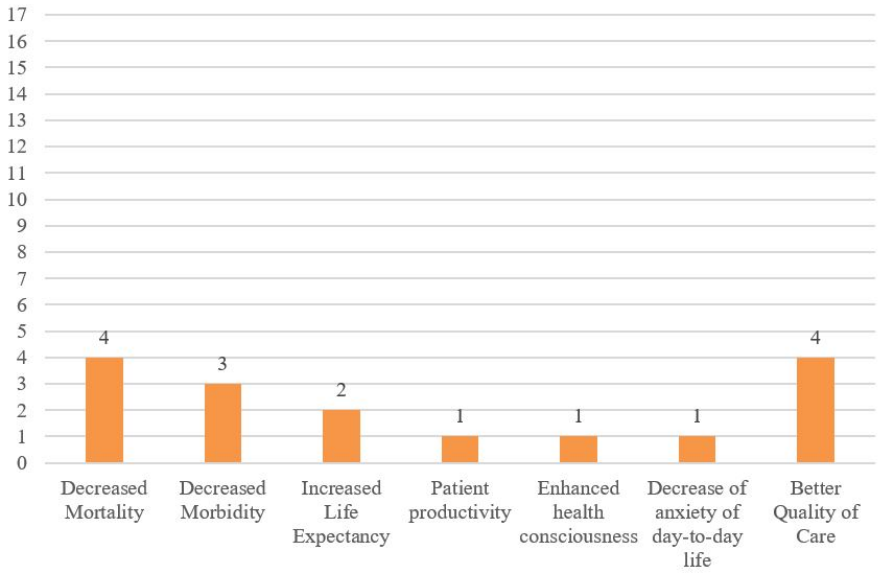

Figure 4.9: Benefit items from patient perspective (number of articles mentioning the item)

Perspective	**Benefit items**	**Monetization method**	Article Title	Authors
Healthcare system	Reduced hospitalization	Cost savings	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
			Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
			Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)
			PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis	Tur-Kaspa et al. (2010)
	Reduced other medical expenditures	Cost savings	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
			Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models	Akiyama and Abraham (2017)
			An evaluation of South Africa's public-private partnership for the localisation of vaccine research, manufacture and distribution	Walwyn and Nkolele (2018)

	Reduced risk/mistake	Cost savings	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
	Increased staff productivity	Increased revenues	A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
		Cost savings	Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	Vannieuwenborg et al. (2016)
Patient	Decreased mortality	Human Capital (suggested WTP)	Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department	Testa et al. (2015)
			Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)
			Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
			Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)
	Decreased morbidity	Human Capital (suggested WTP)	Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost-benefit analysis	Poder et al. (2017)

		Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)
		Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)
Increased life expectancy	Human Capital	Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
		Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs	Jeuland and Whittington (2009)
Increased patient productivity	Human Capital	Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)
Enhanced health consciousness	Willingness to pay	Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Model	Akiyama and Abraham (2017)
Decreased anxiety of day-to-day life	Willingness to pay	Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Model	Akiyama and Abraham (2017)

	Better quality of care	Willingness To pay	Assessment of Economic Effectiveness in Treatment of Neuropathic pain and Refractory Angina pectoris Using Spinal Cord Stimulation	Harat et al. (2012)
			A cost-benefit case for RFID implementation in hospitals: adapting to industry reform	Roper et al. (2015)
			Cost-benefit analysis of applied research infrastructure. Evidence from health care	Battistoni et al. (2016)
			Evaluating the Economic Impact of Smart Care platforms: Qualitative and Quantitative Results of a Case Study	Vannieuwenborg et al. (2016)

Table 4.10: Benefit items in articles with both healthcare and patient perspective

Almost all the authors adopting the healthcare system perspective involve contribution to the hospital or healthcare system efficiency as main outcome of their analysis.
In particular, Roper et al. (2015), Testa et al. (2015), Poder et al. (2017) and Tur-Kaspa et al. (2010) consider as key benefit of their analysis the reduction of hospitalization estimated as costs saving for the hospital.
Tur-Kaspa et al. (2010) outline how the introduction of preimplantation genetic diagnosis (PGD) could completely cut costs for taking care of cystic fibrosis patients, but do not provide estimations of the magnitude of savings.
Differently, Roper et al. (2015) and Poder et al. (2017) estimate the savings resulting from the reduced inventory, labour, laboratory tests, rehabilitation and maintenance. The former values these cost savings through experts' judgments and surveys of practitioners, while the latter's results come from meta-analysis.
Testa et al. (2015), instead, employ literature reviews to estimate the savings attributable to the avoidance of clinical complications; the same report, alongside with reduced hospitalization, considers as benefits coming from the implementation of bedside ultrasonography technology to support the diagnosis phase the reduction of other medical expenditures related to unnecessary treatment or examination.
The benefit derived from the reduction of other medical expenditures is included also by Walwyn and Nkolele (2018). They involve savings related to the "reduced life cycle" resulting from the established Public-Private partnership for the vaccine research and estimate that investing in vaccine would lead to savings in public healthcare "for alternative care"; Akiyama and Abraham (2017) estimate the total

amount of general medical savungs as the weighted average of health care services, drugs and medical suppliers, saved per year due to the implementation of telehomecare for elderly.
The article from Testa et al. (2015) is the only one involving the reduction of risk and mistakes that a technology can guarantee as a benefit for the healthcare system. Specifically, the authors evaluate that the bedside ultrasonography implementation can reduce the diagnostic–therapeutic mistakes, thus resulting in cost savings for the hospital. Due to the relevance of the journal, whose quotation is Q1, the reduction of risk/mistake has been considered as a valuable benefit item to be included in the analysis, even if there are no other contributions within the analysed pool of papers that propose it.
The same authors propose also the increase of patient turnover as a direct benefit of the technology introduction. Precisely, they state that the increase and appropriateness of diagnosis can lead to obtain more revenues for the hospital; therefore, the boost of patient is monetized according to the amount of revenues from a new diagnosis.
In their paper, Roper et al. (2015) consider as benefit of the RFID technology in hospital the enhance of staff productivity. They estimate that improving the efficiency of the operations may result in saving time for staff that can focus on the delivery of better quality of care to patients, bringing more revenues to the hospital. The paper quantifies the impact of higher staff productivity through experts' judgements and survey to practitioners. Similarly, Vannieuwenborg et al. (2016) evaluate the improvement in productivity that derives from the smart-care platform installation: significant decrease in administration time allows to save hours per year and, as consequence, to save money, as estimated by home care managers and staff members during focus groups and semi-structured interviews.
Some of the aforementioned contributions, such those of Roper et al. (2015), Testa et al. (2015) and Vannieuwenborg et al. (2016), discuss also the benefits deriving from the staff satisfaction: as witnessed by Testa et al. (2015), the usage of technologies in their daily work has positive impact on the degree of professional satisfaction of the staff. This sense of gratification, as investigated by the authors, is related to the possibility to offer, thanks to the new technology, higher quality of services or to rely on a better work atmosphere, with better coordination and less stress. However, none of the papers propose a quantification and monetization of the staff satisfaction.

Many authors, although maintaining the healthcare system point of view for the final analysis of costs and benefits, introduce as source of analysis also patient-related benefits. Relevant contribution to the topic comes from Battistoni et al. (2016), Jeuland and Whittington (2009), Testa et al. (2015) and Poder et al. (2017), that introduce in their analyses benefits such as the decrease of mortality achievable through the introduction of technologies or process under investigation. Alongside with the minor mortality, Jeuland and Whittington (2009), Harat et al. (2012) and Poder et al. (2017) value also the benefits of reduction of morbidity.
The method of the Human Capital is an option of monetization expressed by the aforementioned authors to monetize the benefit of reducing mortality and morbidity. The method, as defined by Kattan (2009)in a SAGE publication, places a monetary

value as the lost value of economic productivity due to ill health, disability, or premature mortality. More specifically, the Human Capital approach uses the present value of expected future earnings to estimate the potential loss to society if an individual dies or becomes permanently disabled.
In particular, Battistoni et al. (2016) use the Human Capital to determine the Value of Statistical Life (VOSL[2])and related Value of a Life Year (VOLY[3]) .
Similarly, Jeuland and Whittington (2009) use the VOSL to assess the mortality-related benefit and the Cost of Illness (COI[4]) for the morbidity-related one.
Slightly different, even if always applying the Human Capital method, it is the case of Harat et al. (2012): taking the patient perspective, they determine the impact that spinal cord stimulation procedure has on patient productivity intended as the ability to work. Moreover, these authors propose the practice of Human Capital in combination with Willingness to pay (WTP [5].) to assess patients' preferences.
Other authors, instead, limit their analysis to a qualitative level, stating that not enough evidence allows them to perform a quantitative evaluation of the decreased mortality/morbidity. For example, Harat et al. (2012) adopt uniquely the Visual Analogue Scale (VAS[6]) to estimate the pain and the morbidity condition of an individual after the treatment of pain with spinal cord stimulation.
Another relevant benefit item is proposed by Battistoni et al. (2016): increased life expectancy. The authors consider as remarkable health improvement the increase of life expectancy suitably adjusted by the quality of life. Also in this case, the Human Capital is used as monetization approach.

[2]Amount people are willing to pay to reduce risk so that on average one less person is expected to die from the risk. The analyst estimates the monetary value of the mortality risk reduction from the initiative by using the VSL estimate. The VSL is not intended to value very large reductions in mortality risk or place a value on the lives of identified individuals. VSL measures the monetized value of small reductions in mortality risk for many people. For example, a countermeasure that reduces the annual risk of death by one in a million for 20 million people will, on average, save 20 lives a year. If the VSL is estimated at $5 million, the value of this mortality risk reduction is $100 million (20 expected lives saved times $5 million per life). Most VSL estimates are based on studies of the wage compensation for occupational hazards or studies that elicit people's willingness to pay for mortality risk reduction directly (National Research Council, 2010).

[3]The value of life is an economic value used to quantify the benefit of avoiding a fatality. In social and political sciences, it is the marginal cost of death prevention in a certain class of circumstances. In many studies the value also includes the quality of life, the expected lifetime remaining, as well as the earning potential of a given person especially for an after the fact payment in a wrongful death claim lawsuit (Office of Best Practice Regulation. (2008). Best practice regulation guidance note: value of statistical life).

[4]Cost of illness (COI) is a summary of the costs of a particular disease to society. This value includes direct costs of treating the disease such as healthcare system costs for diagnosis, treatment and management of disease progression and patients' own costs (travel, over-the-counter medication), as well as indirect costs such as productivity loss resulting from time off employment (Consortium, 2016).

[5]Willingness to pay (WTP) is the maximum price at or below which a consumer will definitely buy one unit of a product (MacKie-Mason and Varian, 1995).

[6]The visual analogue scale or visual analog scale (VAS) is a psychometric response scale which can be used in questionnaires. It is a measurement instrument for subjective characteristics or attitudes that cannot be directly measured. When responding to a VAS item, respondents specify their level of agreement to a statement by indicating a position along a continuous line between two end-points.

Some authors, such as Akiyama and Abraham (2017), include in their analysis an evaluation of the so-called intangible benefits. They consider, in fact, that the tele-homecare system can decrease anxiety of patient, enhance stability of physical status and increase the trust in physicians thanks to a higher health consciousness. The authors propose as monetization criteria the WTP of users.
Similarly, even if only qualitatively considered, the benefits of relying on a better quality of care thanks to a better communication and coordination among physicians are reported by Vannieuwenborg et al. (2016).

4.4.4 Time horizon

When running a prospective CBA aiming at evaluating the potential impact of a technology or a process, the decision about the time horizon for the analysis becomes crucial, since it influences the numerical ratio between costs and benefits and thus the final evaluation over the given subject itself.

Several **reviewed articles prove that the time horizon is strictly related to the subject under investigation**: Akiyama and Abraham (2017) perform their analysis over a time horizon of 5 years, equal to the depreciation period of IT equipment; (Battistoni et al., 2016) adopt a 30-years-long perspective basing on the duration of the useful life of the technology under evaluation; (Harat et al., 2012) choose a 5 years long time horizon due to the duration of the battery for Spinal Cord Stimulation Process.
In some cases, as Poder et al. (2017) state, the choice of the time horizon is strongly influenced by the availability of information regarding the technology under evaluation: this reason forces the authors to adopt a short time horizon of only 2 years.
Other authors do not give any explanation about the time horizon adopted: Testa et al. (2015) perform their analysis over 3 years, Vannieuwenborg et al. (2016) over 8 years, Samson et al. (2018) over 10 years and Roudsari et al. (2016) over 1 year. O'Reilly et al. (2011), instead, vary the time horizon of the analysis according to the perspective adopted: when considering the healthcare institution, the time horizon is equal to 10 years; when they analyse the perspective of the patient, the time horizon adopted is equal to 5 years; in the analysis of the healthcare practice and of the healthcare system, the authors choose a time horizon of 1 years. This differentiation of the duration of the analysis is not justified in the article.

Due to the fragmented information available and the different approaches used by different authors, it is difficult to classify the articles in order to draw reliable conclusions regarding time horizons.

4.4.5 Discount rate

The final result of any CBA is usually distributed over a time horizon of several years. As a consequence, the selection and application of a proper rate is necessary for the discount of the costs and benefits.

The British HM Treasury (2003) Minister's "Green Book" for public authorities recommends a base rate of 3.5% when making economic estimates based on cost–benefit

analyses.
However, following criticism by the "Stern Review on the Economics of Climate Change" (Zenghelis, 2006), the Treasury lowered the rate to 3% to eliminate the effect of pure time preference, which was estimated at 0.5% (Cooper et al., 2018).
Moreover, **the choice of the discount rate is influenced by the kind of technology or process taken into consideration** and by the time horizon considered, therefore typically authors rely on pre-defined guidelines to determine their specific rate. Roper et al. (2015) adopt a base real discount rate between 2% and 3% as suggested by Newcomer et al. (2015). Akiyama and Abraham (2017) extract a base discount rate equal to 3% from well-established guidelines on IT equipment and Battistoni et al. (2016) choose their rate of 3% in line with the provisions for CBA adopted by the European Commision for programming period 2014-2020.
Harat et al. (2012) and O'Reilly et al. (2011), instead, state to adopt a discount rate of 5% without giving any explanation.
Other authors do not claim to use any discount rate: some, like Poder et al. (2017) justify their choice with the adoption of a short time horizon perspective.

4.4.6 Sensitivity analysis

Some of the reviewed articles perform a sensitivity analysis to verify the robustness of the results of the CBA.
Sensitivity analysis is the study of how the uncertainty in the output (dependent variable) of a model or system can be divided and allocated to different sources of uncertainty in its inputs (independent variables) (Saltelli et al., 2008).

Roper et al. (2015), following the suggestion of Newcomer et al. (2015), assume a discount rate that varies between 5% and 7% for testing the sensitivity of the results.
Similarly, Akiyama and Abraham (2017) analyse a range of value from 1% to 5% to verify that the choice of the discount rate does not influence the result of the analysis. The authors perform a further step, conducting a two-way sensitivity analysis [7], to see the effect of varying initial system (tele-homecare) costs, device cost per person per year, operational labour costs, operational non labor costs, number of users, prevalence of chronic diseases, medical expenditure saved and WTP among users.
Harat et al. (2012), instead, opt for a one-way sensitivity [8] analysis taking as sensitive parameter the price of the neurostimulator. Similarly, Roudsari et al. (2016) evaluate the influence that different parameters, like the price range for an intervention or the potential effectiveness of an intervention, have on the result of the analysis.
Natafgi et al. (2018) sensitivity analysis is conducted by examining the worst- and best-case scenarios of costs, revenues and savings. Battistoni et al. (2016) involve in their study a marginal percentage of recovered patient instead of punctual values.

[7] Two-way sensitivity analysis is a technique used in economic evaluation to assess the robustness of the overall result (typically of a model-based analysis) when simultaneously varying the values of two key input variables (parameters).

[8] Univariate/one-way sensitivity analysis allows a reviewer to assess the impact that changes in a certain input (parameter) will have on the output results of an economic evaluation.

The sensitivity analysis conducted by Poder et al. (2017) involves different values for the estimation of the potential efficiency of a technology. Also Jeuland and Whittington (2009) agree with the usefulness of performing a sensitivity analysis and, as consequence, report a probabilistic sensitivity analysis (or Monte Carlo analysis [9]) to generate a frequency distribution of benefit-cost ratios under a wide variety of parameter combinations.
Samson et al. (2018) perform a sensitivity analysis with different values of the discount rate.

4.5 Conclusions on cost-benefit analysis

The review revealed how only part of the authors perform a complete CBA. The vaste majority of them declares a perspective and details costs and benefits. Anyway, imprecision increases as it comes to the identification of the time horizon and the discount rate; as well as when performing a sensitivity analysis.
In sum, only 2 out of 17 articles (Battistoni et al. (2016) and Harat et al. (2012)) answer to all the questions through which a CBA is articulated.
As regards the perspective adopted, **14 out of 17 authors adopt the healthcare system perspective** (given that in most cases the healthcare system is the main payer and promoter of a given project) (Roper et al. (2015), Walwyn and Nkolele (2018), Akiyama and Abraham (2017), Battistoni et al. (2016), Jeuland and Whittington (2009), Vannieuwenborg et al. (2016), Testa et al. (2015), Samson et al. (2018), Roudsari et al. (2016), Poder et al. (2017), O'Reilly et al. (2011), Tur-Kaspa et al. (2010), Greenspoon et al. (2013) and Natafgi et al. (2018)). Four of these also involve a patient perspective (Jeuland and Whittington (2009), O'Reilly et al. (2011), Roudsari et al. (2016) and Samson et al. (2018)).
In addition, in healthacare, **CBA results to be mostly employed when assessing technologies**. Secondary relevance is attributed to processes assessment. As a matter of fact, 11 out of 17 articles (Roper et al. (2015), Akiyama and Abraham (2017), Battistoni et al. (2016), Vannieuwenborg et al. (2016), Testa et al. (2015), Roudsari et al. (2016), Poder et al. (2017), O'Reilly et al. (2011), Greenspoon et al. (2013), McKenzie et al. (2010) and Natafgi et al. (2018)) analyse a technological solution, while 6 out of 17 deal with a process (Walwyn and Nkolele (2018), Jeuland and Whittington (2009), Harat et al. (2012), Samson et al. (2018), Sommers (2017), Tur-Kaspa et al. (2010)).
It is relevant to notice that the articles adopting a healthcare system point of view refer to both, technologies and processes and that the same happens in case of patient's point of view.
The analysis of costs outlines how **cost items involved in the assessment change according to both perspective and subject under investigation:**

[9] Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling from specified distributions of the random parameters in a model to compute outcomes. When using Monte Carlo analysis to do probabilistic sensitivity analysis, the basic steps of this approach are as follows: (1) specify probability distributions for all the important uncertain quantitative assumptions; (2) execute a trial by taking a random draw from the distribution of each parameter to arrive at a set of specific values for computing outcome values; (3) repeat the trial many times, to produce a large number of realizations of the outcome values.

technology or process. When dealing with a technology from the healthcare system perspective, 9 out of 10 authors involve the cost for initial investment (Roper et al. (2015), Battistoni et al. (2016), O'Reilly et al. (2011), Testa et al. (2015), Poder et al. (2017), Greenspoon et al. (2013), Roudsari et al. (2016), Natafgi et al. (2018) and Akiyama and Abraham (2017)). Initial investment becomes important also when the healthcare system takes into acocunt a new process.
Shifting towards a patient's perspective, cost for medical services preveals. Only one author analyses a technology form the point of view of the patients (McKenzie et al. (2010)); in this case, costs are excluded as once again patients are not the main payers for the solution.
Even if cost items of a CBA can be categorized according to the nature of the evaluation (technology or process), this assumption is not valid when dealing with benefits. As a matter of fact, it emerged that **benefit items change according to the potential impact of the solution proposed (e.g. it can affect mortality or it can simply affect quality of life) independently from the nature of the intervention**.
In addition, **benefits monetization seems to be controversial**. Except from benefits represented by cost savings, experts are resistant to proceed towards a monetization of potential outcomes of a strategy, favouring, in case, Willingness to pay or Human Capital method.
Analysing benefits, it can be observed that experts claiming to adopt a certain point of view for the analysis, in reality, often overcome the limits of the single adopted perspective and involve benefits for different actors. In particular, when dealing with technologies, contributions evaluating benefits simply from a patient point of view completely lack. Therefore, it is registered a systematic inability in correctly defining boundaries for the benefit analysis in terms of perspective to be adopted.
When dealing with the choice of the time horizon and discount rate, it emerged that only generic guidelines exist and, more in depth, the timeframe in case of technology evaluation is influenced by the peculiarities and life expectancy of the technology itself. As for processes, it is not possible to have a standard answer, since each case is treated differently and justification of choices are often not provided by authors.

Chapter 5

Social return on investment of technologies in healthcare

5.1 Introduction

This section is dedicated to a review through systematic search on the use of the SROI in healthcare for evaluating innovative technologies.

Social return on investment (SROI) is a concept to account for social value[1] when evaluating investments. It goes beyond traditional economic evaluation tools, by considering value produced for multiple stakeholders in all three dimensions of development: economic, social and environmental (Millar and Hall, 2013). **SROI emphasizes broad stakeholder engagement and participation in defining value and its measurement by building on the theory of change**[2]. It can be relevant in the context of advocacy for investments for health and sustainable development (Dyakova et al., 2017).

ROI is used in financial analysis and provides the investor with an indication of the efficiency of an investment by comparing profits related to capital invested. It therefore allows a comparison of alternative investment options based on efficiency. ROI can be estimated using a ratio between the net present value of benefits and the net present value of costs. The net present value is usually discounted for value generated over time (Vishwanath, 2007).

[1] Social value is the quantification of the relative importance that people place on the changes they experience in their lives. Some, but not all of this value is captured in market prices. It is important to consider and measure this social value from the perspective of those affected by an organisation's work. Examples of social value might be the value we experience from increasing our confidence, or from living next to a community park. These things are important to us, but are not commonly expressed or measured in the same way that financial value is (Social Value, UK).

[2] Theory of Change is a specific type of methodology for planning, participation, and evaluation that is used in companies, philanthropy, not-for-profit and government sectors to promote social change. Theory of Change defines long-term goals and then maps backward to identify necessary preconditions. Theory of Change explains the process of change by outlining causal linkages in an initiative, i.e., its shorter-term, intermediate, and longer-term outcomes. The identified changes are mapped – as the "outcomes pathway" – showing each outcome in logical relationship to all the others, as well as chronological flow. The links between outcomes are explained by "rationales" or statements of why one outcome is thought to be a prerequisite for another (Brest, 2010).

ROI only accounts for pecuniary value and it has limitations in accounting for externalities[3] and for investments advancing the public good (Maas and Liket, 2011).
It is in this context that the notion of SROI made its first appearance. The underpinning idea is that investments should not only look at what pecuniary value they produce as direct shareholder value, but they should also include a wider range of benefits. Similarly to ROI, SROI compares the net present value of benefits to the net present value of the resources invested, but it aims to do so by accounting for the whole range of value generated, beyond the narrow microeconomic dimension (Gargani, 2017).

The initial concept of SROI was designed for and applied by philanthropic foundations financing social programs in order to measure and demonstrate their impact (Westall, 2004).
In the late 1990s, the Roberts Enterprise Development Fund (REDF) developed a first version of SROI as a tool to measure the efficiency of the projects they funded. In their initial work, the REDF identified three types of value created by social purpose enterprises: economic value, social value and socioeconomic value. The first is defined by the market value of inputs and outputs; the second accounts for things which are difficult to measure, for lack of a direct market price (i.e. intangibles), for example as the value of knowledge or heritage. Finally, SROI was supposed to capture the socioeconomic value generated by an enterprise by accounting for resulting public expenditure savings and increase in public revenues, in addition to the cash flow of the business.

Since then, the concept of SROI has undergone several revisions. SROI is still being developed and refined in both the organizational and academic fields, and new guidelines are being issued by organizations and academic research centres.
For a while, it has continued to be used predominantly as a tool to account for social value for charities and the non-profit-making sector, which aim to assess their impact or demonstrate their achievements to their founders. The 2012 meta-analysis from the Centre for Social Investment of the University of Heidelberg pointed out that most of the SROI studies have been undertaken in Anglo-Saxon countries, and were initiated mostly by non-profit-making organizations and public agencies to analyse the impact of such organizations and social enterprises. However, the debate surrounding the definition of SROI has triggered further conceptual and methodological discussions and progress and is leading to new areas of application (Krlev et al., 2013).

An SROI analysis can take many different forms. It can encompass the social value generated by an entire organisation, or focus on just one specific aspect of the organisation work. There are also a number of ways to organise the 'doing' of an SROI. It can be carried out largely as an in-house exercise or, alternatively, can be led by an external researcher (Social Value, UK, 2012).
In their "A Guide to Social Return on Investment", Social Value, UK

[3]Externalities refers to situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged for the goods and services being provided (OECD, Glossary of Statistical terms).

(2012), state that SROI was developed from social accounting and cost-benefit analysis and is based on seven principles:

1. **Involve stakeholders**;
2. **Understand what changes**;
3. **Value the things that matter**;
4. **Only include what is material**;
5. **Do not over-claim**;
6. **Be transparent**;
7. **Verify the result**.

Carrying out an SROI analysis involves six stages (Social Value, UK, 2012) that have been graphically represented by Banke-Thomas et al. (2015), as shown in Figure 5.1.

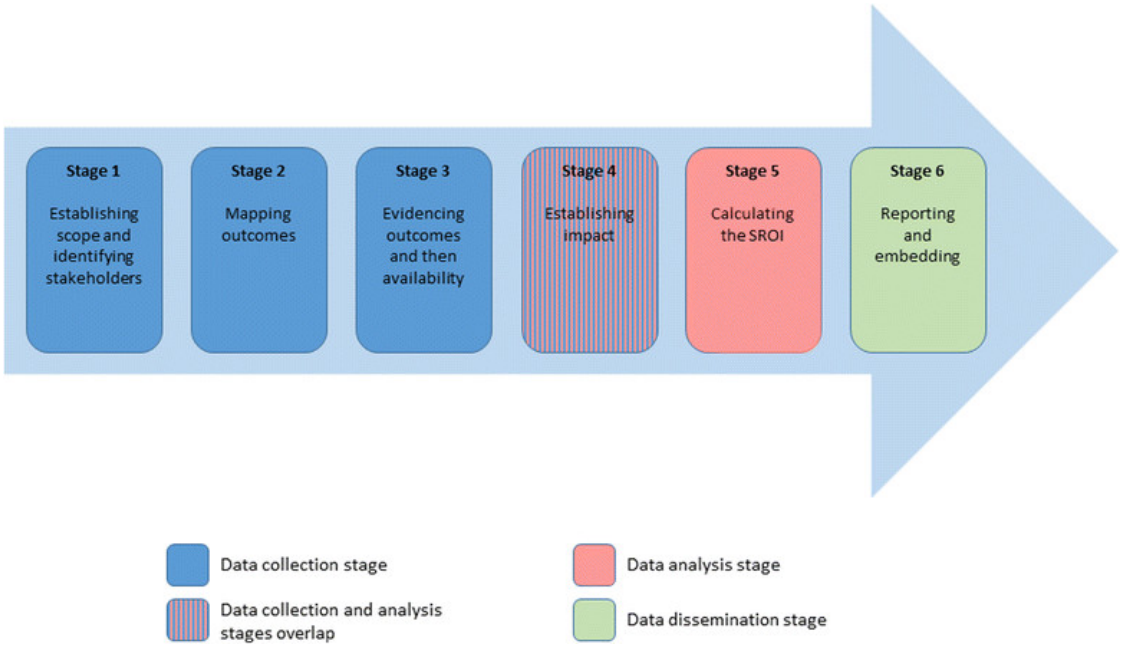

Figure 5.1: Stages of the SROI process

5.2 Social return on investment in healthcare

According to Banke-Thomas et al. (2015), increased scarcity of public resources has led to a concomitant drive to account for value-for-money of interventions. Traditionally, cost-effectiveness, cost-utility and cost-benefit analyses have been used to assess value-for-money of public health interventions. The SROI methodology has capacity to measure broader socio-economic outcomes, analysing and computing views of multiple stakeholders in a singular monetary ratio.

More in depth, the international development community continues to invest significantly in public health. A culture of accountability and value-for-money is central to monitoring and evaluation of public health projects, programmes and policies. In times of austerity, robust and innovative tools are needed. **The SROI methodology provides a platform to systematically account for broader outcomes of interventions and the value-for-money of such interventions. SROI is very relevant and applicable, especially as the global focus shifts from "output" to "impact" and from "generous giving" to "accountable giving"**. It aids identification of the most impactful, cost-beneficial and culturally sensitive public health interventions. It is however clear that the methodology will benefit from increased synergy between SROI practitioners and public health researchers in order to be able to account for the real and broad impact of interventions more robustly (Banke-Thomas et al., 2015).

The UK is the largest proponent and user of the SROI methodology in healthcare. This is consistent with the efforts of the UK Government to stimulate accountability for wider social, economic and environmental benefits to society within the Third Sector, as earlier methodologies were more focused on cost of interventions, efficiency and economies of scale (Nicholls, 2007).

SROI studies are more frequently conducted within the non-profit sector and there has not been significant application of the methodology amongst academia. The SROI methodology evidently emerged from praxis rather than research, therefore, for the methodology to gain wider academic acceptance, its processes have to be self-reflexive, the questions being asked have to be clear and well defined, the methodology replicable and results valid (Husereau et al., 2013).

There is clearly a need for SROI practitioners and public health researchers to collaborate in developing a more widely acceptable and perhaps more robust quality assessment framework for public health SROI studies, similar to the Consolidated Health Economic Evaluation Reporting Standard (CHEERS) framework for economic evaluations (Budgen and Brereton, 2006).

5.3 Methodology

This chapter provides an overview of the most influential scientific literature published on the topic of SROI in healthcare, in particular when dealing with innovative technologies.

To guide the review, the following main research question was formulated: "Which is the framework worldwide researchers employ to compute SROI when dealing with innovative technologies in healthcare?". To manage the research and the analysis in a structured way, the research question has been restructured in 6 sub-questions:

1. "Typically, which are the stakeholders involved when performing an SROI analysis?"

2. "Which are the main input items taken into account by researchers when dealing with an SROI analysis?"

3. "Which are the main outcomes taken into account by researchers when dealing with an SROI analysis?"
   More in detail, the analysis focused on the extrapolation of input items and/or outcomes included in the articles and the methodology of monetization thereof, if present and described.

4. "Which is the time horizon selected for the analysis?"

5. "Which is the value assumed for the discount rate when computing the final result of the analysis?"
   Since the evaluation of a technology is always prospective and oriented towards the future, it is likely to think that each article reported the time horizon for the evaluation and the applied discount rate for actualization.

6. "How is the uncertainty of the analysis managed?"

According to the purpose of the thesis to economically evaluate innovation in healthcare, it has been decided to conduct a systematic literature search of SROI methodology applied in healthcare to deliver a meticulous summary of all the available primary research in response to the aforementioned research questions.
The systematic search phase is crucial to provide transparent report of studies identification, clarifying what was done to identify papers, and how the findings of the review are situated in the relevant evidence (Cooper et al., 2018).
However, alongside with a systematic search, the results and findings have also to be discussed: for this reason, it is suggested to adopt a narrative approach when reporting a literature review (Ferrari, 2015).

The following paragraphs present a systematic search along with a narrative review of the adoption of SROI in healthcare for evaluating innovative technologies.

5.3.1 Systematic search

For the development of an effective systematic search strategy, the 12-step framework proposed by Kable et al. (2012) has been applied.
The framework presents a valuable tool for documenting a systematic search strategy while also guiding researchers to consider all aspects required for locating relevant literature, ensuring that no important aspects are left out. Therefore, the framework is viewed to be an especially valuable tool for inexperienced researchers.
Steps to be followed are:

1. Purpose statement;

2. Databases, search engines used;

3. Search limits;

4. Inclusion and exclusion criteria;

5. Search terms;

6. Exact searches per database, search engine and the results;
7. Relevance assessment of retrieved literature;
8. Table reporting literature included in the review, accompanied with key data such as title, author, but also research subject and findings;
9. Document final number of search results;
10. Quality assessment of retrieved literature;
11. Review;
12. Accurate, complete reference list.

To enhance readability and enable readers to quickly find certain steps, this section presents each of the twelve steps consecutively.

The purpose The purpose has been stipulated as discovering which framework worldwide researchers employ to conduct SROI in healthcare when dealing with innovative technologies.
The purpose statement was formulated together with the principal and project supervisor.

Databses The investigated databases were Scopus, PubMed and Web of Science. The three databases are well-established, multi-disciplinary research platforms, holding a wide variety of peer-reviewed journals, and they are being kept up to date.
The authors chose for three databases to ensure all relevant papers are included, since it is possible that one database omits relevant research (Crossan and Apaydin, 2010).

When conducting systematic search, it is generally considered important to include grey literature in the review to develop a more complete overview (Tranfield et al., 2003).
Grey literature refers to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing. The major online source of grey literature is represented by Google Scholar.
Due to its nature, grey literature is difficult to locate and can be abundant. Therefore, despite its relevance, Google Scholar has been explored only as a starting point of the analysis in order to obtain a broad overview on the magnitude of the topic and understand the main diffused considerations. It has not been included in the systematic search.
Anyway, among the aforementioned databases, Scopus involves grey literature. Therefore, contributions coming from grey literature have not been completely neglected in the search. Analogously, one book dealing with the SROI topic has been preliminarily explored, as suggested by the supervisor , but not included in the systematic analysis: Social Return on Investment Analysis: Measuring the Impact of Social Investment (Then et al., 2018).

Search limits The following search limits have been applied to the searches:

- *Journal articles* Books and books chapters have been excluded from the review in line with the objective of mainly exploring practical applications of SROI in healthcare. In fact, explored books tend to mainly focus on providing theoretical frameworks for the methodology.

- *English language* For journal articles, it is assumed that high impact research on the subject of SROI in healthcare had been translated into English. Therefore, even if they may exist relevant papers in other languages too, it is believed that the articles in English give a sufficiently complete overview of the documentation available.

- *Published between January 1, 2009 and August 31, 2019 (end of the search)* From the database analysis, it emerged that the last 10 years publications have devoted a growing interest towards evaluation tools in the health field. In particular, the databases did not include any contribution reporting the adoption of SROI as an evaluation tool in healthcare before 2009.
  As a consequence, 2009-2019 has been defined as the time limit of search. The final year of consideration, 2019, was the most current research year when this systematic review was initiated and was thus chosen to represent the most current developments in the searched field.

- *Search within* For the databases PubMed and Scopus, the research for the search terms was restricted to title and abstract of the article. For the Web of Science database, searches were restricted to the topic subject and title.

- *Subject area* For the PubMed database, pre-selected filters applied by default by the database were not modified (the authors identified them as suitable for their peculiar analysis): article type (clinical trial, journal article, systematic review, review) and type of journals (nursing and dentistry journals were excluded). Being PubMed a database referring both to humans and to animals, it was necessary to apply an additional filter on species.
  For Scopus and Web of Science, no filters on type of subject area and document type were applied. Given that in the articles selection phase the authors had still little knowledge about the SROI topic, it has been considered too high the risk of losing relevant information from the aprioristic exclusion for subject area or document type.

Relevance assessment Criteria for in- or excluding specific literature manifest the research focus and also point to its limits.
With respect to assessing the relevance of retrieved literature at the end of the search process, Bettany-Saltikov (2012) proposes to conduct a first, quick assessment by means of reading only the titles and abstracts and compare them against the criteria for in- and exclusion. Only those papers classified as relevant or likely to be relevant after this first assessment should then be read in full during a second assessment stage. The benefit of this approach is that potentially large bulks of literature can be assessed rather quickly. These criteria for in- or excluding retrieved articles have been formulated in conjunction with the project supervisor.

The main rationale was that the authors only wanted to include articles that were strictly on the SROI dealing with technologies in the healthcare field. Exclusion criteria were:

1. Articles form Web of Science and Scopus providing contribution in Agromedicine, Environment Protection, Animal and Fishery, Hydrology, Governance, Energy, Aerospace research fields, Environmental science, Social science, Computer science, Agricultural Science, Energy, Nursing, Material science, Chemistry, Mathematics, Physics and Astronomy, Psychology, Veterinary, Arts and humanities, Chemical engineering and Neuroscience were excluded in the abstract and full-article selection phase.

2. Studies that only recommend a future SROI analysis and studies that provide theoretical guidelines to conduct a SROI analysis without actually applying it were excluded in the abstract and full-article selection phase.

Search terms For formulating suitable search terms, the guideline provided in 2009 by the Centre for Reviews and Dissemination (CRD) on reviews suggests consulting the main research question (University of York. Centre for Reviews and Dissemination and Akers, Jo, 2009).
For searching electronic databases, the guideline recommends to also consider "synonyms, abbreviations and spelling variants".
In particular, several queries were searched using different databases and the number of results provided by each query was finally compared to get those search terms that could embrace all the evidence on the topic.

Search terms were identified through an exploration of the literature on SROI in healthcare by employing different queries. In particular, initially, the query «social return on investment OR SROI» was investigated on the databases, since authors may refer themselves to the method through the full name or through its acronym, reporting the results shown in Table 5.1.

Table 5.1: Social return on investment OR SROI queries

	Scholar	Scopus	WoS	PubMed	Total
Social return on investment OR SROI	13500	191	166	54	13991

Consequently, relying on the findings resulted from the search terms for CBA and in order to provide direct comparable reviews, «health» and «drug*» were used as healthcare synonymous to add their contribution to the initial query, obtaining «(social return on investment OR SROI) AND (health OR drug*)». Results are shown in Table 5.2.

Table 5.2: (Social return on investment OR SROI) AND (health OR drug*) queries

	Health OR drug*			
	Scopus	WoS	PubMed	Total
Social return on investment OR SROI	49	46	27	122

Because of the topic of the analysis, also in this query it should have been added the key word «technolog*». Results are shown in Table 5.3.

Table 5.3: (Social return on investment OR SROI) AND (health OR drug*) AND technolog* queries

	Health OR drug*			
	Scopus	WoS	PubMed	Total
	Technolog*			
Social return on investment OR SROI	2	2	1	5

However, due to the limited number of results that the «technolog*» contribution has been able to generate among the databases, it was decided not to include it in the analysis, stopping and maintaining the research query «(social return on investment OR SROI) AND (health OR drug*)».

Documentation of search process The total number of articles resulted from the exploration of the three databases for the query «(social return on investment OR SROI) AND (health OR drug*)» was equal to 122.
More in detail:
For Scopus, the specific query explored was TITLE-ABS (social return on investment OR SROI)) AND TITLE-ABS (health OR drug) and it produced 49 results. Anyway, once applied the filter on language (the authors decided to involve in the analysis only articles written or translated in English), the number of results was reduced to 48 articles. Subsequently, the filter on years (the authors decided to consider only articles of the last 10 years- therefore written between 2009 - 2019) was applied, providing a final number of 47 results. No filters on type of subject area and document type were applied.

For Web of Science, the specific query explored was TOPIC (social return on investment OR SROI) AND TOPIC (health OR drug) and it produced 46 results. Anyway, once applied the filter on language the number of results was reduced to 45 articles. Subsequently, the filter on years was applied, providing a final number of 44 results. No filters on type of subject area and document type were applied.
For PubMed, pre-selected filters applied by default by the database were not modified (the authors identified them as suitable for their peculiar analysis): article type (clinical trial, journal article, review, review) and type of journals (nursing and dentistry journals were excluded). The specific query explored was TITLE-ABS (social return on investment OR SROI) AND TITLE-ABS (health OR drug) and it produced 27 results. The filter on language did not impact the number of results, while the filter on years provided a final number of 26 results. Being PubMed a database referring both to humans and to animals, it was necessary to apply an additional filter on species, leading to a final number of 18 articles human-related. The following Graph 5.2 displays results for this step:

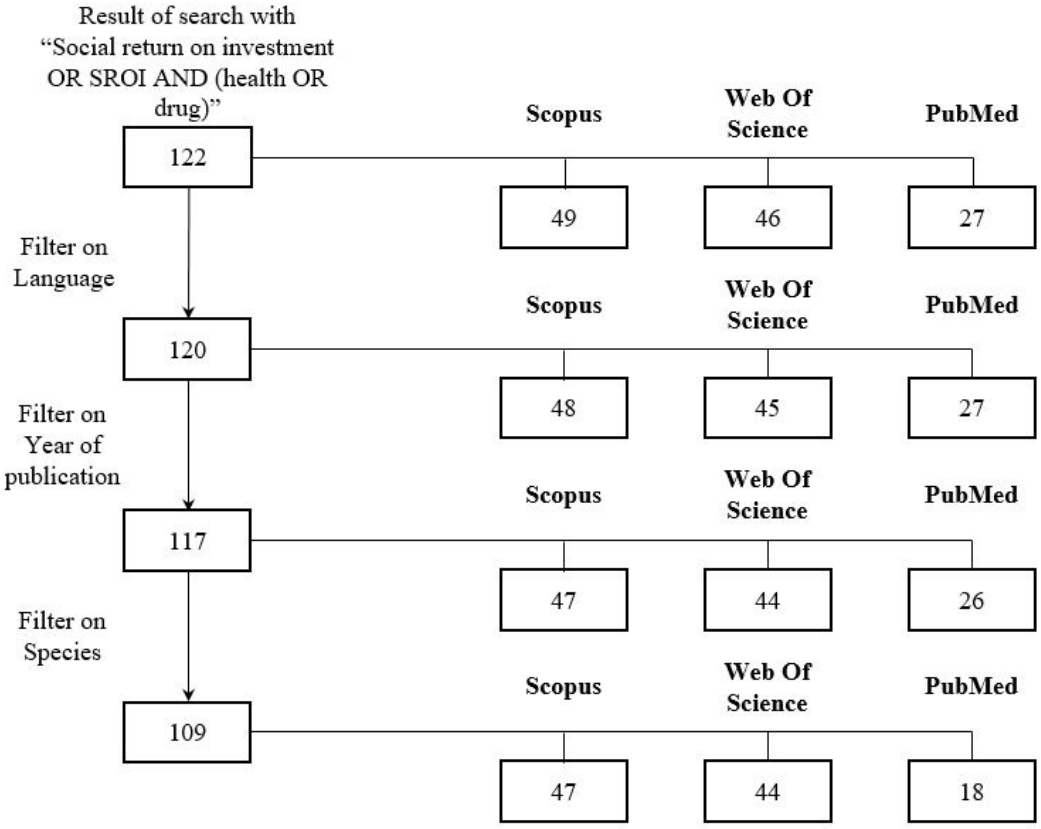

Figure 5.2: SROI Funnel Diagram 1

Test relevance of retrieved articles Relevance of found articles was assessed against the criteria for in- and exclusion.
At first, articles' duplications were eliminated, leading to a final result of 56 articles, that were submitted to the abstracts' reading phase. They were read and assessed

against the criteria for in- and exclusion. Full articles with less informative abstracts were included. This skimming phase produced 18 results.
More in detail, 21 articles were eliminated for reason 1 (articles providing contribution in Agromedicine, Environment Protection, Animal and Fishery, Hydrology, Governance, Energy, Aerospace research fields, Environmental science, Social science, Computer science, Agricultural Science, Energy, Nursing, Material science, Chemistry, Mathematics, Physics and Astronomy, Psychology, Veterinary, Arts and humanities, Chemical engineering and Neuroscience), 15 articles were eliminated for reason 2 (studies that only recommend a future SROI analysis and studies that provide theoretical guidelines to conduct a SROI analysis without actually applying it).
To conclude, 2 articles were kept out of analysis due to the impossibility to have access and read abstracts and full-texts. Among the 18 articles, 13 were directly available as open source, while 5 were asked to be shared by authors via ResearchGate. However, among them, 3 papers, Whelan (2015), Courtney and Baker (2017) and Vivienne (2012) have never been obtained. reducing the number of available articles to be read to 15. From a full-text reading phase, 5 articles were excluded for reason 2. Therefore, the full-text reading step led to consider valuable and eligible for the literature analysis only 10 articles. The flow is shown in Figure 5.3.

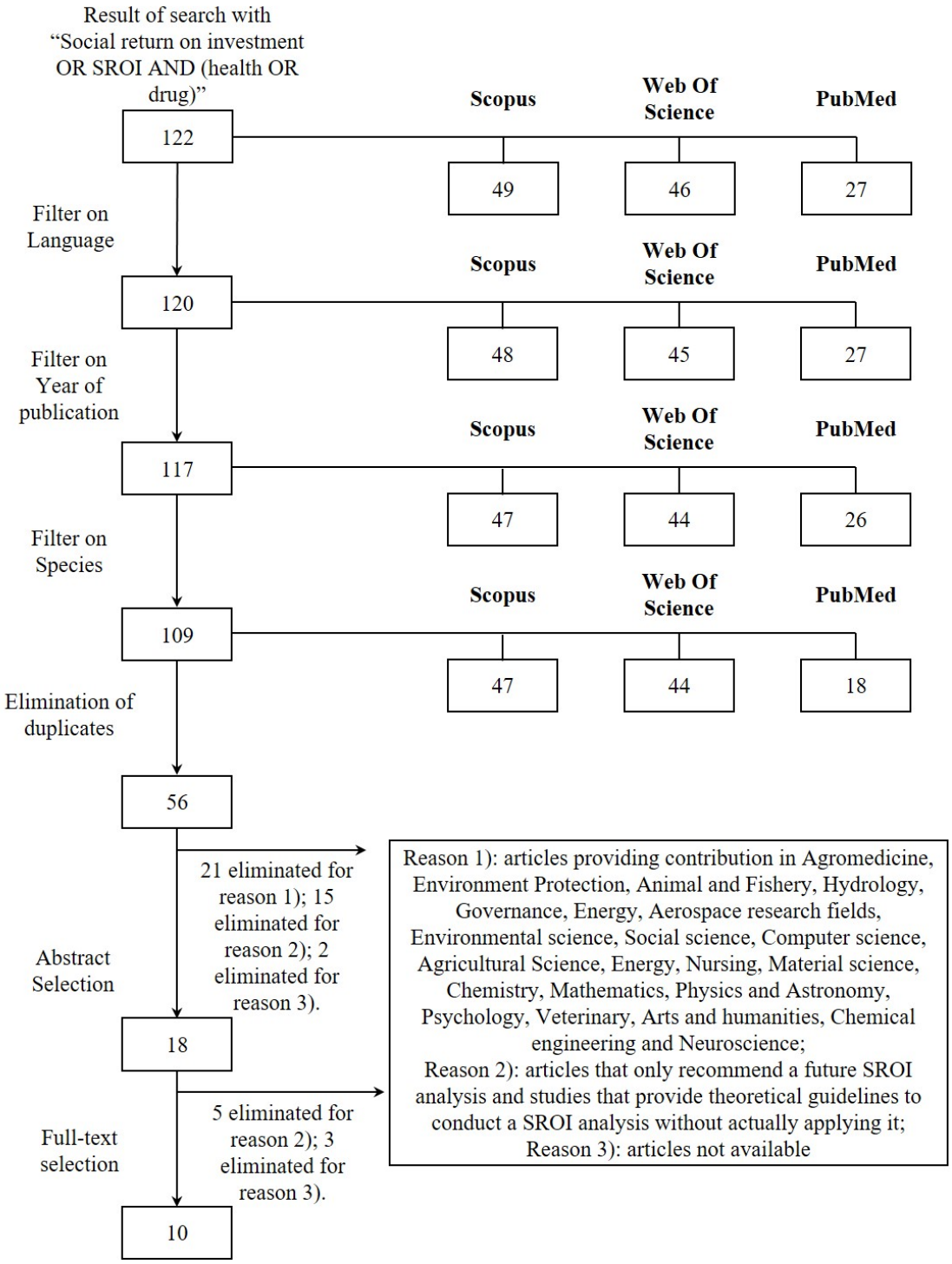

Figure 5.3: SROI Funnel Diagram 2

Summary table of included articles Table 5.4 reports the 10 selected articles for the SROI literature review with the corresponding year of publication, authors, journal of publication and the most recent quartiles of the publishing journal according to Scimago Journal & Country and citations per document (average citations over 4 years - most recent).

Title	Year	Authors	Journal	Quartiles	Citations
Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	2019	Bellucci,M.; Nitti, C.; Franchi, S.	Social Enterprise Journal	None	None
A-Way Express Courier: social enterprise and positive psychology	2015	Akingbola, K.; Phaetthayanan, S.; Brown, J.	Non-profit Management and Leadership	None	None
Early Childhood Education to promote Health Equity: A Community Guide Economic Review	2018	Ramon, I.; Chattopadhyay, S.K.; Barnett. S.W.	Journal of public health management and practice	Q2 (2017)	1.249 (2017)
Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	2019	Tanaree, A.; Assanangkornchai, S.; Thavorn, K.	PloS ONE	Q1 (2017)	3.337 (2018)
Issues in using social return on investment as an evaluation tool	2017	Muyambi, K., Gurd, B., Martinez, L.	Evaluation Journal of Australasia	None	None
Social Return on Investment (SROI) methodology to account for value for money of public health interventions: A systematic review	2015	Banke-Thomas, A. O.; Madaj, B.; Charles, A.	BMC public Health	Q1 (2017)	3.195 (2017)
Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	2018	Goudet, S.; Griffiths, P. L.; Wainaina, C. W.	BMC public health	Q1 (2017)	3.195 (2017)

The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	2019	Ricciuti, E.; Bufali, M. V.	Evaluation and program planning	Q3 (2017)	1.599 (2017)
The social return on investment in community befriending	2014	Arvidson, M.; Battye, F.; Salisbury, D.	International Journal of public Sector Management	Q2 (2017)	2.095 (2017)
The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	2019	Bosco, A.; Schneider, J.; Broome, E.	Maturitas	Q1 (2017)	3.658 (2017)

Table 5.4: SROI summary table of reviewed articles

Retrieved articles at the end of the search process It was not possible to retrieve all the needed articles. 3 articles, Whelan (2015), Courtney and Baker (2017) and Vivienne (2012), that passed the abstract reading phase could not be obtained and, as a consequence, they could not enter the analysis.

Quality appraisal of retrieved articles Quality assessment is crucial to ensure that findings of papers are correct (Popay et al., 2006). For this reason, the quotation according to Scimago Journal & Country has been included in the aforementioned summary tables.
Even if some journals had not explicit quotation, the paper they published were kept for the analysis due to the perceived relevance of their contributions. However, the lack of certified quotation has been taken into account when analysing and comparing the papers' results.

Critical review he critical review entails the three processes of data extraction, analysis and synthesis. To extract relevant data from included literature, a data extraction form was developed in collaboration with the project supervisor.

Data extraction The sum of selected articles is structured as follow:

1. Introduction to the topic;
2. List of stakeholders;
3. Input voices;
4. Outcomes;

5. Financial evaluation of outcomes;
6. Time horizon for the measurement;
7. Cost of capital, Deadweight, Drop-off, Displacement and Attribution;
8. Sensitivity Analysis.

Data analysis The retrieved data were then analysed to answer the main research questions and sub-questions. The collected information for each paper has been summarized in order to allow to report a narrative review of the results.

Synthesis Finally, the findings were discussed in a narrative and systematic synthesis. The synthesis is presented in the following section.

5.4 Narrative review

A first relevant consideration that emerged from the reading phase of the articles is that, **although most of the 10 reports included in the SROI review shows a clear aim of running an SROI analysis, not all the authors offer a complete SROI analysis** (see Table 5.5), **focusing only on a part of the 6 research sub-questions aforementioned**, as graphically represented in Figure 5.4:

1. "Typically, which are the stakeholders involved when performing an SROI analysis?"
2. "Which are the main input items taken into account by researchers when dealing with an SROI analysis?"
3. "Which are the main outcomes taken into account by researchers when dealing with an SROI analysis?"
   More in detail, the analysis focused on the extrapolation of input items and/or outcomes included in the articles and the methodology of monetization thereof, if present and described.
4. "Which is the time horizon selected for the analysis?"
5. "Which is the value assumed for the discount rate when computing the final result of the analysis?"
   Since the evaluation of a technology is always prospective and oriented towards the future, it is likely to think that each article reported the time horizon for the evaluation and the applied discount rate for actualization.
6. "How is the uncertainty of the analysis managed?"

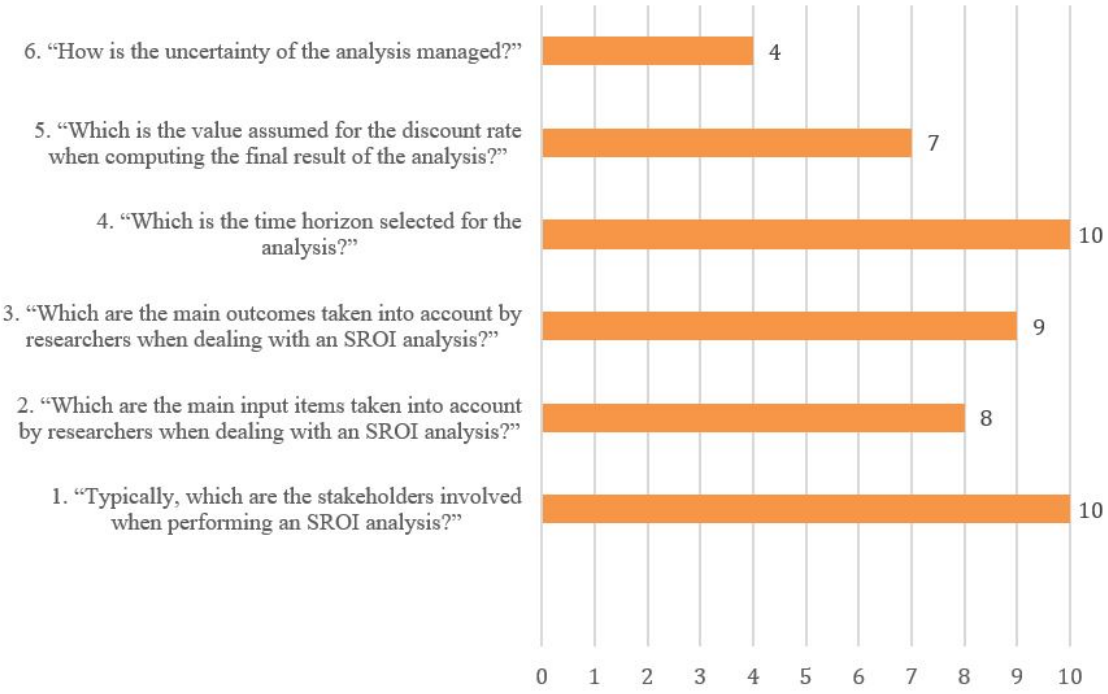

Figure 5.4: Number of artilces replying to the research sub-questions

Article title	Author	Questions					
		Q1	Q2	Q3	Q4	Q5	Q6
Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)	X	X	X	X	X	X
A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)	X	X	X	X	NO	NO
Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)	X	X	X	X	X	NO

Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)	X	X	X	X	X	X
Issues in using social return on investment as an evaluation tool	Muyambi et al. (2017)	X	NO	X	X	NO	NO
Social Return on Investment (SROI) methodology to account for value for money of public health interventions: A systematic review	Banke-Thomas et al. (2015)	X	NO	NO	X	X	NO
Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)	X	X	X	X	X	X
The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)	X	X	X	X	X	NO
The social return on investment in community befriending	Arvidson and Salisbury (2014)	X	X	X	X	NO	NO

The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)	X	X	X	X	X	X

Table 5.5: Articles replying to the research sub-questions

Out of the 10 articles that entered the analysis, only Banke-Thomas et al. (2015) do not identify neither the outcomes nor the inputs to run a public health initiative and, as a consequence, do not propose any monetization method. Muyambi et al. (2017) neglect the analysis of inputs but provide examples of outcomes resulting from a certain health intervention with the corresponding monetization methods. As regards all the other articles investigated, they propose a full and complete SROI analysis, including the evaluation of inputs, outcomes and impacts.

5.4.1 Stakeholder analysis

Reading the papers that entered the reviews, it was noticed that **the identification of inputs and outcomes, alongside with the monetization methods, changes according to the stakeholders involved by the authors to run the analysis**.
As for the CBA review, the papers resulting from the SROI review were read through the lenses of the stakeholders involved and the object under investigation. As regards the latter, it was noticed that **none of the identified articles refers to the evaluation of a technology, but they all concern a health process or intervention**.

Regarding the stakeholder listing phase, reviews report that the first step of the SROI process is exactly to identify the stakeholders (Laing and Moules, 2017).
The choice of the stakeholders to include in the analysis, analogously to the choice of the perspective of analysis in the CBA, is essential to define the wideness of the analysis, the outcomes of the intervention to take into account and the impacts that have to enter the analysis.
Differently from the aforementioned classification of articles proposed for the CBA review, for the SROI it is not possible to define macro-categories of papers according to the list of stakeholders involved in the analysis, due to the fact that for each intervention the type of stakeholders involved dramatically varies.
However, articles have been read and interpreted according to the broadness of analysis: they have been distinguished between papers that consider uniquely beneficiaries' outcomes and papers that, alongside with outcomes for direct users of the intervention, consider also those generated for other stakeholders directly or indirectly involved in the project.
More in detail, **papers can be categorized on three levels, corresponding to the level of involvement of stakeholders (see Figure 5.5): papers that include in the analysis only beneficiaries (first tier), papers considering also the role of promoters and implementers (second tier) and papers taking into account all the stakeholders, direct or indirect, that can be touched by the health initiative (third tier)**.
The results are shown in Table 5.6.

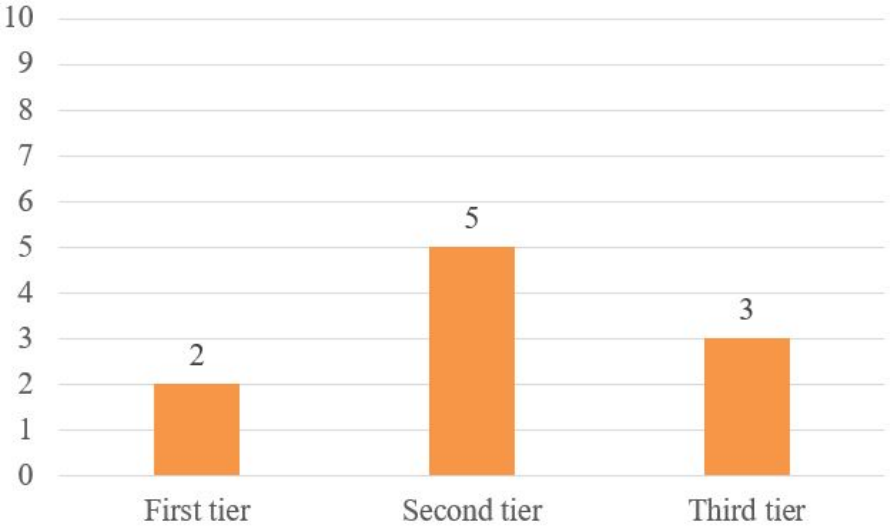

Figure 5.5: Number of articles according to the level of stakeholders' involvement

Article title	Authors	**Level of stakeholders' involvement**
Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)	Third tier
A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015),	First tier
Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)	Third tier
Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)	Third tier

Issues in using social return on investment as an evaluation tool	Muyambi et al. (2017)	Second tier
Social Return on Investment (SROI) methodology to account for value for money of public health interventions: A systematic review	Banke-Thomas et al. (2015)	Second tier
Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)	Second tier
The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)	First tier
The social return on investment in community befriending	Arvidson and Salisbury (2014)	Second tier
The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)	Second tier

Table 5.6: Level of stakeholders' involvement per article

Akingbola et al. (2015) and Ricciuti and Bufali (2019) are the only authors that consider merely beneficiaries to run the SROI analysis.
In particular, the former refers to employees as the major group of stakeholders of A-Way express courier, a service providing supportive employment to people with mental health issues; the latter considers donors as only relevant stakeholders of Blood Donors Associations.
Other authors propose a broader analysis, including both beneficiaries of the initiative, like service users, and other stakeholders, like service implementers and promoters. Muyambi et al. (2017) consider not only the consumers of a mental health rehabilitation program, but also the staff running and managing the initiative; Goudet et al. (2018) cite as stakeholders of a breastfeeding and infant

feeding program the mother and children participating in the intervention, but also the volunteers and healthcare centres; Arvidson and Salisbury (2014) consider the users, promoters and volunteers of a service delivered to families affected by post-natal depression; Bosco et al. (2019) evaluate the effect that art activities have on care home residents, care home personnel and activities' coordinators.
Banke-Thomas et al. (2015) do not propose a practical application of SROI itself but report an overview of SROI applications in health and suggest to include within the list of stakeholders the beneficiaries, the implementers, the promoters and the funders of an initiative.

However, the evaluation can be led to a deeper level of analysis considering also the outcomes that a program may have on third parties, not directly involved as beneficiaries or promoters in the initiative but resenting of its impact. For instance, Bellucci et al. (2019) include as stakeholders of the Ronald McDonald House Charities not only children and families, staff, volunteers and donors, but also hospitals, community, other non-profit organizations and the environment; Ramon et al. (2018) consider the impact that an education program has not only on children and families, but also on schools and educational system, State and society in a whole; Tanaree et al. (2019) run an evaluation of an alcohol intervention program that is declined over drinkers, families, local communities, HCS, labour market and national legal authorities.

5.4.2 Inputs analysis

SROI analyses use different definitions than conventional CBA, adopting, for example, the term investment or inputs instead of cost. Therefore, when conducting a SROI analysis, the authors generally refer to the analysis of costs with the terminology of input analysis. With the term input, they refer to all the contributions, monetary and not, that different stakeholders offer and that make the intervention possible.

The following Table 5.7 reports the major input items involved in the review and the Graph 5.6 displays the number of articles citing each input item.

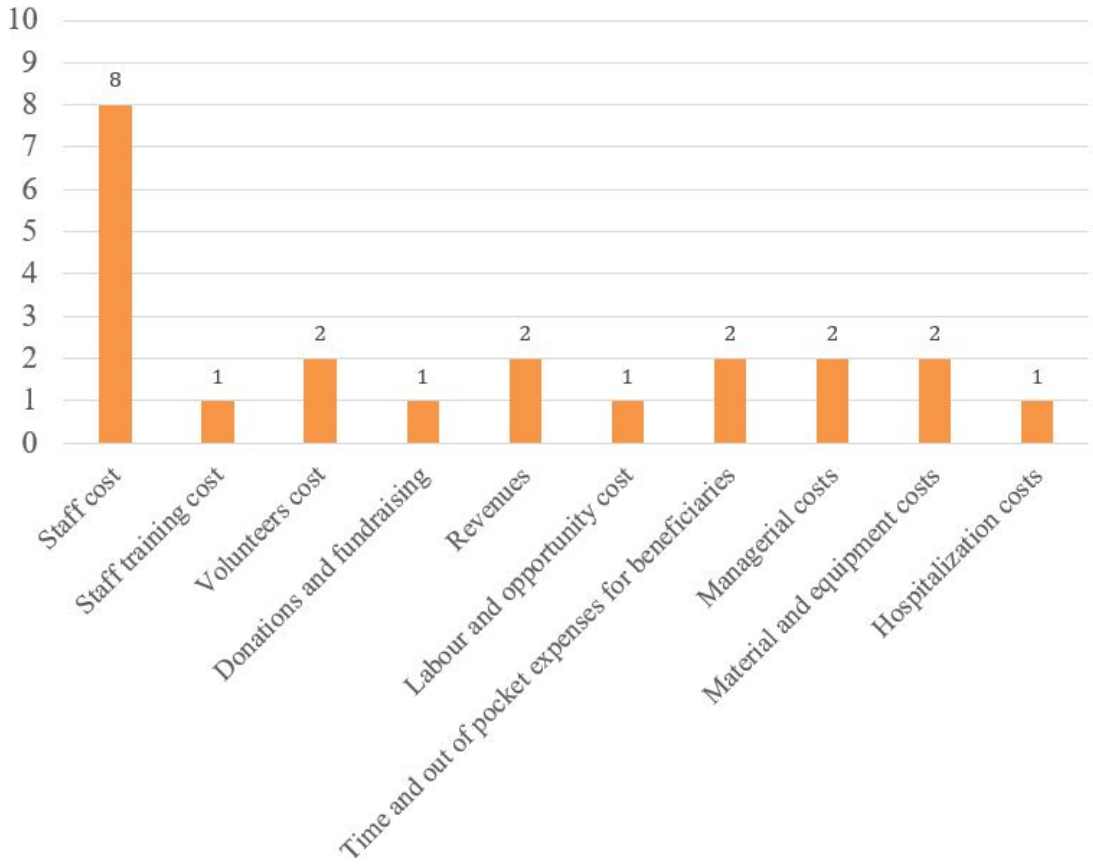

Figure 5.6: Number of articles according to input items involved

Input item	Article Title	Authors
Staff cost	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
	A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)
	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
	Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)

	Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)
	The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)
	The social return on investment in community befriending	Arvidson and Salisbury (2014)
	The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)
Staff training cost	Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)
Volunteers cost	The social return on investment in community befriending	Arvidson and Salisbury (2014)
	A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)
Donations and fundraising	A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)
Revenues	A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)
	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
Labour and opportunity cost	Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)

Time and out of pocket expenses for beneficiaries	Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
	Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)
Managerial cost	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
	The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)
Material and equipment cost	Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
	The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)
Hospitalization cost	Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)

Table 5.7: Input items

Analysing the included-in-the-analysis 10 articles it was noticed that the most common source of input is represented by the cost of staff (where staff, as part of the healthcare system, accoridng to the article, can be the beneficiary of the initiative, the promoter/implementer or merely an involved third part). In fact, Bellucci et al. (2019), Akingbola et al. (2015), Ramon et al. (2018), Tanaree et al. (2019), Goudet et al. (2018), Ricciuti and Bufali (2019), Arvidson

and Salisbury (2014) and Bosco et al. (2019) all include staff as relevant input for, respectively, managing the Roland McDonald House Charities, running the A-Way express courier initiative, conducting the education program, supporting the alcohol intervention program, promoting infant feeding practices, managing blood donors associations, delivering support to families affected by post-natal depression, and for advancing arts activities for older people. Goudet et al. (2018) consider as input source the training for both the staff categories, research team and healthcare providers.

Alongside with the staff work, Akingbola et al. (2015) consider also the input coming from the work of volunteers that have a crucial role in supporting people with mental health to have access to food and clothing. Arvidson and Salisbury (2014) involve as an input the work of volunteers in offering help and charity to those affected by post-natal depression.

Due to the fact that the majority of the initiatives evaluated in this literature review has a social purpose, it is common to have as source of input donations and fundraising.
In particular, Bellucci et al. (2019) can rely on donations coming from families and on the fact that the program is supported through a fundraising system. Akingbola et al. (2015), instead, can rely on both monetary donations from third parties, and on in-kind donations, in the form of food, clothes or other basic-needs items.
Moreover,Bellucci et al. (2019) and Akingbola et al. (2015) consider also as input the revenues generated by the program: the former gains a percentage from McDonald licensee to devolve to the House Charity program, the latter, instead, has the revenues coming from the customers adopting the initiative.

Taking into consideration the input coming directly from the beneficiaries of the health initiative, Tanaree et al. (2019) propose, as input source, the labour and opportunity costs evaluated through the human capital approach, by multiplying hours spent on the program by hourly wage. The same contribution considers the time and out-of-pocket expenses that drinkers, beneficiaries of the alcohol intervention program, have to support to be visited. Similarly, Goudet et al. (2018) calculate the time spent by mothers and grandmothers during counselling sessions.

Talking about the operational costs to deliver the program, Bellucci et al. (2019) and Bosco et al. (2019) consider managerial costs as input, while Ricciuti and Bufali (2019) calculate the costs of consumables and equipment for the blood donations and the building costs. Tanaree et al. (2019), to conclude, consider the hospitalization, material and overhead costs as additional input source of the alcohol intervention program.

5.4.3 Outcomes analysis

When evaluating the benefits resulting from an intervention, SROI analysis uses different definitions from conventional CBA. As a matter of fact, SROI literature results refer to the generated benefits with the term outcomes and report the impact that those outcomes have on the stakeholder involved in the analysis.

It has been observed that, similarly to the above conducted benefit analysis for CBA literature, **the outcomes involved in the analysis can be grouped according to the type of stakeholder they generate the impact for**.
In particular, it is possible to consider: the outcomes for the direct beneficiaries of the initiative, outcomes involving the implementers and promoters of the initiative, and outcomes impacting third parties, including all the direct or indirect stakeholders of the intervention.
The contribution of each article is reported in Table 5.8 and the number of articles citing each outcome si represented in Graph 5.7.

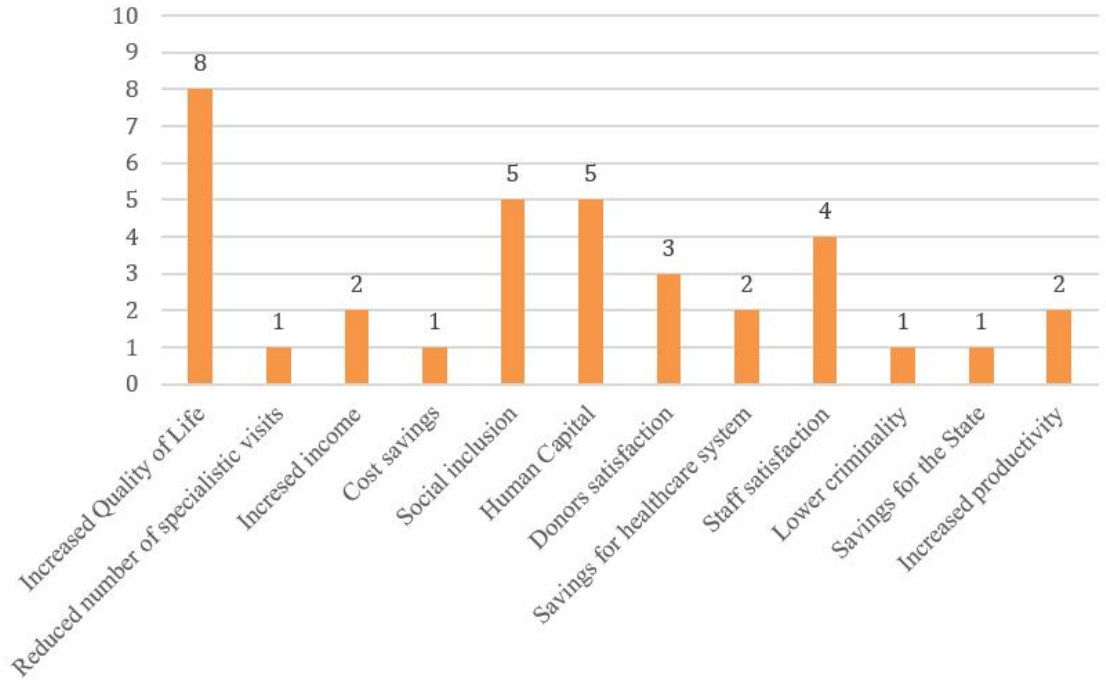

Figure 5.7: Number of articles according to outcome items involved

Stakeholder	**Outcome item**	**Monetization method**	Article Title	Authors
Beneficiaries	Increased Quality of Life	Financial proxies; WTP	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
			A-Way Express Courier: social enterprise and positive psychology	Akingbola et al. (2015)
			Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
			Issues in using social return on investment as an evaluation tool	Muyambi et al. (2017)
			Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)
			The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)

			The social return on investment in community befriending	Arvidson and Salisbury (2014)
			The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)
	Reduced number of specialistic visits	Average cost of a visit	A-Way Express Courier:social enterprise and positive psychology	Akingbola et al. (2015)
	Increased income	Average wage	A-Way Express Courier:social enterprise and positive psychology	Akingbola et al. (2015)
			Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
	Savings for beneficiaries	Cost savings	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
	Social inclusion	Financial proxies	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)

			Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
			Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
			The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)
			The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019).
	Human capital	Financial proxy	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)

			Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
			The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)
			The social return on investment in community befriending	Arvidson and Salisbury (2014)
			The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme	Bosco et al. (2019)
Implementers and promoters	Donors satisfaction	Financial proxy	The social return on investment in community befriending	Arvidson and Salisbury (2014)
			Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)

			Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
Third parties (State, healthcare system and education system)	Savings for healthcare system	Costs of hospitalization	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)
			Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)
	Staff satisfaction	Financial proxy	Accounting for social return on investment (SROI). The costs and benefits of family-centred care by the Ronald McDonald House Charities	Bellucci et al. (2019)

			Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis	Tanaree et al. (2019)
			The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis	Ricciuti and Bufali (2019)
			The social return on investment in community befriending	Arvidson and Salisbury (2014)
	Lower Criminality	Cost savings	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
	Savings for the State	Cost savings	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)
	Increased productivity	Financial proxy	Early Childhood Education to promote Health Equity: A Community Guide Economic Review	Ramon et al. (2018)

			Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi	Goudet et al. (2018)

Table 5.8: Outcome items

Starting from the beneficiaries of the initiative, many authors, including Bellucci et al. (2019), Akingbola et al. (2015), Tanaree et al. (2019), Muyambi et al. (2017), Goudet et al. (2018), Ricciuti and Bufali (2019), Arvidson and Salisbury (2014) and Bosco et al. (2019) suggest the increase of quality of life, deriving from higher physical and mental wellbeing, less anxiety and stress, higher self-esteem, to be the most relevant outcome of the analysed interventions.
The qualitative nature of an outcome such as increase in quality of life (QoL) requires the adoption of financial proxies to compute its monetization.
Bellucci et al. (2019), for example, monetize the reduction of stress with the average price for yoga course; Akingbola et al. (2015), Arvidson and Salisbury (2014) and Bosco et al. (2019) compute mental well-being with the average cost of therapy or visits to psychiatrists; Tanaree et al. (2019) use the counselling fee as indicator for stress management, that is assessed through interviews and surveys; Muyambi et al. (2017) and Ricciuti and Bufali (2019) estimate the improve of QoL through the method of the WTP, gathered via survey and interview for the former and via focus group for the latter; Goudet et al. (2018) use revealed preferences, emerged via interviews and focus group, to attribute financial value to less stress and anxiety.
Akingbola et al. (2015) propose as outcome the reduction to visits to psychiatrists as consequence of the better mental condition of the beneficiaries of the employment program. Moreover, the same authors, as well as Ramon et al. (2018), consider the increase of income for beneficiaries, that can be evaluated according to the average wage, to be an outcome of, respectively, the employment program and the education program. Ramon et al. (2018) take into account as outcome the social consequences of the education program, talking about social inclusion and higher interaction with the community.
Social capital creation is an outcome reported also by Bellucci et al. (2019), Tanaree et al. (2019), Ricciuti and Bufali (2019) and Bosco et al. (2019) .
Costs to participate in/deliver social activities is generally considers by authors as a valuable financial translation of social inclusion outcome. In particular Bellucci et al. (2019) propose as financial proxy the average cost of group therapy; Tanaree et al. (2019) the volunteers' wage for the conduction religious activity, while Bosco et al. (2019) propose session of community singing to monetize social interaction.
Another outcome that interests directly the beneficiaries is the so-called human capital, reported and evaluated by Ramon et al. (2018), Tanaree et al. (2019), Ricciuti and Bufali (2019), Arvidson and Salisbury (2014) and Bosco et al. (2019). These authors, respectively, consider the education of children, the "empathetic attitude" towards drinkers gained by staff, the knowledge acquired by blood donors,

the increased awareness and understanding of post-natal depression obtained the initiative volunteers and the improved skills in caring for older people and in using arts intervention as positive impact and gain in terms of human capital. The monetization path usually considers the formation costs or the cost for course in creativity and meaningful activities.
Shifting to the perspective of those that offer and deliver the services, like staff and volunteers, a common outcome evaluated is the personal satisfaction.

Tanaree et al. (2019), Ricciuti and Bufali (2019) and Arvidson and Salisbury (2014) report that the implementers of the social initiative feel satisfied due to the perception their work is useful and important. Moreover, due to the social and sometimes non-profit nature of the initiatives resulting from the SROI literature, some authors take the point of view of donors and value, as outcome, their satisfaction resulting from giving. The staff satisfaction is monetized through the average pro-bono works cost.

Taking the perspective of third parties, authors cite outcomes from the State, the healthcare system and the education system. Ramon et al. (2018) and Goudet et al. (2018), for example, consider the increase of productivity deriving from the initiatives as a positive outcome for the State. In particular, the former, taking a whole society perspective, considers that having more educated children will result not only in having adults with better jobs and earnings, but in having more productive people, that actively contribute to the national GDP. Goudet et al. (2018), instead, evaluate that the infant feeding initiative contributes to reduce diseases among children and, as consequence, parents can work and be productive. A reduction of disease, for the latter authors, means also less care expenditures for the health care centres. Also Bellucci et al. (2019) consider the savings resulting from the reduction of hospitalization as the lower length of hospital stays for children.
Ramon et al. (2018) involve the avoided costs resulting from the education program; in particular: health care savings for children's parents, lower costs for schools due to the reduction of the grade of retention of students involved in the program and, cost savings for the State resulting from the reduction of criminality expected by the children involved in the education process.

5.4.4 Time horizon

When running a prospective study with the aim of evaluating the impact of a technology or a process, the decision of the time horizon for the analysis is crucial.

Banke-Thomas et al. (2015), giving general guidelines, state that the time horizon to implement a SROI analysis should vary between a range of 4 months to 5 years. The majority of the investigated authors indeed propose analysis within the suggested timeframe.
In particular, Akingbola et al. (2015) and Ricciuti and Bufali (2019) use a 1-year time horizon. It is relevant to notice that only and both these papers consider as stakeholder of analysis uniquely the direct beneficiaries: a possible reasoning behind may be that both the employment program for people with mental health issue and the value generated by blood donors associations are initiatives with a strong and

immediate impact on the direct beneficiaries and that one year may be sufficient to obtain the results expected as outcomes. However, no evidence or explanation is provided by the authors on this topic: Akingbola et al. (2015) simply state that the analysis is computed within the fiscal year 2014, while Ricciuti and Bufali (2019) that they chose the most recent year with complete and reliable data in the Avis database.
Bosco et al. (2019), in line with the Vineburgh Regeneration Initiative SROI study, use a 4-year perspective for the impact of the outcomes. Muyambi et al. (2017) and Goudet et al. (2018) select a time horizon of 5 years. While the former does not provide any explanation, the latter states that, due to the complexity of assessing future health benefits of a current intervention, it is decided not to value future health benefits and to limit the duration of impact to not more than 5 years (even if they acknowledge that this may underestimate the social value of the intervention).
Ramon et al. (2018), differently from the other authors that followed the guidelines proposed by Banke-Thomas et al. (2015), consider a timeframe of 75 years: this seems necessary since the study considers the impact that an educational program on children will have on their future and adult lives.
Bellucci et al. (2019) and Tanaree et al. (2019) do not propose a static time frame but consider different horizons according to the outcome under investigation. In particular, outcomes, like savings, that are registered and measured as a single event during the period of intervention, are given a duration of 1 year; outcomes that have medium-to-long-term effects, like improvement in competences, have a duration of 3 years according to Bellucci et al. (2019) and of two years for Tanaree et al. (2019); outcomes linked to an improvement in medical, physical or psychological conditions are regarded as changes that have enduring effects on stakeholders and, therefore, have a duration of 5 years.
To conclude, Arvidson and Salisbury (2014) propose a SROI computation on 3, 6 and 30 years in order to evaluate the validity of the program even with conservative assumptions.
To sum up, **authors conducting SROI analysis are aligned in the choice of the time horizon: it is typically coherent with the outcome under control and fluctuating between 1-year to 5-year of analysis**.

5.4.5 Discount rate, drop-off, deadweight, displacement and attribution

Bellucci et al. (2019), Ramon et al. (2018) and Tanaree et al. (2019) adopt a discount rate equal to 3%, in line with the guidelines of the British Treasury Minister's Green Book (HM Treasury, 2003). The former considers also a drop-off of 100%, 50% and 35% depending on the short, medium or long term impacts; Tanaree et al. (2019), instead, consider a drop-off varying according to the type of outcome: drop-off of 50% for higher productivity and drop-off of 25% for increased staff satisfaction.
Banke-Thomas et al. (2015) and Bosco et al. (2019) propose the usage of a 3,5% discount rate as typically recommended in the UK. The latter, moreover, includes in the analysis the implications resulting from deadweight, drop-off, displacement

and attribution: from a discussion with artists involved in the program, it emerged that the initiative was the only opportunity for them to perform artistically and engage with older people. For this reason, the authors agreed that a low percentage of deadweight and attribution (equal to 10% each) was an adequate estimate. As regards drop-off, it was assessed a value of 10%, while displacement was considered to be around 0%.
Ricciuti and Bufali (2019), following the guideline from Istat (2014), select a discount rate of 4,92%; due to the 1-year time horizon chosen, the drop-off considered for all outcomes is 100%; the attribution effect changes with the type of outcome, varying from 25% to 55%.
Goudet et al. (2018), without providing any justification, chose 6,5% as base discount rate, 5-100% as base deadweight, 0-25% as attribution and 20% as drop-off.
Akingbola et al. (2015) report only a deduction of 5 percent for deadweight for outcomes that would have happened regardless of A-Way.
Authors like Muyambi et al. (2017) and Arvidson and Salisbury (2014) do not cite any discount rate, deadweight, drop-off, displacement or attribution within their evaluation.

5.4.6 Sensitivity analysis

Within the same article, the discount rate and other effects may vary depending on the use for which it is intended. In fact, some articles perform a sensitivity analysis to verify the robustness of the results of the SROI: sensitivity analysis is the study of how the uncertainty in the output (dependent variable) of a model or system can be divided and allocated to different sources of uncertainty in its inputs (independent variables) (Saltelli et al., 2008).
In particular, Bellucci et al. (2019) propose to calculate SROI with a conservative and an inclusive scenario to be compared with the base one; Tanaree et al. (2019) consider how the evaluated social return vary with a discount rate fluctuating between 0%-6% and with deadweight and attribution increasing/decreasing by 20% respect to the base case; Goudet et al. (2018) perform a sensitivity analysis to test the variables and assumptions made for the base scenario by changing deadweight, attribution, displacement, drop-off and discount rate, the frequency of the outcome and the value of outcomes; Bosco et al. (2019) consider a displacement of 15% compared to the 0% of the base case as sensitivity analysis.

5.5 Conclusions on social return on investment

The review revealed how only part of the authors perform a complete SROI analysis. The majority of them describes stakeholders involved, details input, outcome items and time horizon. Anyway, imprecision increases as it comes to deal with discount rate and uncertainty (deadweight, drop-off, attribution and displacement).
In sum, only 4 out of 10 articles (Bellucci et al. (2019), Tanaree et al. (2019), Goudet et al. (2018) and Bosco et al. (2019)) answer to all the questions through which an SROI analysis is articulated.
As regards the stakeholders, 2 out of 10 articles (Akingbola et al. (2015)

and Ricciuti and Bufali (2019)) **involve in the analysis only beneficiaries**; **5 out of 10 authors** (Muyambi et al. (2017), Bosco et al. (2019), Banke-Thomas et al. (2015), Goudet et al. (2018) and Arvidson and Salisbury (2014)) **involve also promoters and implementers**; **3 out of 10 involve a braoder plethora of stakeholders** potentially, directly and indirectly, affected by the initiative (State, healthcare system, education system) (Bellucci et al. (2019), Ramon et al. (2018), Arvidson and Salisbury (2014)).
Looking at the distinction between process and technology, **no author reports an analysis of a technology**.
Even if input items of an SROI analyis cannot be categorized according to the nature of the stakeholders involved, more rigour is possible when dealing with outcomes. Authors dealing simply with beneficiaries mainly cite increased Quality of Life an average cost of a visit. Authors involving also promoters and implementers add donors' satisfaction. Broadest analyses cite savings for the healthcare system and the State, staff satisfaction, lower criminality and increased productivity.
In addition, **outcome monetization is simplified (respect than monetization of benefits for a CBA) thorugh the employment of proper financial proxies**.
A major criticality emerged from the review is that **authors provide a poor justification when selecting a percentage value for displacement, drop-off, attribution and deadweight**. Only 5 out of 10 authors (Bellucci et al. (2019), Tanaree et al. (2019),Goudet et al. (2018), Ricciuti and Bufali (2019) and Bosco et al. (2019)) complete the analysis by mentioning them, even without detailed exploration of reasonable numbers.

Chapter 6

Conclusions and gaps

The following table resumes and displays the most relevant retrieved results when dealing with both, CBA and SROI, in literature:

Topic	**CBA**	**SROI**
Subject assessed	Technology AND Process	Process
Perspectives involved	Typically, point of view of one single stakeholder involved in the project: healthcare system OR patients. However, there are some articles combining both healthcare system and patients' point of view.	Stakeholders' engagement. Articles can be grouped into three categories: -Articles analysing the initiative only from beneficiaries' point of view; -Articles analysing the initiative from beneficiaries' AND promoters and implementers' point of view; -Articles analysing the initiative from beneficiaries' AND promoters and implementers' AND third parties' point of view.
Cost/input items involved	Different according to perspective adopted and subject assessed (cost items involved are only those for the entity whose perspective is assumed).	Input items involved become more exhaustive as the analysis shifts from mere beneficiaries' involvement to promoter and implementers' and third parties' involvement.

Benefit/outcome items involved	Independent from the subject assessed. Different according to perspective adopted (benefit items involved are only those for the entity whose perspective is assumed). Anyway, declared perspective is not always strictly respected.	Outcome items involved become more exhaustive as the analysis shifts from mere beneficiaries' involvement to promoter and implementers' and third parties' involvement.
Benefit/outcome items monetization	Controversial. Authors avoid monetizing outcomes not quantifiable as cost savings.	Easily enabled by proper financial proxies.
Time horizon and discount rate	Poorly justified.	Poorly justified.
Deadweight, drop-off, attribution, displacement (peculiar for SROI analysis)	-	When involved, scarce explanation provided.

Table 6.1: Comparison between CBA and SROI

It is of paramount importance to notice that **the authors' search did not produce any result in terms of SROI analysis dealing with the evaluation of a technology**. The traditional CBA, instead, is adopted for dealing with both innovative technologies and processes.
This is revelant to consider that the major SROI strengths (such as the possibility of involving a broader plethora of stakeholders and dealing with economic and social implications of a project) should in theory perfectly enrich the analysis of both technologies and processes.
In order to deeply understand how the subject under investigation (process or technology) influences the evaluation of a project, a focus on the results retrieved form the CBA review is needed. Focusing on the CBA literature review, it resulted that cost items can be categorized according to the nature of the subject under evaluation (technology or process). In fact, the two entities require fundamentally different practices to be properly implemented and exploited.
This assumption is not valid when dealing with benefits. As a matter of fact, benefit items change according to the potential impact of the solution proposed (e.g. it can affect mortality, or it can simply affect quality of life), independently from the nature of the intervention.
Consequently, **it does not emerge a clear reason why SROI methodology should not be employed when dealing with a technology, as it involves and values inputs analogously to CBA with costs**.

A second limit encountered when studying CBA in literature, already underlined

by Ackerman (2008), is that benefits monetization seems to be controversial.
Except from benefits represented by cost savings, experts are resistant to proceed towards a monetization of potential outcomes of a strategy, favouring, in case, Willingness to pay or Human Capital method.
Authors conducting SROI analysis, instead, as already noticed by Brady (2011), manage in overcoming this obstacle by utilizing financial proxies to estimate not-financial outcomes, that, in almost all the papers, are retrieved through interviews, surveys and focus groups.

A further **relevant gap emerged from the CBA literature review is that experts claiming to adopt a certain point of view for the analysis (e.g. patient or healthcare system) often overcome the limits of the single adopted perspective and involve benefits for different actors**. It is registered a systematic inability in correctly defining boundaries for the benefit analysis in terms of perspective to be adopted.
This limit is partially overcome in the SROI methodology: the refusal of a single perspective, and the **drafting of a list of all the possible stakeholders directly or indirectly involved in the analysis**, allow to perform a broader evaluation, without getting stuck in the single-perspective-approach.
The involvement of several stakeholders becomes the mean, for the SROI methodology, to account for broader social and environmental outcomes: benefits such as "social inclusion" and "decreased criminality" appear as totally unknow to the traditional CBA and find dignity in the SROI sphere.
In sum, it seems that experts traditionally adopting a CBA are unconsciously shifting towards a more SROI-oriented approach in order to overcome invalidating restrictions of the CBA.

When dealing with the choice of the time horizon and discount rate (for both CBA and SROI), it emerged that only generic guidelines exist.
As already observed by Brady (2011), similar considerations subsist for the definition of deadweight, drop-off, attribution and displacement to calculate the SROI ratio.

A final consideration emerged from both literatures is that many authors consider essential the definition of a sensitivity analysis.
In fact, all the benefits, outcomes, discount rates and other variables involved in the mentioned articles are the results of assumptions whose modification can lead to considerable changes in the analysis' results. Even in this case, however, there is not a standard procedure to follow and each paper approaches the sensitivity analysis in a different way.

In conclusion, the performed reviews confirmed how part of CBA limits, in healthcare, are being overcome through an SROI-oriented approach. Anyway, SROI itself, as observed by Brady (2011), is not free from complexities: dealing with several stakeholders introduces some ambiguities in the analysis that often the concepts of deadweight, drop-off, attribution and displacement fail in solving.
To the authors, having explored all the facets of the healthy ageing concept, it seems possible to pave the way for the application of the SROI in the evaluation of technologies promoting healthy ageing.

Part III

Empirical research

Chapter 7

Objectives and method

7.1 Objectives

This chapter is dedicated to the design of the specific objective of the thesis in the light of the gaps emerged from the state of art analysis. The purpose is to decline the SROI analysis in the healthcare field. In particular, **noticed the most relevant gap in the SROI literature (i.e. the lack of studies concerning SROI analysis of technologies), the authors aim at developing and validating a model for performing an SROI analysis when evaluating innovative technologies in healthcare**.

Having conducted a detailed literature review on both, SROI and CBA, the authors have identified SROI as a suitable decision tool for supporting decision-makers in the healthcare field.
Even if the traditional tool employed to support decision-making in healthcare is represented by CBA (National Institute for Clinical Excellence, 2004), it has historically been under discussion due to the difficulties in its practical implementation (Ackerman, 2008).
Therefore, authors considered the SROI as a valuable alternative instrument to be explored and applied. In fact, it allows to overcome some of the CBA-related limits (stakeholders' engagement and simplified monetization of outcomes through proper financial proxies), still being based on a rational choice logic (Zappala and Lyons, 2009) and fundamentally being linked to the concept of CBA (Rotheroe and Richards, 2007).
The SROI methodology has capacity to measure broader socio-economic outcomes, analysing and computing views of multiple stakeholders in a singular monetary ratio (National Institute for Clinical Excellence, 2004).
As the CBA, the SROI analysis translates both, costs and benefits into monetary terms. Anyway, while the CBA merely captures health and non-helath related impacts, the SROI analysis captures health and non-health impacts, underpinned by the "triple bottom line" approach, evidencing both social and economic aspects. In addition, it seeks to account for and value potential negative effects of interventions (Ackerman, 2008).
The CBA suffers from incompleteness by simply listing benefits that cannot be easily monetised (and thus involved in the final result) and explains why they

cannot be monetised. The SROI analysis, instead, uses financial proxies to estimate monetary value of benefits that cannot be easily monetised (Zappala and Lyons, 2009).

SROI, indeed, helps to make clearly visible to what extent a given social investment creates impact. In this way, it results in being a strategic tool to support decision-makers in (Social Value, UK, 2012):

- Ensuring that the initiative in which they are willing to invest is managing the most material economic and social risks;
- Managing unexpected outcomes, both positive and negative;
- Facilitating strategic discussions, creating a formal dialogue with stakeholders;
- Identifying common ground between what they want to achieve and what their stakeholders want to achieve.

Moreover, the impact dimensions or objective indicators developed in the course of an SROI analysis might be used for project tracking on a regular basis helping the management to run their organisation effectively. Looking particularly at the healthcare field, an SROI analysis should, therefore, be considered as a supporting instrument towards continuous improvement (Krlev et al., 2013).
In sum, in healthcare, SROI methodology is considered as a valuable and worth to be adopted tool to address the purposes of (Krlev et al., 2013):

- Executives (decision-making function; i.e. health institutions);
- Target groups (beneficiaries of the initiative);
- Funders (resourcing function);
- Society (legitimacy function).

As above stated, the authors' purpose is the development and validation of a model for performing an SROI analysis when evaluating innovative technologies in healthcare.
Considered all the relevant health branches constituting a potential framework for the development of an SROI model in the healthcare sector, authors decided to focus on technologies for health promotion fostering healthy ageing.
The choice is based on the awareness that at a time of unpredictable challenges for health, one trend is certain: **the populations around the world are rapidly ageing and this demographic transition will impact on almost all aspects of society** (World Health Organization, 2017).
As well as the social impact of ageing, also **the social impact of healthy ageing has been declared by WHO** (2015). In fact, **the WHO states as crucial social goal for populations, healthcare systems and States the maximization in the number of people who experience a positive trajectory of ageing (healthy ageing)**.

Therefore, the choice of developing a model for performing an SROI analysis in the field of health promotion fostering healthy ageing is mainly based on the synergies between the process of healthy ageing and the SROI methodology itself: the latter seems to be perfectly employable to measure the success and the feasibility of the former. SROI analysis allows to measure whether resources invested in a healthy ageing path are effectively generating a positive outcome for all the actors impacted by the ageing of society (population, healthcare systems, States).

In order to reach the final objective of developing and validating a model for an SROI analysis of technologies for health promotion fostering healthy ageing, authors have established a set of sub-objectives, including:

1. The definition of the stakeholders who revolve around the figure of the senior and sick adults and that, as a consequence, could be both positively and negatively affected by the launch of initiatives promoting a healthy ageing path;

2. The definition of the inputs necessary to promote an initiative for healthy ageing;

3. The identification of the outcomes resulting from an initiative for healthy ageing and the investigation of the consequent impacts for each of the addressed stakeholders;

4. The definition of relevant indicators that allow the measurement of the detected outcomes;

5. The definition of monetizing criteria to convert the highlighted outcomes into monetary terms;

6. The definition of the most suitable time horizon to capture all the relevant impacts of the healthy ageing promoting initiative with a certain degree of confidence;

7. The definition of a proper discount rate to actualize impacts that would be generated in a long-term horizon.

7.2 Research design

In order to properly meet all the sub-objectives for developing a consistent SROI model for technologies for healthy ageing, it is necessary to clearly define the research setting of analysis.

To offer a consistent, solid and validated model of SROI for health promotion fostering healthy ageing, **authors intend to proceed through an inductive method: starting from a real case and then generalize the model developed**.
As a matter of fact, the definition of an SROI model for a generic health promotion technology would lack of consistency, due to the differences in terms of stakeholders

involved, inputs necessary and outcomes generated that can occur among different projects.
The basic principle of inductive generalization is that what is obtained through a specific application of a tool can be generalized to all. Its best-known form is the venerable induction by simple enumeration, or, more briefly, enumerative induction. This means that by designing an SROI model able to suit a specific case, it can be inferred that the same SROI model can be generalized as valuable for all health promotion-fostering technologies. **The utilization of a real case is a research approach used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context** (Crowe et al., 2011).
A case study can be defined in a variety of ways, but the central tenet is the need to explore an event or phenomenon in-depth and in its natural context (Stake, 1995). According to Yin (2017), case studies can be used to explain, describe or explore events or phenomena in the everyday contexts in which they occur.
The adoption of a real case study as starting point for the construction of the SROI model allows to understand and explain all the implications, causal links and pathways resulting from the adoption of a technology for healthy ageing.

To attain this purpose, **the real case selected and employed for the development of the SROI model is the case study of NESTORE (Non-intrusive Empowering Solutions and Technologies for Older people to Retain Everyday life activity)**.
NESTORE is a research and development project funded by the European Commission under the H2020 program - Societal challenge, Personalized Medicine, SC1-PM-15-2017 (Grant agreement n. 769643).
The authors choice fell on NESTORE since it represents one of the most innovative eHealth solutions leveraging technological advancements in order to support population ageing. **NESTORE, indeed, incorporates all the features of a cutting-edge virtual coach active in the healthy ageing world**.
Virtual coach, first of all, is the cutting-edge solution in the field of computer-based technologies for patient education, counselling, health behaviour training and coaching (Callejas et al., 2014). Virtual coach, as a matter of fact, is able to monitor how the user performs activities and provides situational awareness and gives feedback and encouragement matched to cognitive and physical current state of its user (Brandenburgh et al., 2014). It is able to establish a relationship with the trainee, leveraging on his or her desires, expectations and attitudes in order to offer tailor-made coaching solutions (Fasola and Mataric, 2013). This aims at maximising the trainee adherence to the program and, as a consequence, its effectiveness, resulting in a higher probability of reaching the goal of health promotion (Oinas-Kukkonen, 2010).
Virtual coaches fostering health promotion for heathy ageing prevent and delay individuals' cognitive and physical decline due to natural ageing. In doing that, they work on multiple dimensions of healthy ageing simultaneously (Mastropietro et al., 2018). While other e-solutions, such as mobile apps, focus on one dimension at a time (i.e physical, mental or social well-being), a virtual coach is able to work on all of them, offering a complete and consistent support through all the aspects

of the life of its user (Kulyk et al., 2014).
As a H2020 project, NESTORE can guarantee the availability of public, valuable and trustworthy information on the project strictly necessary to set the analysis. Indeed, being Politecnico di Milano a major player in the project, the authors had the possibility to get in touch and discuss with the most important partners involved in NESTORE project, to participate in techinical and review meetings, to access confidential documents regarding the whole initiative and, most of all, to validate their model.
Another crucial factor that drove the choice towards NESTORE is represented by the synergies between the purpose of the SROI methodology and that of H2020 projects. The H2020, as a matter of fact, has highlighted, among its priority challenges, the willingness to invest in research and innovation projects that can have a real impact for citizens, focusing, therefore, on those initiatives which demonstrate to maximise the societal and economic impact of Research & Innovation (R&I) funding.

From this preamble, it clearly emerges the utility and need of evaluating the NESTORE project not uniquely form an economic point of view, as it could have done a CBA implementation, but also from a societal one.
The design of an SROI model built for and on NESTORE is of high relevance for the authors, who can thus rely on a high-level case study as the starting point for inductive generalization of the SROI model for technologies for healthy ageing. High value comes also for NESTORE project owners, that could utilize the thesis results to demonstrate and communicate the utility and validity of their virtual coach in addressing the societal challenge of population ageing. The communication of the SROI result interests the funders of the project, that benefit from the demonstration of the social return on their investment, and the stakeholders involved in the NESTORE ecosystem, whose awareness on the potentiality of the project can be raised.
To sum up, computing SROI for NESTORE does not only represent a sensible choice of a random technology for healthy ageing from the authors, but it also intends to be a useful tool to support and foster the diffusion of the NESTORE solution itself.

It has to be noticed that NESTORE project is still in a development phase. This means that the authors performed a prospective SROI analysis, aiming at the best possible estimation (supported by members of the NESTORE Consortium itself) of outcomes and inputs involved by the initiative.

Chapter 8

The case study of NESTORE

8.1 Introduction

NESTORE, a project funded by the European Union Horizon 2020 Research and Innovation Programme, **is a multi-dimensional and personalized virtual coaching technology for the enhancement of people's well-being and quality of life after their 65**.
More specifically, **it aims at supporting the healthy ageing-related dimensions (physical, mental and social well-being) by leveraging on five different levers: physical activity, nutrition, social, cognitive and psychological**.
It motivates the users to take care of their health with personalised nutritional, physical, and mental health suggestions and also encourages them to maintain social interactions to improve their emotional health and general self-awareness.
As a coach, NESTORE proposes activities according to the user's personality, punctual needs, preferences and moods, taking into account environment, current situation and health status. Simultaneously, it generates motivation to take care of one's own health and to preserve well-being. NESTORE can be considered a friend able to understand the emotional and physical status of the user as well as its "weaknesses" and able to propose tailor-made actions and activities through a multi-functional tangible object delivering friendly messages and encouraging motivation.

NESTORE is a specifically developed and novel knowledge-based system able to gather user data through a multi-parametric and multidimensional sensing layer and to process them to generate personalised advice.
By leveraging ICT social connectivity, the NESTORE system operates through tangible objects and sensors, as well as software and apps, enabling monitoring and coaching.
NESTORE system embeds novel ICT technologies at 3 levels: Sensing, Reasoning and Coaching. First, a multi-parameter and multi-domain physical sensing layer able to gather user's key parameters (in the five well-being dimensions: physical activity, nutrition, cognitive well-being, psychological well-being and social interactions) and comprehensive of a wearable smart bracelet, a set of beacons for environmental monitoring and social interaction assessment, third-party balance and a set of sleep

monitoring sensors; second, the cloud and the intelligent Decision Support System (DSS) based on the identification of personalized "pathways of interest" following the health action process approach (HAPA); third, the multi-function tangible objects which can assume different configurations in order to establish effective communication to engage users with personalized coaching activities.

The NESTORE virtual coach is the main interface between the users and the whole NESTORE system. Although being virtual, i.e. animated by the cloud-based decision-making system, it appears to the user as a tangible friend, with whom the user can discuss in a natural manner, either physically or through digital communication means.
The coach intends to guide the users towards a healthy lifestyle, helping them to select a pathway to follow by suggesting the pathways that the decision-making system considered as more important for the user, based on data collected by the monitoring system.
To increase the trust in the system, the interface aims at appearing to the user as more natural as possible, making use of natural communication means, such as vocal interaction with a tangible embodiment of the coach or chats in messaging applications.

Figure 8.1: Graphic overview of NESTORE

While the current situation is understood on the basis of a comprehensive sensors' system able to monitor the different key parameters, the experience and coaching abilities of NESTORE are based on well-grounded psychological and behavioural theories jointly with relevant know-how on the ageing process.
As a matter of fact, NESTORE strategy is to differentiate itself from all the already existing eHealth solutions, that aim at promoting healthy path to its users, by exploring a "blue ocean", positioning at the intersection between well-being and medicine as a validated and multi-dimensional personalized system based on scientific knowledge.
The effectiveness of its feedback, in fact, **is ensured by the scientific-validated multi-disciplinary knowledge provided by experts in each health domain** (e.g. geriatricians, nutritionists, psychologists).

Summarizing, NESTORE leverages on novel ICT technologies: 1) multi-domain unobtrusive monitoring system, including wearable and environmental sensors and tangible objects, 2) intelligent Decision Support System, to analyse the seniors' behaviour and provide personalized targets towards well-being 3) active coaching, developed as conversational agent, embodied in a physical companion that assumes different forms, able to establish affective relationship through multi-modal communication channels and to engage older people with personalized coaching activities in multiple domains.

The methodological strengths of NESTORE project are: 1) co-design research adopted throughout the project practices and methodologies, suitable to form the whole design and implementation process together with the users they are meant for 2) thorough system validation with respect to usability, acceptability and effectiveness 3) development of a sustainable ecosystem involving citizens and stakeholders for the co-production of wellness.

8.2 NESTORE as H2020 project

NESTORE is a research and development project funded by the European Commission under the H2020 program - Societal challenge, Personalized Medicine, SC1-PM-15-2017 (Grant agreement n. 769643).
The project started in September 2017 and will last three years.
The partners that collaborate in the project, being part of the NESTORE Consortium, are sixteen and come from seven different countries (Italy, Spain, United Kingdom, Holland, Switzerland, Romania and Belgium): **Politecnico di Milano (coordinator - with the support of the Fondazione Politecnico of Milano)**, Universitat de Barcelona, University of Applied Sciences and Arts Western Switzerland, Shieffield Hallam University, University of Zurich, Technische Universiteit Delft, Loubourgh University, National Research Council, Eurecat, Flextronics Design, Ropardo, Neosperience, La Meridiana due Social Cooperative, Fundaciò Salut i Envelliment, Preventie Collectief and AGE Platform Europe AISBL.

The project team, aiming at a successful Horizon 2020 project, needs to reflect and address the guidelines provided by the European Commis-

sion.
As a matter of fact, **H2020 projects have to consider that impact is not limited to economic or commercial aspects; it can also be societal, environmental, technical, educational, or scientific**.
The successful implementation of an H2020 project requires to define a proper exploitation strategy. Exploitation can be defined as the utilisation of results in further research activities other than tohse covered by the action corcerned or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardisation activities. As for the exploitation strategy, NESTORE aims at exploring integrating mobility, IoT, gamification and life science to motivate individuals to adopt healthy ifestyles, thorugh the use of personalisation techniques and incentives that will be delivered through the NESTORE system.

8.3 NESTORE technology

8.3.1 NESTORE as a virtual coach

The purpose of this section is to provide a deeper understanding of the technological features behind a virtual coach as NESTORE.
The intent is to provide all the necessary insights on the topics of coaching, health coaching and virtual coaching systems in order to place a solid base for the downstream sections that apply the SROI methodology to a real case of virtual coach.
Due to the pure cognitive and informative purpose of this section, the research on virtual coach has been carried out without performing a systematic literature analysis, but through a cherry-picking approach aimed at capturing the most relevant contributions on the topic of virtual coaching.

Coaching systems

When dealing with coaching systems, it is hard to provide a unique definition. Ives (2008) argues that coaching systems are characterized by a goal-oriented approach: a coaching system contributes in helping individuals to use and exploit their resources in better achieving their goals. In detail, Ives (2008) affirms that, at first, an individual should be assisted by the coach in identifying and setting suitable goals and, consequently, provided with an effective action plan by the system itself.
Barlett and colleagues (2014) present coaching as a combination of two main critical tasks: 1) creating and establishing a collaborative relationship with the individual addressed by the coaching system, i.e. the learner, and 2) strengthening the vision of the learner on the topic of interest.
Similarly, Hayes and Kalmakis (2007) state that coaching can be seen as a tailored and collaborative interaction enhancing the individual self-understanding and goal achievement.

In sum, it emerges that the building blocks of coaching systems are, on the one side, the creation of a collaborative relationship between two parties, and, on the other

side, the possibility for the coachee to self-understand, self-monitor and self-manage for goal achievement.

Health coaching

Health coaching has been defined in varying ways over the past decade.
Palmer (2008) defined health coaching as the practice of health education and health promotion within a coaching context, to enhance the well-being of individuals and to facilitate the achievement of their health-related goals.
Butterworth et al. (2006) defined health coaching as a service through which providers facilitate participants in establishing and attaining health-promoting goals and in changing lifestyle-related behaviours in order to improve participants' health and quality of life.
More recently, the National Consortium for Credentialing Health and Wellness Coaches (NCCHWC) proposed the following definition, which delineates core elements of the practice of coaching: "health and wellness coaches are professionals from diverse backgrounds and education who work with individuals and groups in a client-centred process to facilitate and empower the client to achieve self-determined goals related to health and wellness. Successful coaching takes place when coaches apply clearly defined knowledge and skills so that clients mobilize internal strengths and external resources for sustainable change" (Jordan et al., 2015).

Although these definitions share some similar components, there is no agreement on what exactly health coaching entails (e.g., practices, strategies, delivery methods), what the role of the coach actually is (e.g., educator, navigator, facilitator, partner), and which background and competencies enable the coach to provide health coaching competently.
To overcome ambiguity, R. Wolever et al. (2010) define wellness coaching as a patient-centred approach wherein patients, at least partially, determine their goals, use self-discovery or active learning processes and self-monitor behaviours to increase accountability towards the achievement of health-related goals, all within the context of an interpersonal relationship with a coach. The coach is a healthcare professional trained in behaviour change theory, motivational strategies, and communication techniques, which are used to assist patients to develop intrinsic motivation and obtain skills to create sustainable change for improved health and well-being. This definition is consistent with the evolving science of human motivation and the psycho-social underpinnings of sustainable behavioural change [1].
Reaching back to the theoretical roots of Adler, Jung and Rogers, (Williams, 2012) states that health and wellness coaching conceptualizes patients as lifelong learners whose individual personal values and innate internal resources can be cultivated in the context of a supportive relationship to guide them toward their own desired vision of health.

[1] Behavioural change refers to any transformation or modification of human behaviour. Further explanation regarding the concept of behavioural change are reported in the next paragraph.

Behavioural change techniques

Behavioural change refers to any transformation or modification of human behaviour. In particular, many health interventions seek to modify the attitude of people, turning them away from risky behaviours and towards healthful behaviours (Bartholomew et al., 2001).
There is evidence that behaviour change and learning occur most reliably when there is a helping relationship that 1) acknowledges the individual, 2) is collaborative, and 3) encourages the individual (Ruth Q Wolever et al., 2013).

Traditionally, behaviour change policies and interventions in healthcare focused on providing new information, seeking to change the way people think about their behaviour, or providing incentives in order to change the consequences of behaviour (Cecchini et al., 2010).
These interventions rely on the assumption that people change behaviour accordingly when motivations and intentions are changed (Schneider et al., 2009).
However, several meta-analysis imply that the variance in behaviour is not explained by intentions (Sheeran et al., 2013). In fact, strategies that rely on educational path or focus on a "you should" approach tend to be ineffective or insufficient to promote a behaviour change.
Therefore, behavioural economists and psychologists have started to show interest into behavioural sciences suggesting that human behaviour and people decision-making are actually led by a set of variables, including personality, emotions and the context and the environment within which the decisions are taken (Kahneman, 2011).

The strategy that emerged from this new evidence is that of nudging: by understanding that behaviour is influenced by the context within which it is placed, the intention is to create the perfect environment that "nudges" people in the desired direction.
Thaler and Sunstein (2008) define a 'nudge' as "any aspect of the choice architecture (the environments within which people make choice) that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives".
Applying the concept of nudge in relation to food, it has been shown that ease of access, proximity to the food, and the amount of effort needed to get it affect consumption. Thus, by changing the choice architecture in the supermarket, e.g. changing the positioning of alcohol products, there will be a reduction in the amount being purchased (Rozin et al., 2011).
In this regard, a plausible interpretation of the current state of health is that it is due to multiple factors and influences that have nudged citizens in the direction of obesity, diabetes, ill-health, etc. (Quigley, 2013). From this example, it emerges that the nudge management approach applies insights from behavioural science to design organizational contexts so to optimize fast thinking and unconscious behaviour of nudgee in line with the desired goals (Ebert and Freibichler, 2017).
This definition is in line with the nudges classification proposed by (Felsen et al., 2013) that categorize nudges as overt or covert: overt nudges target conscious decision-making and covert ones target subconscious decision-making.

Another noteworthy classification regards the degree of transparency of the nudge. According to Hansen and Jespersen (2013) nudge is transparent if it is "provided in such a way that the intention behind it, as well as the means by which behavioural change is pursued, could reasonably be expected to be transparent to the agent being nudged as a result of the intervention". An example of transparent nudge is represented by the graphic warnings on cigarette packages: the intention behind the nudge are clear, without explicit explanations. Contrarily, a nudge is non-transparent if individuals cannot understand the intentions behind it or which behaviour change that is targeted.
Different personal characteristics of nudgee, degree of transparency and the architectural choices, can affect attitude toward and the effectiveness of nudges.

Virtual coaching

A definition The recent advances in technology have allowed the entrance of coaching systems into the digital world, opening new possibilities in many different fields and establishing a new emerging trend (Banos and Nugent, 2018): virtual coaching, also named e-coaching.
Even in this case, a unique definition lacks.

Warner (2012) defines e-coaching systems as pedagogical agents, or avatars, that provide "questions to coachees and responses based on coachees' entries or selections". However, this definition has been highly criticized since it introduces and implies the idea of a pedagogical agent which is typically defined as an element having life-related interfaces. Virtual coaches, instead, lack this feature, being limited to the generation of interaction via messages or voice.
Staman et al. (2013), in 2013 , published an advisory report on the recent trends observed in coaching practices and on their effects. In the report, an e-coaching system is defined as a system able to collect data, analyse them, determine a plan of actions, and give persuasive advice.
In their work Callejas et al. (2014) identify a virtual coaching system as a conversational agent that embodies coaches' main functions in supporting the individual. The authors state that the agent could be developed as a mobile application coupled with sensors able to provide meaningful advice.
Brandenburgh et al. (2014) in the same year, define e-coaching systems as behaviour change support systems (BCSSs). Oinas-Kukkonen (2010) defines a BCSS as follows: "a behaviour change support system (BCSS) is a socio-technical information system with psychological and behavioural outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception. BCSSs highlight autogenous and voluntary approaches in which people use information technologies to change their own attitudes or behaviours through building upon their own motivation or goals" (Oinas-Kukkonen, 2010).
The concept of virtual coaching as an instrument for behaviour change is in the last few years becoming very popular and many studies are concentrating their effort in understanding its effectiveness. Indeed, Albaina et al. (2009) identify a virtual coaching as a system that can contribute in motivating, stimulating, encouraging and persuading the individual in changing their behaviour towards the reaching of a specific goal.

An additional perspective is also provided by Fasola and Mataric (2013) that define virtual coaching systems as social agents that can interact, engage and motivate the user in his personal tasks.
Kamphorst (2017) provides in his work a comprehensive definition of e-coaching stating that "an e-coaching system is a set of computerized components that constitutes an artificial entity that can observe, reason about, learn from and predict a user's behaviours, in context and over time, and that engages proactively in an ongoing collaborative conversation with the user in order to aid planning and promote effective goal striving through the use of persuasive techniques."

Fundamental features A systematic definition of the most recurrent features of a virtual coaching system has been proposed by Kamphorst (2017) and they are:

1. The basement on behavioural change techniques: the knowledge on behaviour changing models should be embedded in this system since it should be able to elaborate an effective strategy based on the theory (Klein et al., 2014);

2. Social ability, intended as the capacity to establish a connection and a stable relationship with the coachee;

3. Credibility, described as the ability to appear trustworthy to the user and therefore equipped with sufficient expertise to give advice;

4. Awareness of the context in which the user is inserted, in order to allow a coherent matching between the goal definition and the individual's values;

5. Ability to ask precise questions and give tailored advice (Fogg, 2003), learning continuously from the user experience and providing a personalized content (Brandenburgh et al., 2014);

6. Ability to gather, process and measure different type of data (e.g. directly coming from sensors on the user but also mood self-assessments, sleeping patterns, etc.);

7. Proactivity (Wooldridge and Jennings, 1995) in order to stimulate the coachees when they are giving up their goals;

8. Ability to guide the user towards an effective future-oriented planning.

Architecture A virtual coach, continuously monitoring its users' activities and surroundings, detects situations where intervention would be desirable and offers prompt assistance.
Siewiorek et al. (2012) stress how virtual coaches represent the result of a technological development initiated two decades ago.
The advent, in the early 1990's, of powerful microprocessors capable of running an operating system with real-time responsiveness in small, energy-efficient pages, enabled a new generation of personal computing systems that provided access to information any time, anywhere.
Handheld Personal Digital Assistant (PDA) gave access to addresses, notes, and

schedules via a new interface access modality featuring stylus and handwriting recognition and more recently touch screen and voice control.
Another novel technology, head-mounted displays, enabled revolutionary new body-worn systems, termed Wearable Computers, that allowed instantaneous access to reference information in application areas such as complex plant operations, manufacturing, maintenance, and group collaboration.
In the end, MEMS (Micro-electro-mechanical systems) created low cost, low energy sensors that could sense physical parameters such as acceleration, orientation, temperature, and light that, when coupled with signal processing and machine learning algorithms allowed personal systems to infer user context in Context-Aware Systems.
Virtual coaches embody five different architectural elements: they monitor user performance on defined activities and user context (Sensor Processing), determine appropriate feedback (Coaching Model), and provide feedback and encouragement (User Engagement). A care provider could upload new capabilities to the virtual coach, as required (Prescription). Over time a customized personal interaction evolves (User Interaction).
The most basic difference between coaches is the Coaching Model: Rule-Based models require extensive engagement of end-users (patients, caregivers, and clinicians) during the design process to ensure capture of the relevant situations. On the other hand, machine learning uses examples (labelled training data) to create a statistical model of the activities.

Virtual coaching systems for healthy ageing Computer-based virtual coaches are increasingly being explored for patient education, counselling, and health behaviour training and coaching. Aids currently available are simplistic, providing only scheduled reminders and rote instructions: they operate open-loop without regard for the user's activities or environment. In contrast, virtual coaches monitor how the user performs activities, provides situational awareness and gives feedback and encouragement matched to their cognitive and physical state and circumstances at the time. In particular, one important application domain for virtual coaches is in assisting individuals whose own cognitive and physical capabilities have been impaired due to natural ageing, thus promoting a healthy ageing path (Hudlicka, 2013).

One of the most emerging trends in the field of health involving ICT is represented by mHealth technologies, that represent a perfectly suitable solution to promote active and healthy ageing (Helbostad et al., 2017). Mobile health, or mHealth, is an aspect of electronic health, or eHealth, that focuses on the delivery of healthcare services via mobile communication devices, thus reducing the workload for healthcare operators.
The World Health Organization (WHO) has described it as medical and public health practice that enables continuous monitoring of an individual's health conditions and effective prevention interventions (Organization, 2013).
Data demonstrate that the potential for the development of new services based on such technology and targeting specifically healthy ageing

is extraordinary. In 2014 over 75% of 65+ in the USA had a mobile phone and over 50% used smartphones or tablets. In 2012 roughly 50% of the EU citizens is an Internet-user, which is projected to rise to 90% by 2020 (Eurostat, 2017).
Alongside with mobile device, there is a growing number of technologies, like monitoring systems, that allow the detection of health parameters and the understanding of the habits of the individual through the use of sensors (Staman et al., 2013).

Additional advances have brought from systems able to track information such as weight, steps and general activity to virtual systems capable of changing the behaviour of the individuals and help them to achieve predefined goals. These systems, by leveraging on the aforementioned behaviour changing techniques, are able to elaborate the collected information in order to deliver tailored advice and feedback to the user. Thanks to these technologies, **virtual systems can play the role of virtual coaches, due to their power in motivating, stimulating and persuading people towards the desired behaviour** (Hamari et al., 2014).
This application has found validity in the healthy ageing domains: studies on the virtual coach adoption in the domains of healthy ageing show an increase of effectiveness in physical activity for people aged 65+ (Consolvo et al., 2008), an improvement in eating behaviours (Orji et al., 2014) and a higher social involvement (Castorina et al., 2010).

8.4 NESTORE scenarios

The project is still in a development phase and no definitive guidelines regarding the exploitation strategy for NESTORE are available.
However, **the NESTORE Consortium has designed some possible scenarios for the dissemination of NESTORE**: they are currently under discussion to define the most suitable strategy.
In particular, **the variables considered to design the best implementation scenario regard 1) the openness of NESTORE system and 2) the entity in charge of the payment and distribution of NESTORE**.

1) The openness of NESTORE system is intended, on one hand, as the possibility or impossibility for the NESTORE ecosystem to interact with no NESTORE-branded devices; on the other hand, openness is described as the possibility for NESTORE to interact with suppliers of physical products/services (e.g. Ticketone for the acquisition of show tickets; hotel and restaurants for making reservation, etc.).
NESTORE Consortium has highlighted that having a closed system along the value chain would make it easier the communication and data-sharing among all the NESTORE smart things. Anyway, it would also mean potential poor reliability of those data that the user retrieves via no NESTORE-branded devices (e.g. Fitbit).
On the contrary, an open system allows the user to continue using already possessed smart things without the need of acquiring new NESTORE-branded ones and offers a complete experience to users. Anyway, it results in higher complexities in the management of users' data and in the development phase of NESTORE software, since it has to be capable of interacting with multiple interfaces.

2) The options under consideration, as regards the payer, take into account that NESTORE has a high potential either as a B2B or B2C business model.
NESTORE could be paid and provided by a) healthcare institutions for supporting healthy ageing of citizens, b) health insurance companies for their clients, c) large corporations for the well-being of their employees.
A further possibility is that the citizens themselves acquire NESTORE out-of-pocket.

NESTORE Consortium, in order to test the assumptions in terms of service design and business model configurations, delivered a survey (400+ respondents in Italy and 300+ in Spain).
The survey investigated, as a matter of fact, the reaction of citizens in the event that NESTORE was distributed via a B2B or B2C business model.
Respondents were asked their level of agreement to have NESTORE as B2C business model and, as consequence, to pay for it out-of-pocket: the surveys confirmed that citizens are willing to pay out-of-pocket to access to NESTORE as a commercial product. From the survey, it was also detected that citizens may end up not trusting the NESTORE system without the reassurance from medical-relevant actors, that would guarantee the effectiveness of the NESTORE solution. According to this evidence, the 55% of respondents declared the General Practitioner to be the most relevant influencer to guide their purchase.
Considering the option to configure NESTORE as a B2B solution, the actors that the NESTORE Consortium evaluated as potential distributors of the solution are: the healthcare institutions, health insurances companies, large corporations. In the distributors' role, they would become the sponsor of NESTORE, paying for and providing NESTORE system in a freemium formula for citizens.
The freemium formula appears to NESTORE Consortium to be the most suitable since it allows to deal with the requirement of affordability explicated by an European project. As a matter of fact, among the prerequisites of a European project, there is the offering of solutions that have a large-scale impact, which are not exclusive or discriminatory and, therefore, which are economically accessible for each user interested in the solution.

When considering healthcare institutions as promoters for NESTORE project, it becomes evident that they would accept the role only in case of NESTORE configured as a medical device [2], thus respecting the legal specifications necessary to be defined as such.
This option appears to be the most suitable to the Consortium since it would allow NESTORE to put itself on a different level of validity in comparison to all the existing solutions for fostering healthy ageing.
Having NESTORE recognized as a medical device and, thus, distributed as pre-

[2]Medical device means any instrument, apparatus, implement, machine, appliance, implant, reagent for in vitro use, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings, for one or more of the specific medical purpose(s) of: diagnosis, prevention, monitoring, treatment or alleviation of disease; diagnosis, monitoring, treatment, alleviation of or compensation for an injury; investigation, replacement, modification, or support of the anatomy or of a physiological process; supporting or sustaining life;and does not achieve its primary intended action by pharmacological, immunological or metabolic means, in or on the human body, but which may be assisted in its intended function by such means.

scription for 65+ from general practitioners, would guarantee a high level of trust in the NESTORE solution, resulting in a rapid spread of it.
However, this solution also presents cons: it would require more years for its configuration since it is necessary to design NESTORE CE approved in respect of the Medical Device Regulation within the EU.
CE marking is the medical device manufacturer's claim that a product meets the essential requirements of all relevant European Medical Device Directives. The CE mark is a legal requirement to place a device on the market in the EU. The procedure to be accepted as a medical device is long-lasting, complex and expensive, requiring the design and lunch of a clinic trial. The estimated time-to-market in this scenario, indeed, corresponds to more than 24 months.

Considering the perspective of health insurances (conceived as a complementary entity to the healthcare system, and not part of the system itself), they would distribute NESTORE as part of their insurance policy. This framework may work in two directions: B2C and B2B. As a matter of fact, the individual can decide to subscribe an insurance policy in an autonomous way, obtaining NESTORE as an integrated service. Otherwise, a large corporation (B2B) can decide to offer to its employees NESTORE as part of the corporate welfare, becoming itself the promoter of the system.
In both cases, health insurances would benefit from higher revenues due to the sell of a new service and large corporations could obtain and collect a wide range of health-related data, that could be used as source of revenue, being sold to third parties, as the healthcare institutions. NESTORE Consortium, moreover, would benefit from the no need to configure NESTORE as medical device, avoiding all the technical and legal implications of it. In this situation, the time-to-market would be between 12 and 24 months.

8.5 NESTORE ecosystem

A key task carried out by the NESTORE Consortium has been the construction and validation of the **NESTORE ecosystem (i.e. all the actors contributing to the development and implementation of the project)**.
Having identified key stakeholders, the Consortium analysed their potential role in the project as well as their contribution in the promotion of healthy ageing.

The result considers the presence of 9 main types of stakeholders. Each category is made up by different actors, that concur in parallel for the creation, implementation and diffusion of NESTORE.
Here they are reported all the actors that may have a key role in the exploitation strategy of NESTORE, regardless the definitive scenario that the Consortium will choose to implement. In fact, some actors are mutually exclusive, meaning that the presence of one would imply the exclusion of others from the reference scenario.

- **Standard makers**: e.g. scientific communities, health authorities, technology standards, privacy and ethics;
- **Manufacturers of hardware and software for connected care**: manufacturers of tangible and intangible devices representing the final outcome

of NESTORE and the services of coaching embedded in it; e.g. wearable, chatbot, homecare assistants, serious game providers, environmental sensors;

- **Providers of physical products and services**: e.g. gyms, sport clubs, museaums and exhibitions, third age clubs, travel agencies;
- **Channels**: channels through which NESTORE is delivered to final users, coherent with the actors distributing and paying for it; e.g. pharmacies and drug stores, tech retailers, gyms and fitness centers, eCommerce;
- **Innovators**: further potential innovators to be involved in NESTORE project; e.g. universities, research centers, laboratories, incubators;
- **Investors/funders**: providers of financial resources for a proper, consistent and legal development of the project; e.g. European Commission, institutional funds, private funds, business angels;
- **Payers and Distributors**: e.g. health authorities, health insurance, citizens, pharma and biomedical companies;
- **Influencers**: e.g. mass media, physicians and specialists, society as a whole, third age advocacy groups;
- **NESTORE Consortium** (palying the coordinator role).

Chapter 9

Towards the model

9.1 Methodology

This section explores the **methodology employed** by the authors to **develop an SROI model for evaluating a virtual coach for healthy ageing and, more specifically, for the NESTORE virtual coach**.
In their "A Guide to Social Return on Investment", Nicholls and Lawlor (2012) state that carrying out an SROI analysis involves six main stages:

1. **Establishing scope and identifying key stakeholders**.
   There are three steps in this stage:

   - Establishing scope;
   - Identifying key stakeholders;
   - Deciding how to involve stakeholders.

   The scope of an SROI analysis is an explicit statement about the boundary of what is being considered. It requires to take into account: the purpose, the audience, the background, the resources, the range of activities to focus on, the period of time over which the intervention will be or has been delivered, whether the analysis is a forecast or an evaluation.
   The following step is to identify and involve stakeholders: stakeholders are defined as people or organizations that experience change, affect or are affected by the initiative, whether positively or negatively.

2. **Mapping outcomes**
   This stage is concerned with the building of an Impact Map that outlines the stakeholders' engagement. This details how the activities under investigation use certain resources (inputs) to deliver products or services (measured as outputs) which result in outcomes for stakeholders. The Impact Map is central to the SROI analysis.

There are five steps when filling out an Impact Map:

- Identifying inputs (what stakeholders are contributing in order to make the activity possible);
- Valuing inputs (to give a value to non-monetised inputs);
- Clarifying outputs (to identify what is delivered to stakeholders);
- Describing outcomes.

3. **Evidencing outcomes and giving them a value**
There are four steps to follow to evidencing and valuing outcomes:

   - Developing outcome indicators;
   - Collecting outcomes data;
   - Establishing the duration of outcomes;
   - Valuing outcomes.

   In sum, this stage requires to develop outcome indicators in order to collect evidence on the outcomes that are occurring and assess their relative importance by valuing them.
   The purpose of valuation is to assign to outcomes generated by the initiative a certain value: this process of valuation is often referred to as monetization, since here it is assigned a monetary value to those outcomes that can not be assessed referring to their market price.
   To reach this purpose, in SROI analysis, financial proxies are used to estimate the social value of non-traded goods. Sometimes monetization is a fairly straightforward process (where it relates to a cost saving for a certain stakeholder, for example) other times, instead, monetization is harder.
   To overcome this issue, traditional economic appraisal left out these outcomes, while SROI includes them in the analysis by leveraging on the several techniques available. Some examples are represented by Stated Preference [1] and Contingent Valuation [2], during which people are asked directly how they value the outcome either relative to other outcome (i.e status-quo) or how they would be willing to pay to have or avoid a certain outcome.

[1] Stated Preference approaches are based on constructed or hypothetical markets, i.e. they ask people what economic value they attach to those goods and services. In other words, the economic value is revealed through a hypothetical or constructed market based on questionnaires.

[2] Contingent Valuation is a method of estimating the value that a person places on a good. The approach asks people to directly report their willingness to pay (WTP) to obtain a specified good, or willingness to accept (WTA) to give up a good, rather than inferring them from observed behaviours in regular market places.

4. **Establishing impact**
   This stage refers to estimating how much of the outcome would have happened anyway without the initiative and what proportion of the outcome can be isolated as being added by the analysed initiative.

   There are four elements in this stage:

   - Deadweight;
   - Displacement;
   - Attribution;
   - Drop-off.

   Deadweight is a measure of the amount of outcome that would have happened even if the initiative had not taken place: it is calculated as a percentage and it is assessed referring to comparison groups or benchmarks.
   Displacement is an assessment of how much of the outcome displaced other outcomes (e.g. reducing crime in one area may displace criminal activity to another area).
   Attribution is an assessment of how much of the outcome was caused by the contribution of other organizations or people: attribution is calculated as a percentage.
   Drop-off is an assessment of the mitigation or decay of the outcomes of the initiatives of the course over time.

5. **Calculating the SROI**
   This stage involves adding up all the benefits, subtracting any negative effect and comparing the result to the investment.

   There are four steps to calculating the SROI ratio, with an optional fifth:

   - Projecting into the future (project the value of all the outcomes achieved into the future, according to the duration of outcomes previously defined);
   - Calculating the Net Present Value;
   - Calculating the ratio;
   - Conducting a sensitivity analysis;
   - Computing the payback period.

   To calculate the Net Present Value (NPV) the costs and benefits paid or received in different time periods need to be added up.
   In order to make these costs and benefits comparable, it is necessary to actualize them: the so-called discounting process recognises that people generally prefer to receive money today rather than tomorrow because there is a risk (e.g. that the money will not be paid) or because there is an opportunity cost (e.g. potential gains from investing the money elsewhere).
   This is known as the 'time value of money'.
   There is a range of different rates, but, for the public sector, the basic rate recommended in HM Treasury (2003) Green Book is 3.5%.

The SROI ratio is then computed by dividing the NPV by the value of inputs. After calculating the ratio, **it is important to assess the extent to which the obtained results would change by changing some of the assumptions** made within the model construction: in particular, standard requirement is to check changes to financial proxies, the quantity of the outcome, and the value of inputs, where non-financial inputs have been used. In conclusion, the payback period allows to describe how long it would take for an investment to be paid off: many funders and investors adopt it as a way of determining the risk of a project.

6. **Reporting, using and embedding**
   This stage refers to the need of communicating the results of the calculation to the audiences previously decided to be the scope of the SROI analysis. The reporting phase is essential since it represents the opportunity for making recommendations to the audience and to create accountability to stakeholders. The SROI report should include qualitative, quantitative and financial aspects to provide the user with the important information on the social value being created within the evaluated initiative.

9.2 Design of the model

9.2.1 Establishing scope and identifying key stakeholders

Establishing the scope of analysis means defining the boundaries of analysis. This implies identifying and selecting one among the aforementioned exploitation strategies for NESTORE on which to build an SROI model.

The authors selected the following **scenario for NESTORE exploitation: NESTORE configured as a closed system (not integrated with other devices) and distributed and paid by the healthcare system as a medical device**. This alternative represents the only viable solution to meet the Consotium initial will to present and conceive NESTORE as a medical device.
The authors performed a prospective analysis under the hypothesis to distribute NESTORE among 40-79 individuals in health (not affected by chronic diseases), living in the Lombardy Region and willing to adopt a virtual coach. The computed SROI ratio represents a forecast of the potential impact that NESTORE could provide if implemented in the Region.
The choice to limit the analysis within the Lombardy Region boundaries was driven by the Italian healthcare system configuration itself, which works on regional logics. Therefore, in order to have a specific and well-defined entity in charge of the distribution of NESTORE, the analysis has been limited to the Lombardian healthcare system. Moreover, being Lombardy the region in which the analysis was carried out, it was considered to be easier to retrieve data and information regarding the population and the morbidity in the Lombardy Region.
As regards the choice of the age range, even if NESTORE had been initially designed for promoting healthy ageing among 65+ population, the World Report on Ageing and Health (World Health Organization, 2015) suggests that the most coherent strategy to reduce the burden of morbidity in older age is to promote healthy behaviours and to control risk factors early in life. Promoting a healthy path among younger adults (40+) can lead to more effective results once reached the most advanced adult age. For this reason, the target group of analysis is constituted by the Lombardian population aged 40-79. It was considered not useful to deliver NESTORE to 80+ population since the average life expectancy in Lombardy is 83,2 years (Regione Lombardia, 2019).
According to the selected scenario, the main **channel of distribution for NESTORE is represented by General Practitioners (GPs), properly trained by the regional healthcare system**. GPs have to be presented with NESTORE features and potentialities to foster them to prescribe it to their patients. They are also trained with the soft skills necessary to engage their patients towards the adoption of NESTORE. Moreover, GPs are supported with a fee for any prescription of NESTORE solution they pursuit, given that NESOTRE adoption requires an active role of the practitioners in monitoring patients' results from the interaction with NESTORE and in intervening in case of detection of alarm factors.
A toll-free number in charge of solving any doubt regarding the features of the application of NESTORE is created.
All expenses oversee the regional healthcare system.

Having selected and defined the implementation scenario for NESTORE, it is possible to **identify the key stakeholders involved**. To tackle this task, it has been decided to design the ecosystem rotating around senior adults, in order to have complete visibility on all the actors directly or indirectly interacting with the target of NESTORE.
The ecosystem is constituted by: healthcare institutions (hospitals, GPs, physicians and specialists), familiar caregivers, family and friends, enterprises (professional caregivers, pharma and biomed companies, companies in which beneficiaries and familiar caregivers are employed), influencers, municipalities, Not for Profit and Non-Governmental organizations (NPOs and NGOs) and health insurances.
The key stakeholders selected for the SROI analysis come from the combination of those actors rotating around senior adults and those actors belonging to NESTORE ecosystem. They are entities and individuals that would be affected, positively or negatively, by the introduction of NESTORE:

1. **Beneficiaries**: they are the target of NESTORE. 40-79 years old healthy (not affected by chronic diseases) men and women living in the Lombardy Region and willing to use a virtual coach. NESTORE aims at promoting and encouraging a healthy lifestyle for its target by monitoring daily life activities and parameters. This should allow to reduce beneficiaries' morbidity of diseases that typically affect senior adults. The reduction of morbidity for beneficiaries due to the utilization of NESTORE impacts, both positively and negatively, many of the stakeholders above reported.

   In particular,

2. **Healthcare institutions**: they are represented by the Lombardy healthcare system, that benefits from the reduction of morbidity of beneficiaries since it reduces the economic burden related to raising of morbidity in the region. Moreover, the Lombardy healthcare system is in charge of the payment and distribution of NESTORE among beneficiaries.

3. **Familiar caregivers**: they are the relatives of the beneficiaries that cover the role of caregivers in case of beneficiaries' morbidity. Its reduction, therefore, prevents them from becoming familiar caregivers and suffering from a deterioration of their own health state. This situation would allow them to get a job position since they are not totally devoted and absorbed by the caring activity.

4. **Professional caregivers**: they are professionals offering support, in exchange for a salary, to people that are not autonomous in their daily life. The beneficiaries' morbidity reduction would result in job destruction, negatively impacting the economy of caring services.

5. **Companies where beneficiaries and familiar caregivers are employed**: the reduction in beneficiaries' morbidity means diminished absence due to illness from the beneficiaries and avoidance of leaving job position from familiar caregivers.

6. **NPO and NGOs:** they are entities delivering and offering services to senior adults. The reduction in beneficiaries' morbidity implies that the efforts of volunteers and the resources devoted to morbids can be oriented to other fields of need, thus improving and enlarging the social impact of the NPO/NGO.

7. **Municipalities**: similarly to the NPOs, they deliver and offer services to senior adults and morbids. The reduction in beneficiaries' morbidity implies that the efforts and resources of municipalities devoted to morbid can be oriented in another field of needs thus improving the social impact in the region.

As regards the potential stakeholders (part of NESTORE or senior adults' ecosystem) that the authors decided not to involve in the analysis:

1. Pharma and biomed companies: even if they could suffer from the introduction of NESTORE (since reduction in beneficiaries' morbidity means reduction in drugs sold), authors decided to keep them out of the analysis due to the difficulty in declining the loss in revenues for international pharmaceutical and biomedical companies in losses for the Lombardy Region economy, with the risk of exiting the boundaries set for the analysis.

2. Health insurances: excluded from the analysis due to the scenario chosen. If NESTORE is distributed by the healthcare system, insurances will not enter the ecosystem of NESTORE.

3. Influencers: they are kept out of the analysis since it is considered that no relevant impact would occur for them in case of NESTORE introduction.

4. Family and friends: they are kept out of the analysis since it is considered that the impact affecting them in the case of NESTORE introduction is already included thanks to the involvement of familiar caregivers.

As regards NPOs and Municipalities, even if they were considered to benefit from the reduction of beneficiaries' morbidity, a deeper analysis of the services they offer for senior adults revealed that they are assimilable to the services offered by a professional caregiver. As a matter of fact, the Lombardy Region municipalities offer a set of services devoted to the care of senior adults affected by fragilities and morbidity. In particular, they offer qualified assistance, information and consultancy services for the matching of job supply and demand to 1) people in a condition of fragility, known self-sufficiency and to their families who need home care services and 2) to workers, available to find employment as family assistants. As regards NPOs, Italianoprofit offers an overview of the services and activities offered in the Lombardy Region on behalf of senior adults. Mainly all the initiatives aim at curing, caring and assisting, at home and in hospice, patients with diseases. Some organizations differentiate themselves by offering additional services to that of caregiving. An example is offered by Associazione Volontari Caritas Ambrosiana that operates in Milan. The project consists of the delivery meals and, on request, of drugs. Even if the services offered by Municipalities and NPOs differ slightly from the traditional service of caregiving, it has been considered that burdens such

as delivering meals, shopping or drugs can be assimilable to the work performed by a familiar/professional caregiver.
For this reason, it has been assumed that the contribution coming from the elderly-devoted Municipalities and NPOs activities is embedded in that coming from the professional caregivers themselves and they have been excluded from the analysis.

Eventually, **stakeholders that are kept into the analysis**, being considered for the SROI model design are:

- **Beneficiaries**;
- **Lombardy Region healthcare system**;
- **Familiar caregivers**;
- **Enterprises (Lombardy Region broad economic system)**.

9.2.2 Mapping and valuing outcomes

This stage is concerned with the development of an **Impact Map that displays the stakeholders' engagement**. The Map details how the **activities under investigation use certain resources (inputs) to deliver products or services (measured as outputs) which result in outcomes for stakeholders**.

It is important to highlight that NESTORE project is still in a development phase. Therefore, the authors performed a prospective SROI analysis aiming at the best possible estimation of outcomes and inputs. The final SROI ratio represents a forecast of the impact that NESTORE could generate if implemented in the Lombardy Region. In detail, inputs have been estimated with the support of the members of NESTORE Consortium itself. The list of outcomes, instead, derives from the in-depth analysis of preventive interventions for healthy ageing, interpreted through the lenses of the Lombardy Region current features and conditions. Outcomes quantification and monetization has been estimated employing data employing data coming from ISTAT databases and Lombardy Region healthcare system official website..

It follows a visual representation of NESTORE Impact Map 9.1 and a detailed exploration of the role of every single stakeholder.

Stakeholder	Input	Output	Outcome	Indicator	Quantific./ Proxy	Outcome Value
Beneficiaries		Virtual coaching service	Reduced beneficiary's morbidity (risk of contracting the disease)	Percentage reduction in beneficiary's morbidity	Willingness to Pay for reduced morbidity	Willingness to Pay for reduced morbidity * number of beneficiaries
			Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Cost saving equal to the annual wage for a full-time professional caregiver	Annual wage for a full-time professional caregiver * reduction in the number of employed full-time professional caregivers
Healthcare system	Virtual coach distribution cost; installation costs; renovation/update of virtual coach; training courses for GPs;fee for GPs; toll- free number (assistance service)	Virtual coaching service provision	Reduced beneficiaries' morbidity (rate of illness)	Reduction in the number of morbid beneficiaries	Cost saving equal to the annual healthcare system cost for a given disease	Annual healthcare system cost for a given disease * reduction in the number of morbid beneficiaries

			Reduced familiar caregivers' morbidity	Reduction in the number of morbid familiar caregivers	Cost saving equal to the annual healthcare system cost for a given disease	Annual healthcare system cost for a given disease * reduction in the number of morbid familiar caregivers
Familiar caregivers			Reduced need for full-time familiar caregivers	Reduction in the number of needed full-time familiar caregivers	Income increase equal to yearly average income	Income increase * reduction in the number of needed full-time familiar caregivers
Enterprises			Reduced beneficiaries' work absence due to illness	Reduction in beneficiaries' annual work absence days due to illness	Cost saving equal to the cost of a day of work absence	Cost of a day of work absence * reduction in beneficiaries' annual work absence days due to illness
			Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Annual loss equal to the annual wage for a full-time professional caregiver	Annual wage for a full-time professional caregiver * reduction in the number of employed full-time professional caregivers

Table 9.1: NESTORE Impact Map

Beneficiaries

Stakeholder	Outcome	Indicator	Quantification/ proxy	Outcome value
Beneficiaries	Reduced beneficiary's morbidity (risk of contracting the disease)	Percentage reduction in beneficiary's morbidity	Willingness to Pay for reduced morbidity	Willingness to Pay for reduced morbidity * number of beneficiaries
	Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Cost saving equal to the annual wage for a full-time professional caregiver	Annual wage for a full-time professional caregiver * reduction in the number of employed full-time professional caregivers

Table 9.2: Beneficiaries' outcomes

Profile Beneficiaries are the target of NESTORE: senior adults.
NESTORE aims at promoting and encouraging a healthy lifestyle for its target by monitoring daily life activities and parameters. This should allow to reduce beneficiaries' morbidity of diseases that typically affect senior adults.
Form the literature it emerges that senior adults can undermine a healthy ageing path only as a natural and inevitable consequence of a health promotion path. Therefore, the authors found it reasonable, coming to the NESTORE case study, to define as beneficiaries all those 40-79 adults in health living in the Lombardy Region and willing to use a virtual coach.
In detail, **data regarding 40-79 adults in health in Lombardy are draft form ISTAT databases**. ISTAT defines as in health those adults that are not affected by any chronic disease.
Most recent data available date to 2017.
In particular,

- Population in health (Lombardy Region; 40-64) - Women: 927.864;
- Population in health (Lombardy Region; 40-64) - Men: 981.456;
- Population in health (Lombardy Region; 65-79) - Women: 376.743;
- Population in health (Lombardy Region; 65-79) - Men: 383.208;
- Total population of women in health (40-79): 1.304.607;
- Total population of men in health (40-79): 1.364.664.

The application of the Technology Acceptance Model[3] to the case of a virtual coach for healthy ageing revealed an Intention to Use equal to 64,2% (Visconti and Volani, 2018). As a consequence, the authors found it reasonable to involve a **therapeutic adherence equal to 64,2% for the computation of the number of beneficiaries**.
The number of beneficiaries results in:

- Population in health (Lombardy Region; 40-64) - Women: 595.689;
- Population in health (Lombardy Region; 40-64) - Men: 630.095;
- Population in health (Lombardy Region; 65-79) - Women: 241.869;
- Population in health (Lombardy Region; 65-79) - Men: 246.020;

[3]The technology acceptance model (TAM) is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it, notably. Perceived usefulness (PU) – This was defined by Fred Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance". Perceived ease-of-use (PEOU) – Davis defined this as "the degree to which a person believes that using a particular system would be free from effort" (Davis et al., 1989). The TAM has been continuously studied and expanded—the two major upgrades being the TAM 2 (Venkatesh and Davis, 2000) and the Unified Theory of Acceptance and Use of Technology (or UTAUT, Dennis et al. (2003)). A TAM 3 has also been proposed in the context of e-commerce with an inclusion of the effects of trust and perceived risk on system use (Venkatesh and Bala, 2008).

- Total population of women in health (40-79): 837.558;
- Total population of men in health (40-79): 876.114.

Reason for inclusion The authors found it necessary to involve in the calculation of the SROI for a virtual coach for healthy ageing the population it targets. Evidence on the relevance to involve the target in the analysis comes from the literature analysis on CBA and SROI in healthcare.

Outcomes For beneficiaries, two main outcomes have been indentified.

Outcome 1: Reduced beneficiary's morbidity Evidence from the literature shows that morbidity reduction represents the major relevant outcome for senior adults in case of adoption of a virtual coach for healthy ageing.
More in detail, the adoption of a healthy ageing path results in reduced beneficiary's morbidity[4] of[5]:

- Hypertension (Howard and McDonnell, 2015);
- Type 2 diabetes mellitus (Howard and McDonnell, 2015);
- Osteoporosis (Heath and Stuart, 2002);
- Heart failure (Heath and Stuart, 2002);
- Obesity (Heath and Stuart, 2002);
- Risk of falling and get a fracture (Sherrington et al., 2019);
- Stoke (Howard and McDonnell, 2015);
- Alzheimer's (Scrafford et al., 2019).

Coming to NESTORE case study and its adoption in the Lombardy Region, the authors decided a priori to eliminate from the analysis:

- Obesity, it is the cause of other morbidities already included in the list. Therefore, in order to avoid the double-counting of the morbidity reduction for correlated pathologies, obesity is neglected.
- Risk of falling and get a fracture, since it can be a consequence of osteoporosis, already included in the aforementioned morbidity list. Therefore, in order to avoid the double-counting of the morbidity reduction for correlated pathologies, the risk of falling and get a fracture is neglected.

[4]The relative incidence of a particular disease.
[5]Colon cancer has been excluded from the analysis since its relevance in terms of morbidity in the Lombardy Region is widely negligible.

Indicator: Percentage reduction in beneficiary's morbidity The authors found it reasonable to define the following indicator:
Percentage reduction in beneficiary's morbidity of:

- Hypertension (Howard and McDonnell, 2015);
- Type 2 diabetes mellitus (Howard and McDonnell, 2015);
- Osteoporosis (Heath and Stuart, 2002);
- Heart failure (Heath and Stuart, 2002);
- Stoke (Howard and McDonnell, 2015);
- Alzheimer's (Scrafford et al., 2019).

The authors investigated the literature in order to catch how performing **physical activity and having proper nutrition can reduce the risk of contracting each of the listed diseases respectively for women and men** (the authors decided to involve only two out of all NESTORE dimensions, given the complexity (emerged also from the literature) in detecting how social and cognitive stimulation can affect chronic diseases).
The following results have been found (Table 9.10):

Disease	Risk reduction Physical Activity Women	Risk reduction Physical Activity Men	Risk reduction Nutrition Women	Risk reduction Nutrition Men
Hypertension	15,0% (Abramson and Melvin, 2014)	14,0% (Chase et al., 2009)	18,0% (Cook et al., 2007)	18,0% (Cook et al., 2007)
Type 2 diabetes mellitus	30,0% (Bassuk and Manson, 2005)	11,0% (Bassuk and Manson, 2005)	40,0% (Salmeron et al., 2001)	16,0% (Van Dam et al., 2002)
Osteoporosis	36,0% (Gregg et al., 1998)	12,0% (Kujala et al., 2000)		
Heart failure	25,0% (San Raffaele, n.d.)	25,0% (San Raffaele, n.d.)	24,0% (Pfister et al., 2011)	24,0% (Pfister et al., 2011)
Stroke	25,0% (Howard and McDonnell, 2015)	25,0% (Howard and McDonnell, 2015)	26,0% (Fisher et al., 2006)	25,0% (Fisher et al., 2006)
Alzheimer			36,0% (Hu et al., 2013)	36,0% (Hu et al., 2013)

Table 9.3: Morbidity risk reduction for physical activity and nutrition

Given the lack of studies evaluating the combined impact of both nutrition and physical activity, the authors decided, when dealing with diseases that can benefit from both dimensions, to design two different scenarios:

- **Pessimistic**, in which it is considered only the contribution of the dimension with the greatest impact (the highest between physical activity and nutrition);
- **Optimistic**, in which risk reductions form physical activity and nutrition are summarized and adjusted by the overlying effect:

*Risk(Physical acrtivity) + Risk(Nutrition) - (Risk(Phyisical activity)*Risk(Nutrition)).*

The result is shown in Table 9.11. The following analysis develops the **optimistic scenario, assumed by authors as base case. The pessimistic scenario is instead deepened as part of the sensitivity analysis**.

					Pessimistic		Optimistic	
Disease	Risk reduction Physical activity - Women	Risk reduction Physical activity - Men	Risk reduction Nutrition Women	Risk reduction Nutrition Men	Risk reduction Women	Risk reduction Men	Risk reduction Women	Risk reduction Men
Hypertension	15,0%	14,0%	18,0%	18,0%	18%	18%	30,3%	29,5%
Type 2 diabetes mellitus	30,0%	11,0%	40,0%	16,0%	40,0%	16,0%	58%	25,2%
Osteoporosis	36,0%	12,0%			36,0%	12,0%	36,0%	12,0%
Heart failure	25,0%	25,0%	24,0%	24,0%	25,0%	25,0%	43%	43%
Stroke	25,0%	25,0%	26,0%	25,0%	26,0%	25,0%	44,5%	43,8%
Alzheimer			36,0%	36,0%	36,0%	36,0%	36,0%	36,0%

Table 9.4: Morbidity risk reduction in pessimistic and optimistic scenario

Quantification/Proxy: Willingness to Pay for reduced morbidity Literature review on CBA and SROI analysis reveals that reduced beneficiary's morbidity is typically valued in terms of **beneficiary's Willingness To Pay**.
Coming to NESTORE case study and its application in the Lombardy Region, it emerged the criticality of dealing with a prospective study. This led to the need to estimate Willingness To pay for NESTORE.
Given NESTORE features and potentialities, the authors found it reasonable to **select as a proxy the sum of the average value for an annual gym fee in the Lombardy Region plus the estimation of the annual cost for a nutritionist**.
The following result was obtained:

- Annual gym fee: €475,00 (Federconsumatori, 2017);
- Annual nutritionist cost (one first visit: €130,00 and eleven monthly routine visits: €60,00): €790,00.
- Willingness to Pay estimation: €1265,00.

Outcome value Outcome value is obtained by multiplying Willingness To Pay for the overall number of beneficiaries involved along a selected time horizon.

Outcome 2: Reduced need for full-time professional caregivers Evidence from the literature reveals that 15% of individuals in need of a caregiver in Italy recur to a professional caregiver (Quotidiano sanità, 2018).
As a consequence, the undermining of healthy ageing practices and the consequent **reduction in beneficiaries' morbidity can lead to a consistent fall in the number of employed professional caregivers** and thus to an important **saving for beneficiaries hiring them**.
Given the diseases on which healthy ageing practices can have a positive effect, the authors found it reasonable to **involve in the analysis only those diseases requiring assistance from a full-time caregiver: stroke**.
In sum, NESTORE adoption leads to a reduced need for full-time professional caregivers by individuals affected by stroke.

Indicator: Reduction in the number of employed full-time professional caregivers The reduction in the number of employed full-time professional caregivers by individuals affected by stroke seemed to the authors the most appropriate indicator the express the aforementioned outcome. The indicator has been counted as follows:

1. It has been defined, approximately, the number of healthy 40-79 individuals in the Lombardy Region with an intention to use NESTORE who will be affected by stroke every year (after the potential start of the program, when they are still healthy) both with and without the virtual coach (Table 9.5).

Outcome	Useful data for indicator			
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Beneficiaries suffering from stroke each year without virtual coach - Women	Beneficiaries suffering from stroke each year without virtual coach - Men	Beneficiaries suffering from stroke each year with virtual coach - Women	Beneficiaries suffering from stroke each year with virtual coach - Men
Stroke	215	266	119	149

Table 9.5: Beneficiaries suffering from stroke each year without and with the virtual coach

2. Considering that 100% of the affected beneficiaries are in need of assistance from a full-time caregiver and that 15% (Quotidiano sanità, 2018) of them will employ a professional caregiver, the authors managed in computing the number of newly employed professional caregivers every year, with and without the virtual coach (Table 9.6).

Outcome	Useful data for indicator	
Reduced number of employed full-time professional caregivers by beneficiaries affected by	New full-time professional caregivers each year without virtual coach	New full-time professional caregivers each year with the virtual coach
Stroke	72	40

Table 9.6: New full-time professional caregivers each year without and with the virtual coach

3. By subtracting the two values, it is obtained the **reduction in terms of newly employed full-time professional caregivers every year**.

Outcome	Indicator
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Reduction in the number of employed full-time professional caregivers each year with the virtual coach
Stroke	32

Table 9.7: Reduction in the number of new full-time professional caregivers each year with the virtual coach

Quantification/Proxy: Cost saving equal to the annual wage for a full-time professional caregiver The authors found it reasonable to monetize the outcome in terms of annual wage in Lombardy Region for a full-time professional caregiver: €17.940 (Assistere.net, n.d.).

Outcome value By multiplying the annual wage for the reduced number of newly employed full-time professional caregivers, the annual saving with the virtual coach for the beneficiaries is obtained (Table 9.8).

Outcome	Quantification	
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Annual wage in Lombardy Region for a full-time professional caregiver	Annual cost saving with the virtual coach (Cost saving (n))
Stroke	€17.940	€570.248

Table 9.8: Annual cost saving with the virtual coach

Outcome value is obtained by summing up savings year after year along the selected time horizon:
Total cost savig for a given year= Total cost saving (n-1)+Cost saving (n).
Total cost saving for a given year represents the value to be discounted and summed up over time in order to get the NPV.

Healthcare system

Stakeholder	Input	Output	Outcome	Indicator	Quantific./ proxy	Outcome value
Healthcare system	Virtual coach distribution cost; installation costs; renovation/update of virtual coach; training courses for GPs; fee for GPs; toll- free number (assistance service)	Virtual coaching service is made available for beneficiaries	Reduced beneficiaries' morbidity (rate of illness)	Reduction in the number of morbid beneficiaries	Cost saving equal to the annual healthcare system cost for a given disease	Annual healthcare system cost for a given disease * reduction in the number of morbid beneficiaries
			Reduced familiar caregivers' morbidity	Reduction in the number of morbid familiar caregivers	Cost saving equal to the annual healthcare system cost for a given disease	Annual healthcare system cost for a given disease * reduction in the number of morbid familiar caregivers

Table 9.9: Healthcare system input, output and outcomes

Profile The healthcare system is the stakeholder in charge of distributing and paying for the virtual coach.
Therefore, it represents the key player for the diffusion of the virtual coach towards the target population, for its maintenance and renovation, and for the provision of supportive and assistance services related to it.
Moreover, the healthcare system can importantly benefit from an initiative aiming at supporting healthy behaviours. A virtual coach, with its promotion of a healthy lifestyle, can reduce beneficiaries' morbidity of diseases that typically affect senior adults, thus reducing the economic burden on the healthcare system itself.
Recent studies have concluded that familiar caregivers may result in developing diseases as a consequence of their effort in taking care of their relatives.
Therefore, from a healthcare system perspective, the diffusion of a virtual coach fostering a healthy lifestyle does not only mean cost savings due to a lower risk of getting ill for the direct users of the virtual coach but includes also cost savings related to the lower risk of getting ill for their familiar caregivers.

Reason for inclusion The authors found it necessary to involve in the calculation of the SROI for a virtual coach for healthy ageing the healthcare system (especially when conceived as main payer and distributor, as in NESTORE case). Evidence on the relevance to involve the healthcare system in the analysis comes from the literature analysis on CBA and SROI in healthcare.

Input The healthcare system represents the stakeholder in charge of providing NESTORE to the beneficiaries, paying for it.
As discussed with the NESTORE Consortium, the Lombardy Region healthcare system will not go through any investment into fixed or intangible assets to provide NESTORE service. It will **purchase from external providers** (identified by the consortium), **on a monthly basis, all the elements needed to run the service** (hardware, software, technical assistance, formation courses), simply paying for them to be provided to beneficiaries.
In addition, the healthcare system will be in charge of paying a fee to GPs for each NESTORE prescription they realize.

In sum, the Lombardy Region healthcare system bears a monthly cost including:

- The purchase (form hardware and software providers) and the distribution to final users of NESTORE tangible devices;
- The installation of tangible devices at users' homes;
- The renovation and updates of the release of NESTORE;
- The formation courses designed to make General Practitioners (GPs) aware of NESTORE features and potentialities and to provide them with the soft skills necessary to engage their patients towards the adoption of NESTORE;
- Telephone assistance to support GPs in the monitoring phase of patients using NESTORE;

- Telephone assistance to solve doubts or technical problems emerged for beneficiaries in the interaction with NESTORE;
- The fee paid to GPs for each medical device prescribed and for the monitoring of patients in using it.

Since the NESTORE project is still in a development phase, no guarantee on the final cost in charge of the healthcare system is available. However, it has been possible to **define a range of costs with NESTORE Consortium, moving between an optimistic scenario and a pessimistic scenario**:

- Monthly and annual cost for implementing the project (optimistic): €50 and €600;
- Monthly and annual cost for implementing the project (pessimistic): €80 and €960.

Multiplying the annual costs for the number of beneficiaries involved in the trial (1.713.672), it is obtained the total annual cost for implementing the project:

- Total annual cost for implementing the project (optimistic): €1.028.203.189;
- Total annual cost for implementing the project (pessimistic): €1.645.125.103.

Outcomes For the healthcare system, two main outcomes have been identified.

Outcome 1: Reduced beneficiaries' morbidity Evidence from the literature shows that reduced beneficiaries' morbidity represents the major relevant outcome for the healthcare system in case of adoption of a virtual coach for healthy ageing.

Indicator: Reduction in the number of morbid beneficiaries The authors found it reasonable to define the following indicator:
Reduction in the number of morbid beneficiaries affected by:

- Hypertension (Howard and McDonnell, 2015);
- Type 2 diabetes mellitus (Howard and McDonnell, 2015);
- Osteoporosis (Heath and Stuart, 2002);
- Heart failure (Heath and Stuart, 2002);
- Stoke (Howard and McDonnell, 2015);
- Alzheimer's (Scrafford et al., 2019).

The indicator has been counted as follows:

1. The authors investigated the literature in order to catch how **performing physical activity and having proper nutrition can reduce the risk of contracting each of the listed diseases respectively for women and men**. The following results have been found (Table 9.10):

Disease	Risk reduction Physical Activity Women	Risk reduction Physical Activity Men	Risk reduction Nutrition Women	Risk reduction Nutrition Men
Hypertension	15,0% (Abramson and Melvin, 2014)	14,0% (Chase et al., 2009)	18,0% (Cook et al., 2007)	18,0% (Cook et al., 2007)
Type 2 diabetes mellitus	30,0% (Bassuk and Manson, 2005)	11,0% (Bassuk and Manson, 2005)	40,0% (Salmeron et al., 2001)	16,0% (Van Dam et al., 2002)
Osteoporosis	36,0% (Gregg et al., 1998)	12,0% (Kujala et al., 2000)		
Heart failure	25,0% (San Raffaele, n.d.)	25,0% (San Raffaele, n.d.)	24,0% (Pfister et al., 2011)	24,0% (Pfister et al., 2011)
Stroke	25,0% (Howard and McDonnell, 2015)	25,0% (Howard and McDonnell, 2015)	26,0% (Fisher et al., 2006)	25,0% (Fisher et al., 2006)
Alzheimer			36,0% (Hu et al., 2013)	36,0% (Hu et al., 2013)

Table 9.10: Morbidity risk reduction for physical activity and nutrition

Given the lack of studies evaluating the combined impact of both nutrition and physical activity, the authors decided, when dealing with diseases that can benefit from both dimensions, to design two different scenarios:

- **Pessimistic**, in which it is considered only the contribution of the dimension with the greatest impact (the highest between physical activity and nutrition);
- **Optimistic**, in which risk reductions form physical activity and nutrition are summarized and adjusted by the overlying effect:

*Risk(Physical acrtivity) + Risk(Nutrition) - (Risk(Phyisical activity)*Risk(Nutrition)).*

The result is shown in Table 9.11.
The following analysis develops the optimistic scenario, assumed as base case. The pessimistic scenario is instead deepened as part of the sensitivity analysis.

					Pessimistic		Optimistic	
Disease	Risk reduction Physical activity - Women	Risk reduction Physical activity - Men	Risk reduction Nutrition Women	Risk reduction Nutrition Men	Risk reduction Women	Risk reduction Men	Risk reduction Women	Risk reduction Men
Hypertension	15,0%	14,0%	18,0%	18,0%	18%	18%	30,3%	29,5%
Type 2 diabetes mellitus	30,0%	11,0%	40,0%	16,0%	40,0%	16,0%	58%	25,2%
Osteoporosis	36,0%	12,0%			36,0%	12,0%	36,0%	12,0%
Heart failure	25,0%	25,0%	24,0%	24,0%	25,0%	25,0%	43%	43%
Stroke	25,0%	25,0%	26,0%	25,0%	26,0%	25,0%	44,5%	43,8%
Alzheimer			36,0%	36,0%	36,0%	36,0%	36,0%	36,0%

Table 9.11: Morbidity risk reduction in pessimistic and optimistic scenario

2. To shift from the percentage of risk reduction to an absolute risk of morbidity with the virtual coach, it has been first investigated the current probability of morbidity (without the virtual coach) in the Lombardy Region. People affected by a certain morbidity (for gender and range of age) have been divided by the total population belonging to that category.
   Having available the data on the current risk of morbidity (without the virtual coach) and the risk reduction due to the utilization of the virtual coach, it has been computed the absolute risk of morbidity with the virtual coach (Table 9.12) as: *(1-Morbidity reduction with the virtual coach)* current probability of morbidity without the virtual coach*

Outcome	Useful data for indicator			
Reduced beneficiaries' morbidity (rate of illness) of	Morbidity with the virtual coach (Lombardy Region; 40-64) - Women	Morbidity with the virtual coach (Lombardy Region; 40-64) - Men	Morbidity with the virtual coach (Lombardy Region; 65-79) - Women	Morbidity with the virtual coach (Lombardy Region; 65-79) - Men
Hypertension	8,5%	9,5%	26,5%	21,2%
Type 2 diabetes mellitus	1,4%	3,6%	4,8%	13,0%
Osteoporosis	10,8%	1,4%	17,1%	4,8%
Heart failure	0,1%	0,4%	0,3%	0,6%
Stroke	0,1%	0,2%	0,3%	0,4%
Alzheimer	0,0%	0,0%	0,4%	0,3%

Table 9.12: Morbidity reduction with the virtual coach

3. It has been computed the **number of beneficiaries that become affected by each one of the aforementioned diseases every year**, both with and without the virtual coach.
   To simplify the calculations, it has been considered as centroid age of analysis 65 years old (the threshold between the two target groups included in the trial: 40-64 and 65-79). In this way, it can be assumed that all beneficiaries are healthy people being 65 years old in the year n=0 of analysis.
   In detail:

   - The probability to get morbidity between 65 and 79 years is obtained from the difference between Morbidity of (Lombardy Region; 80+) and Morbidity of (Lombardy Region; 40-64).
   - The probability of morbidity between 65 and 79 years is considered to be evenly distributed for each year of the 15 years of the range (from 65 to 79).

   The percentage of beneficiaries who get ill every year is computed as follows: *Probability of morbidity between the 65 and 80 years old/ 15 years.*

   The same reasoning is adopted for the scenario without and with virtual coach and for the gender women and men taken into account (Table 9.13).

Outcome	Useful data for indicator							
Reduced beneficiaries' morbidity (rate of illness) of	Probability of morbidity between 65 and 79 without the virtual coach (probability that you are in health at 65 and become affected within 79) -Women	Probability of morbidity of between 65 and 79 without the virtual coach - Men	Probability of morbidity of between 65 and 79 with the virtual coach - Women	Probability of morbidity of between 65 and 79 with the virtual coach - Men	Probability of becoming affected by morbidity in a certain year between 65 and 79 without the virtual coach - Women	Probability of morbidity in a certain year between 65 and 79 without the virtual coach - Men	Probability of morbidity in a certain year between 65 and 79 with the virtual coach - Women	Probability of morbidity in a certain year between 65 and 79 with the virtual coach - Men
Hypertension	24,107%	12,366%	16,803%	8,721%	1,607%	0,824%	1,120%	0,581%
Type 2 diabetes mellitus	10,425%	13,350%	4,379%	9,980%	0,695%	0,890%	0,292%	0,665%
Osteoporosis	52,739%	19,328%	33,753%	17,009%	3,516%	1,289%	2,250%	1,134%
Heart failure	0,250%	0,300%	0,142%	0,171%	0,017%	0,020%	0,009%	0,011%
Stroke	0,385%	0,455%	0,214%	0,256%	0,026%	0,030%	0,014%	0,017%
Alzheimer	2,503%	1,736%	1,602%	1,111%	0,167%	0,116%	0,107%	0,074%

Table 9.13: Percentage of new morbids in a certain year without and with the virtual coach

4. Obtained the probability of morbidity in a certain year, it is possible to know, for each morbidity, **the number of beneficiaries that become affected every year both with and without the virtual coach** (Table 9.14). And thus, **the reduction in the number of morbid beneficiaries granted by the adoption of the virtual coach**.

Outcome	Indicator		
Reduced beneficiaries' morbidity (rate of illness) of	Beneficiaries becoming affected by each year between 65 and 79 without virtual coach	Beneficiaries becoming affected by each year between 65 and 79 with virtual coach	Reduction in the number of morbid beneficiaries
Hypertension	20.684	14.476	6.208
Type 2 diabetes mellitus	13.618	8.274	5.344
Osteoporosis	40.737	28.781	11.956
Heart failure	315	179	135
Stroke	481	269	212
Alzheimer	2.411	1.543	868

Table 9.14: Reduction in the number of new morbid beneficiaries each year with the virtual coach

Quantification/Proxy: Cost saving equal to the annual healthcare system cost for a given disease In order to quantify and monetize the outcome of reduced beneficiaries' morbidity, the authors found it reasonable to utilize the cost saving generated by the avoided cost of illness for the healthcare system.

The annual unitary Lombardy healthcare system cost for morbidity is (Cerbino, 2019):

- Hypertension: €864
- Type 2 diabetes mellitus: €1.300
- Osteoporosis: €900
- Heart failure: €1.500
- Stroke: €1.180
- Alzheimer: €4.269

Outcome	Outcome value
Reduced beneficiaries' morbidity (rate of illness) of	Annual cost savings with the virtual coach (Cost saving(n))
Hypertension	€5.363.699
Type 2 diabetes mellitus	€6.947.630
Osteoporosis	€10.760.412
Heart failure	€202.906
Stroke	€250.053
Alzheimer	€3.706.069

Table 9.15: Annual cost saving for the healthcare system due to reduced beneficiaries' morbidity with the virtual coach

Outcome value Knowing the annual unitary Lombardy healthcare system cost for morbidity, it can be computed the annual Lombardy healthcare system cost saving due to the reduced number of morbid beneficiaries (Table 9.15).
For each year n of project implementation: *Total cost saving for a given year= Total cost saving (n-1)+Cost saving (n).*

Outcome 2: Reduced familiar caregivers' morbidity In order to estimate the cost savings for the healthcare system due to the lower incidence of caregiving related diseases, it is first necessary to estimate the number of caregivers entering the analysis.
In particular, a familiar caregiver is defined as a person that, free of charge and being bound by emotional ties, helps his or her own relative who is no longer self-sufficient because of advanced age or chronic debilitating diseases. It is a full-time or partial assistance, but it tends to satisfy all the needs related to personal care.
To simplify the analysis, here they are considered only those familiar caregivers offering full-time assistance to their relatives. To be consistent with this hypothesis, they have to be taken into account only those morbidities actually requiring the presence of full-time assistance. Literature suggests (Howard and McDonnell, 2015) that stroke events, in most cases, lead to permanent brain damage and chronic disabilities resulting in a condition of self-insufficiency and complete dependence, which requires the constant presence of an aide. As regards the other beneficiaries' morbidities, they are considered not to lead to permanent dependence from an assistant and, as a consequence, are not included in the familiar caregivers' morbidity analysis.

Firstly, it is considered the number of beneficiaries that each year requires a caregiver (without and with the virtual coach) as a consequence of a stroke event. Taking the aforementioned **hypothesis that 100% of people that had a stroke event remains aid-dependent for the rest of their lives, the ratio morbid:caregiver is 1:1**. According to an ISTAT investigation in Italy (Quotidiano sanità, 2018), **85% of the caregivers in Italy are familiar caregivers**, resulting in the definition of the total annual number of familiar caregivers.

Once defined the number of familiar caregivers without and with the virtual coach, it has to be defined which are the morbidities that can affect familiar caregivers. Literature reports as **potential diseases for familiar caregivers and related causes** (Bizzarri, 2015):

- Alzheimer (cause: lack of sleep);
- Heart failure (cause: lack of sleep);
- Type 2 diabetes mellitus (cause: lack of sleep);
- Osteoarthritis (cause: heavy load handling);
- Hypertension (cause: stress);
- Stroke (cause: stress).

Indicator: Reduction in the number of morbid familiar caregivers As indicator for reduced familiar caregivers' morbidity, the authors decided to use reduction in the number of familiar caregivers affected by:

- Alzheimer (cause: lack of sleep);
- Heart failure (cause: lack of sleep);
- Type 2 diabetes mellitus (cause: lack of sleep);
- Osteoarthritis (cause: heavy load handling);
- Hypertension (cause: stress);
- Stroke (cause: stress).

The indicator has been computed as follows:

1. The number of **new morbid beneficiaries that each year require a caregiver (without and with the virtual coach) as consequence of a stroke event**, are:
    - Population becoming affected by stroke each year between 65 and 80 without virtual coach - Women: 335;
    - Population becoming affected by each year between 65 and 80 without virtual coach - Men: 414;
    - Beneficiaries becoming affected by each year between 65 and 80 without virtual coach - Women: 119;
    - Beneficiaries becoming affected by each year between 65 and 80 without virtual coach - Men: 149.
2. Taking the hypothesis that 85% of them hire a full-time professional caregiver:

- **New full-time familiar caregivers each year without virtual coach: 636**;
- **New full-time familiar caregivers each year with the virtual coach: 228**.

3. **To detect the increased morbidity as a consequence of being a caregiver, it is first identified which is the current morbidity for each disease** (Table 9.16), resulting from the ratio between the current population affected by the investigated morbidity (for age range and gender) and the total population belonging to the category.

Outcome	Useful data for indicator				
Reduced familiar caregivers' morbidity of	Morbidity of (Lombardy Region - 40-64) Women	Morbidity of (Lombardy Region - 40-64) Men	Morbidity of (Lombardy Region - 65-79) Women	Morbidity of (Lombardy Region - 65-79) Men	Average morbidity (Lombardy Region)
Alzheimer	0,01%	0,01%	0,66%	0,46%	0,20%
Heart failure	0,6%	1,4%	0,4%	1,0%	0,76%
Type 2 diabetes mellitus	3,4%	4,8%	11,4%	17,4%	6,58%
Osteoarthritis	15,8%	14,4%	24,5%	23,1%	18,15%
Hypertension	12,2%	13,4%	38,0%	30,1%	19,79%
Stroke	0,3%	0,6%	0,5%	0,8%	0,45%

Table 9.16: Morbidity of each disease

4. According to a study conducted in Italy (Giuliani, 2018) in order to analyse the socio-demographic characteristics of familiar caregivers, it is found out that the 75% of familiar caregivers is composed by women (25% composed by men), of which 31% are under the age of 45, 38% are aged between 46 and 65, 18% are between 66 and 70 and 13% are over 70 .
   The distribution of morbidity varies according to age and gender, thus leading to the necessity to define an **Average morbidity (Lombardy Region) considering the composition of the familiar caregivers (in terms of age and gender)**. In particular, the Average morbidity (Lombardy Region) is computed as:

   *Morbidity of (Lombardy Region - 40-64) Women*75%*(31%+38%)+ Morbidity of (Lombardy Region - 40-64) Men*25%*(31%+38%)+Morbidity of (Lombardy Region - 65-79) Women*75%*(18%+17%)+Morbidity of (Lombardy Region - 65-79) Men*25%*(18%+17%).*

   The results of Average morbidity (Lombardy Region) for familiar caregivers are:

- Alzheimer: 0,20%;
- Heart failure: 0,76%;
- Type 2 diabetes mellitus: 6,58%;
- Osteoarthritis: 18,15%;
- Hypertension: 19,79%;
- Stroke: 0,45%.

5. Literature reports the following **percentage of increase in morbidity as a consequence of being a caregiver**:
   - Alzheimer: 34% (J.-C. Chen et al., 2016);
   - Heart failure: 7% (Walia et al., 2014);
   - Type 2 diabetes mellitus: 67% (Chaput et al., 2007);
   - Osteoarthritis: 26% (Verbeek et al., 2017);
   - Hypertension: 67% (Gangwisch et al., 2006);
   - Stroke: 24% (Miller et al., 2014).
6. The morbidity for a caregiver is, as a consequence, computed as: *Average morbidity (Lombardy Region) + (Average morbidity (Lombardy Region) * Increase in morbidity as a consequence of being a caregiver)*
   - Alzheimer: 0,27%;
   - Heart failure: 0,82%;
   - Type 2 diabetes mellitus: 10.98%;
   - Osteoarthritis: 22,87%;
   - Hypertension: 33,05%;
   - Stroke: 0,55%.
7. Having information regarding the morbidity of a caregiver and knowing the new full-time familiar caregivers each year, it is possible to obtain (Table 9.17):
   - Familiar caregivers affected each year without virtual coach;
   - Familiar caregivers affected each year with virtual coach;
   - **Reduction in the number of morbid familiar caregivers each year**.

Outcome	Indicator		
Reduced familiar caregivers' morbidity of	Familiar caregivers affected by each year without virtual coach	Familiar caregivers affected by each year with the virtual coach	Reduction in the number of morbid familiar caregivers each year
Alzheimer	1,08	0,61	0,48
Heart failure	3,34	1,87	1,47
Type 2 diabetes mellitus	44,86	25,09	19,78
Osteoarthritis	93,46	52,26	41,20
Hypertension	135,05	75,51	59,54
Stroke	2,26	1,26	1,00

Table 9.17: Reduction in the number of morbid familiar caregivers each year with the virtual coach

Quantification/Proxy: Cost saving equal to the annual healthcare system cost for a given disease The authors found it reasonable to monetize the outcome in terms of annual wage in Lombardy Region for a full-time professional caregiver: €17.940 (Assistere.net, n.d.).
In order to quantify and monetize the outcome of reduced familiar caregivers' morbidity, the authors found it reasonable to compute cost savings for the healthcare system due to the reduced number of affected caregivers with the virtual coach. It has to be considered the annual unitary Lombardy healthcare system cost for (Cerbino, 2019):

- Alzheimer: €4.269;
- Heart failure: €1.500;
- Type 2 diabetes mellitus: €1.300;
- Osteoarthritis: €890;
- Hypertension: €864;
- Stroke: €1.180.

Outcome value Knowing the annual unitary Lombardy healthcare system cost for morbidity, it can be computed the annual Lombardy healthcare system cost saving due to the reduced number of morbid familiar caregivers (Table 9.18).

Outcome	Outcome value
Reduced number of familiar caregivers morbidity of	Annual cost saving with the virtual coach (Cost saving (n))
Alzheimer	€1.175
Heart failure	€36.671
Type 2 diabetes mellitus	€2.210
Osteoarthritis	€25.712
Hypertension	€2.041
Stroke	€51.439

Table 9.18: Annual cost saving for the healthcare system due to reduced familiar caregivers' morbidity with the virtual coach

Familiar caregivers

Stakeholder	Outcome	Indicator	Quantific./ proxy	Outcome value
Familiar caregivers	Reduced need for full-time familiar caregivers	Reduction in the number of needed full-time familiar caregivers	Income increase equal to average income	Income increase * reduction in the number of needed full-time familiar caregivers

Table 9.19: Familiar caregivers' outcome

Profile Familiar caregivers are those who help, free of charge in everyday life, their own dependents, with problems due to seniority, disability or any pathologies. Evidence from the literature reveals that 85% of individuals in need of a caregiver in Italy recurs to a familiar caregiver (Quotidiano sanità, 2018).
They are generally women (74%), of whom 31% under the age of 45, 38% aged between 46 and 60, 18% between 61 and 70 and 13% over 70 (Giuliani, 2018). The authors found it reasonable to **involve in the analysis of NESTORE project only full-time employed familiar caregivers** who are forced to leave their job for assisting their relatives.
Given the diseases on which healthy ageing practices can have a positive effect, **stroke implies assistance form a full-time familiar caregiver** (Howard and McDonnell, 2015).
Given the number of people who have been affected by a stroke in the Lombardy Region, it has been possible to determine the **number of full-time familiar caregivers currently employed in the Lombardy Region** and to get an idea of the magnitude of their role and contribution in assisting senior adults.
Most recent available data date back to 2017:

- Population affected by stroke (Lombardy Region; 40-79): 18.836;
- Population affected by stroke and that recurs to a full-time familiar caregiver: 16.011.

Reason for inclusion The authors found it necessary to involve in the calculation of the SROI for a virtual coach for healthy ageing the familiar caregivers that provide assistance to the beneficiaries it targets.
In fact, their role in Italy is generating growing interest especially in normative and economic terms (Legge 104) and has led to the rise of several advocacy groups in defence of their rights.
Thus, it seemed interesting for both, familiar caregivers and public authorities who should be in charge of drafting proper norms, to frame in quantitative terms how they could benefit from NESTORE project and its effects.

Outcomes For familiar caregivers it has been identified one main outcome.

Outcome 1: Reduced need for full-time familiar caregivers The undermining of healthy ageing practices and the consequent reduction in the morbidity of stroke can lead to a consistent fall in the number of full-time familiar caregivers. In sum, NESTORE adoption leads to a reduced need for full-time familiar caregivers by individuals affected by stroke.

Indicator: Reduction in the number of needed full-time familiar caregivers The reduction in the number of needed full-time familiar caregivers by individuals affected by stroke seemed to the authors the most appropriate indicator the express the aforementioned outcome.
The indicator has been quantified as follows:

1. The analysis of the healthcare system as a stakeholder in NESTORE project resulted in defining, approximately, the absolute number of **healthy 40-79 individuals in the Lombardy Region** with the intention to use a virtual coach (i.e. beneficiaries) **who suffer from stroke every year** both with and without the virtual coach (Table 9.20).

Outcome	Useful data for indicator			
Reduced need for full-time familiar caregivers	Beneficiaries becoming affected by each year without virtual coach – Women	Beneficiaries becoming affected by each year without virtual coach - Men	Beneficiaries becoming affected by each year without virtual coach - Women	Beneficiaries becoming affected by each year without virtual coach - Men
Stroke	215	266	119	149

Table 9.20: Beneficiaries affected by stroke each year

2. Considering that **100% of them are in need of assistance from a full-time professional caregiver and that 85% of them will employ a familiar caregiver**, the authors managed in computing the **number of new full-time familiar caregivers every year**, with and without the virtual coach (Table 9.21).

Outcome	Useful data indicator	
Reduced need for full-time familiar caregivers	New full-time familiar caregivers each year without virtual coach	New full-time familiar caregivers each year with the virtual coach
Stroke	409	228

Table 9.21: New full-time familiar caregivers each year without and with the virtual coach

3. By subtracting the two values, it is obtained the **reduction (Table 9.22) in terms of new full-time familiar caregivers every year thanks to the virtual coach**.

Outcome	Indicator
Reduced need for full-time familiar caregivers	Reduction in the number of full-time familiar caregivers each year with the virtual coach
Stroke	180

Table 9.22: Reduction in the number of new full-time familiar caregivers each year with the virtual coach

Quantification/Proxy: Income increase equal to yearly average income The authors found it reasonable to **monetize the outcome in terms of the average annual wage in the Lombardy Region**. In fact, the immediate consequence for a familiar caregiver of not having to assist a relative is represented by the possibility of starting to work again. According to D'Andrea (2019), this value equals €32.255.

Outcome value By multiplying the reduction in the number of full-time familiar caregivers with the virtual coach for the annual wage, it is possible to compute the **annual income increase thanks to the virtual coach** (Table 9.23).

Outcome	Quantification	
Reduced need for full-time familiar caregivers	Annual income in Lombardy Region for a full-time job	Increase in annual income with the virtual coach (Income increase (n))
Stroke	€32.255	€5.809.863

Table 9.23: Annual income increase for familiar caregivers with the virtual coach

Outcome value is obtained by summing up income increases year after year along the selected time horizon:
Total income increase for a given year= Total income increase (n-1)+Income increase (n).
Total income increase for a given year represents the value to be discounted and summed up over time in order to get the NPV.

Enterprises

Stakeholder	Outcome	Indicator	Quantific./ proxy	Outcome value
Enterprises	Reduced beneficiaries' work absence due to illness	Reduction in beneficiaries' annual work absence days due to illness	Cost saving equal to the cost of a day of work absence	Cost of a day of work absence * reduction in beneficiaries' annual work absence days due to illness
	Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Annual loss equal to the annual wage for a full-time professional caregivers	Annual wage for a full-time professional caregiver * reduction in the number of employed full-time professional caregivers

Table 9.24: Enterprises outcomes

Profile The authors employed the term enterprises to refer to the whole Lombardy Region economic system.

Reason for inclusion Given the nature of the NESTORE project (European H2020 project supported by the regional healthcare system) and the aim of the SROI analysis to capture broad implications of an initiative, the authors found it reasonable to involve the regional economic system in the analysis as one of the actors that should be mostly affected by a plan that points at promoting and encouraging healthy ageing among senior adults in the Region.

Outcomes For the enterprises, two main outcomes have been identified.

Outcome 1: Reduced beneficiaries' work absence due to illness Reduced beneficiaries' morbidity immediately implies reduced beneficiaries' work absence due to illness for:

- Hypertension (Howard and McDonnell, 2015);
- Type 2 diabetes mellitus (Howard and McDonnell, 2015);
- Osteoporosis (Heath and Stuart, 2002);
- Heart failure (Heath and Stuart, 2002);
- Stoke (Howard and McDonnell, 2015);
- Alzheimer's (Scrafford et al., 2019).

Indicator: Reduction in beneficiaries' annual work absence days due to illness The authors found it reasonable to define the following indicator: annual reduction in work absence days due to illness thanks to beneficiaries' reduced morbidity of:

- Hypertension (Howard and McDonnell, 2015);
- Type 2 diabetes mellitus (Howard and McDonnell, 2015);
- Osteoporosis (Heath and Stuart, 2002);
- Heart failure (Heath and Stuart, 2002);
- Stoke (Howard and McDonnell, 2015);
- Alzheimer's (Scrafford et al., 2019).

The indicator has been counted as follows:

1. The analysis of the healthcare system as a stakeholder for the NESTORE project led to quantify the number of **healthy 40-79 individuals in the Lombardy Region** with an intention to use NESTORE (i.e. beneficiaries) who become **affected by each one of the aforementioned diseases every year** both with and without the virtual coach (Table 9.25).

Outcome	Useful data for indicator			
Reduced work absence due to illness due to reduced morbidity of	Beneficiaries becoming affected by each year without virtual coach - Women	Beneficiaries becoming affected by each year without virtual coach - Men	Beneficiaries becoming affected by each year without virtual coach - Women	Beneficiaries becoming affected by each year without virtual coach - Men
Hypertension	13.461	7.223	9.382	5.094
Type 2 diabetes mellitus	5.821	7.797	2.445	5.829
Osteoporosis	29.448	11.289	18.847	9.934
Heart failure	140	175	80	100
Stroke	215	266	119	149
Alzheimer	1.397	1.014	894	649

Table 9.25: Beneficiaries becoming morbid each year

2. Literature has been investigated to determine the **average hospital length of stay in the Lombardy Region for each of these diseases** producing the following results:

   - Hypertension: 6,9 days (OECD, 2017);
   - Type 2 diabetes mellitus: 7 days (Donnan et al., 2000);
   - Osteoporosis: 6,9 days (OECD, 2017) ;
   - Heart failure: 7 days (Martin-Sanchez et al., 2016);
   - Stroke: 18,6 days (Kim et al., 2013);
   - Alzheimer: 6,9 (OECD, 2017).

   In particular, the investigation of the literature did not produce any relevant result specifically about the Lombardy Region, thus the authors found it reasonable to broaden the search to analyses performed at least in Europe.

3. Subsequently, by multiplying the data at points 1) and 2), it has been computed the **total number of annual days of absence from work for the newly affected beneficiaries in a given year for each disease** both with and without the virtual coach (Table 9.26).

Reduced work absence due to illness due to reduced morbidity of	Total annual days of work absence for beneficiaries becoming affected that year without the virtual coach	Total annual days of work absence for beneficiaries becoming affected that year with the virtual coach
Hypertension	142.719	99.884
Type 2 diabetes mellitus	95.329	57.919
Osteoporosis	281.086	198.590
Heart failure	2.202	1.255
Stroke	8.941	4.999
Alzheimer	16.639	10.649

Table 9.26: Total annual days of beneficiaries' work absence due to illness without and with the virtual coach

4. By subtracting the number of days of absence in both cases, with and without the virtual coach, it has been obtained the **annual reduction in work absence days from newly affected beneficiaries in a specific year** (Table 9.27).

Outcome	Indicator
Reduced work absence due to illness due to reduced morbidity of	Reduction in annual days of work absence
Hypertension	42.835
Type 2 diabetes mellitus	37.410
Osteoporosis	82.496
Heart failure	947
Stroke	3.942
Alzheimer	5.990
Total	**173.620**

Table 9.27: Reduction in beneficiaries' annual days of work absence due to illness with the virtual coach

Quantification/Proxy: Cost saving equal to the cost of a day of work absence The cost of a day of work absence in the Lombardy Region has been employed to value the outcome. This cost has been drafted starting from the average daily wage in the Lombardy Region and neglecting the fact that a certain percentage (50%) of the value is subsidized by INPS (Istituto Nazionale di Previdenza Sociale). In fact, independently from the specific actor, the broader regional economic system is in charge of paying for work absence days. The cost equals €75,27 (D'Andrea, 2019).

Outcome value By multiplying the cost of work absence for the reduction in annual days of absence with the virtual coach, it has been calculated the annual cost saving coming from beneficiaries enabled to work that specific year with the virtual coach.(Table 9.28).

Outcome	Quantification
Reduced work absence due to illness due to reduced morbidity of	Annual cost savings with the virtual coach (Cost saving(n))
Hypertension	€3.224.315
Type 2 diabetes mellitus	€2.815.976
Osteoporosis	€6.209.736
Heart failure	€71.275
Stroke	€296.688
Alzheimer	€450.894

Table 9.28: Annual cost saving for enterprises due to reduced beneficiaries' work absence due to illness with the virtual coach

Outcome value is obtained by summing up savings year after year along the selected time horizon:
Total cost saving for a given year= Total cost saving (n-1)+Cost saving (n).
Total cost saving for a given year represents the value to be discounted and summed up over time in order to get the NPV.

Outcome 2: Reduced need for full-time professional caregivers Evidence from the literature reveals that 15% of individuals in need of a caregiver in Italy recur to a professional caregiver (Quotidiano sanità, 2018).
As a consequence, the undermining of healthy ageing practices and the consequent reduction in their morbidity can lead to a consistent fall in the number of employed professional caregivers and thus to a loss for the entire regional economic system.
Given the diseases on which healthy ageing practices can have a positive effect, the authors found it reasonable to involve in the analysis only those requiring assistance form a full-time caregiver: stroke (Howard and McDonnell, 2015).
In sum, NESTORE adoption leads to a reduced need for full-time professional caregivers by individuals affected by stroke.

Indicator: Reduction in the number of employed full-time professional caregivers The reduction in the number of employed full-time professional caregivers by individuals affected by stroke seemed to the authors the most appropriate indicator the express the aforementioned outcome. The indicator has been counted as follows:

1. The analysis of the healthcare system as a stakeholder in NESTORE project resulted in defining, approximately, the number of healthy 40-79 individuals in the Lombardy Region with an intention to use NESTORE who suffers from stroke every year both with and without the virtual coach (Table 9.29).

Outcome	Useful data for indicator			
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Beneficiaries suffering from stroke each year without virtual coach - Women	Beneficiaries suffering from stroke each year without virtual coach - Men	Beneficiaries suffering from stroke each year with virtual coach - Women	Beneficiaries suffering from stroke each year with virtual coach - Men
Stroke	215	266	119	149

Table 9.29: Beneficiaries suffering from stroke each year

2. Considering that **100% of the affected beneficiaries are in need of the assistance from a full-time professional caregiver and that 15% of them will employ a professional caregiver**, the authors managed in computing the **number of newly employed professional caregivers every year** in both scenarios, with and without the virtual coach (Table 9.30).

Outcome	Useful data for indicator	
Reduced number of employed full-time professional caregivers by beneficiaries affected by	New full-time professional caregivers each year without virtual coach	New full-time professional caregivers each year with the virtual coach
Stroke	72	40

Table 9.30: New full-time professional caregivers each year without and with the virtual coach

3. By subtracting the two values, it is obtained the **reduction in terms of newly hired full-time professional caregivers every year** (Table 9.31).

Outcome	Indicator
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Reduction in the number of employed full-time professional caregivers each year with the virtual coach
Stroke	32

Table 9.31: Reduction in the number of new full-time professional caregivers each year with the virtual coach

Quantification/Proxy: Annual loss equal to the annual wage for a full-time professional caregivers The authors found it reasonable to monetize the outcome in terms of annual wage in Lombardy Region for a full-time professional caregiver: €17.940 (Assistere.net, n.d.).

Outcome value By multiplying the annual wage for the reduced number of newly employed full-time professional caregivers, the annual loss with the virtual coach is obtained. (Table 9.32).

Outcome	Quantification	
Reduced number of employed full-time professional caregivers by beneficiaries affected by	Annual wage in Lombardy Region for a full-time professional caregiver	Annual loss with the virtual coach (Loss (n))
Stroke	€17.940	€570.248

Table 9.32: Annual loss for enterprises due to reduced number of new full-time professional caregivers each year with the virtual coach

Outcome value is obtained by summing up losses year after year along the selected time horizon:
Total loss for a given year= Total loss (n-1)+Loss (n).
Total loss for a given year represents the value to be discounted and summed up over time in order to get the NPV.

9.2.3 Establishing impact

This stage requires to **account for deadweight, drop-off, displacement, and attribution**. Given the prospective nature of the analysis performed by the authors, it was impossible to practically collect data on deadweight, drop-off, displacement, and attribution.
Anyway, dealing with each item in a detailed way, it seemed reasonable to the authors to assume a **displacement equal to 0%**. In fact, the undermining of a prevention path for senior adults in the Lombardy Region cannot result in worse health conditions for senior adults in adjacent regions or for those who are unwilling to join the NESTORE project.
Analogously, the authors assumed a **drop-off value equal to 0%**. They decided to deal with time effects exclusively in the selection of a proper time horizon for the analysis: the project can last only until the technology becomes obsolete. They found it reasonable, in fact, that promotion and engagement encouraged by GPs results in an effective implementation of the project and resonance of its results along the whole selected time horizon.
Deadweight is typically estimated through the creation of a control group. Therefore, the authors **assumed a value equal to 0%**. Anyway, the impossibility to estimate deadweight is involved as one of the limitations of the present research analysis.
The authors involved an **attribution equal to 95% (5% outcome loss) for all outcomes** (percentage of the outcome that is attributable to the NESTORE project itself). They assumed that only 5% of beneficiaries' morbidity reduction (and thus of all the outcomes it provokes) is caused by prevention interventions different from NESTORE. Such a low value is justified by the fact that **beneficiaries involved in the analysis are individuals explicitly willing to adopt NESTORE**. As a consequence, it is assumed that NESTORE itself represents the major prevention mean for them, otherwise, they would think not to be in need of it and of the aid it provides.

9.2.4 Calculating the SROI

Net Present Value and SROI calculation

This step consists in **translating the outcomes and the inputs into a single value that is projected into the future**.
The idea is to compute the NPV for all involved outcomes and then to divide it for the discounted value of inputs (Equation 9.1):

$$\sum_{n=1}^{10} \frac{\frac{Outcome(n)}{(1+k)^n}}{\frac{Input(n)}{(1+k)^n}} \tag{9.1}$$

The discounting process implies the selection of a proper time horizon (potentially different for different outcomes and inputs) and of a proper discount rate.
The authors, with the aid of the project supervisor, considered **10 years to be the maximum time horizon that allows a complete overview of the**

benefits that NESTORE can offer, without the risk of obsolescence of the technology. The sensitivity analysis offers a more complete overview on how the SROI value changes according to the identified time horizon.
The **cost of capital has been assumed equal to 3,5%** as the HM Treasury (2003) Green Book for public authorities recommends when making economic estimates based on SROI.

The following tables display which is the **value assumed by each single outcome and input when projected on a time horizon of 10 years with a discount rate equal to 3,5%**. The result is then **corrected assuming an attribution equal to 95% in order to obtain the impact** (Equation 9.2).

$$\left(\sum_{n=1}^{10} \frac{\frac{Outcome(n)}{(1+k)^n}}{\frac{Input(n)}{(1+k)^n}}\right) * Attribution \tag{9.2}$$

Beneficiaries

Outcome 1: Reduced beneficiary' morbidity

- Annual WTP for NESTORE for a single beneficiary: €1.265,00;
- Annual total WTP for NESTORE: (annual WTP * number of beneficiaries) €2.167.795.057;
- NPV (simple discount) (Table 9.33):

n (year)	Discounted Total WTP
1	€2.094.487.978
2	€2.023.659.882
3	€1.955.226.939
4	€1.889.108.154
5	€1.825.225.269
6	€1.763.502.676
7	€1.703.867.320
8	€1.646.248.618
9	€1.590.578.375
10	€1.536.790.700
NPV	**€18.028.695.911**

Table 9.33: NPV of Reduced beneficiary's morbidity for Beneficiaries

Outcome 2: Reduced need for full-time professional caregivers

- Annual wage in Lombardy Region for a full-time professional caregiver: €17.940;
- Annual cost saving with the virtual coach: (reduced number of employed professional caregivers * annual wage = Cost saving in (n)) €570.248;
- In Table 9.34 it is computed the NPV: (in n, value to be discounted, *Total cost saving (n) = Total cost saving (n-1)+Cost saving (n)*).

n (year)	Value to be discounted	**Discounted cost saving**
1	€570.248	€550.964
2	€1.140.496	€1.064.665
3	€1.710.743	€1.542.992
4	€2.280.991	€1.987.752
5	€2.851.239	€2.400.667
6	€3.421.487	€2.783.381
7	€3.991.734	€3.137.467
8	€4.561.982	€3.464.422
9	€5.132.230	€3.765.676
10	€5.702.478	€4.042.594
NPV		**€24.740.580**

Table 9.34: NPV of Reduced need for full-time professional caregivers for Beneficiaries

Healthcare system

Outcome 1: Reduced beneficiaries' morbidity

- The annual unitary Lombardy healthcare system cost for morbidity is (Cerbino, 2019):
  - Hypertension: €864;
  - Type 2 diabetes mellitus: €1.300;
  - Osteoporosis: €900;
  - Heart failure: €1.500;
  - Stroke: €1.180;
  - Alzheimer: €4.269.
- Annual healthcare system cost saving (n) due to reduced beneficiaries' morbidity of:
  - Hypertension: €5.363.699;
  - Type 2 diabetes mellitus: €6.947.630;
  - Osteoporosis: €10.760.412;
  - Heart failure: €202.906;
  - Stroke: €250.053;
  - Alzheimer: €3.706.069;
  - Total cost saving: €27.230.769.
- In Table 9.35 it is computed the NPV: (in n, value to be discounted, *Total cost saving (n) = Total cost saving (n-1)+Cost saving (n)).*

Outcome 2: Reduced familiar caregivers' morbidity

- The annual unitary Lombardy healthcare system cost for morbidity:
  - Alzheimer: €4.269;
  - Heart failure: €1.500;
  - Type 2 diabetes mellitus: €1.300;
  - Osteoarthritis: €890;
  - Hypertension: €864;
  - Stroke: €1.180.
- Annual healthcare system cost saving (n) due to reduced familiar caregivers' morbidity of
  - Alzheimer: €2.041;

n (year)	Value to be discounted	**Discounted cost saving**
1	€27.230.769	€26.309.921
2	€54.461.538	€50.840.428
3	€81.692.306	€73.681.780
4	€108.923.075	€94.920.167
5	€136.153.844	€114.637.883
6	€163.384.613	€132.913.488
7	€190.615.382	€149.821.967
8	€217.846.150	€165.434.884
9	€245.076.919	€179.820.526
10	€272.307.688	€193.044.043
NPV		**€1.182.345.936**

Table 9.35: NPV of Reduced beneficiaries' morbidity for Healthcare system

  - Heart failure: €2.209;
  - Type 2 diabetes mellitus: €25.712;
  - Osteoarthritis: €36.670;
  - Hypertension: €51.439;
  - Stroke: €1.175;
  - Total: €119.247.

- It has been considered, according to literature results on the consequences of lack of sleep and stress on individual health, that the conditions of a caregiver start to reveal their effect after a period of 5 years of full-time assistance. Therefore, the NPV (Table 9.36) starts to consider the contribution of this outcome from n=6: (in n, value to be discounted, *Total cost saving (n) = Total cost saving (n-1)+Cost saving (n))*.

n (year)	Value to be discounted	**Discounted cost saving**
6	€119.247	€97.007
7	€238.494	€187.454
8	€357.742	€271.673
9	€476.989	€349.982
10	€596.237	€422.683
NPV		**€1.328.802,6**

Table 9.36: NPV of Reduced familiar caregivers' morbidity for Healthcare system

Input 1: Cost for NESTORE

- Total annual cost for implementing the project (optimistic): €1.028.203.189.

n (year)	**Discounted Cost**
1	€993.433.033
2	€959.838.679
3	€927.380.366
4	€896.019.678
5	€865.719.495
6	€836.443.957
7	€808.158.412
8	€780.829.384
9	€754.424.526
10	€728.912.585
NPV	**€8.551.160.116**

Table 9.37: NPV of Cost for NESTORE for Healthcare system

Familiar caregivers

Outcome 1: Reduced need for full-time familiar caregivers

- Annual wage in Lombardy Region for a full-time job: €32.255;
- Increase in annual income with the virtual coach: (Reduced number of new full-time familiar caregivers * annual wage = Income increase (n)) €5.809.863;
- NPV: (in n, value to be discounted, *Total income increase = Total income increase (n-1)+Income increase (n)*).

n (year)	Value to be discounted	**Discounted cost saving**
1	€5.809.863	€5.613.394
2	€11.619.725	€10.847.138
3	€17.429.588	€15.720.489
4	€23.239.450	€20.251.838
5	€29.049.313	€24.458.742
6	€34.859.175	€28.357.961
7	€40.669.038	€31.965.496
8	€46.478.900	€35.296.614
9	€52.288.763	€38.365.885
10	€58.098.625	€41.187.209
NPV		**€252.064.766**

Table 9.38: NPV of Reduced need for full-time familiar caregivers for Familiar caregivers

Enterprises

Outcome 1: Reduced beneficiaries' work absence due to illness

- Reduction in beneficiaries' annual days of work absence: 173.620 days;
- Annual cost saving with the virtual coach: (Reduction in annual work absence * cost of a day of absence = Cost saving (n)) €13.068.884;
- NPV: (in n, value to be discounted, *Total cost saving (n) = Total cost saving (n-1)+Cost saving (n)*).

n (year)	Value to be discounted	**Discounted cost saving**
1	€13.068.884	€12.626.941
2	€26.137.769	€24.399.887
3	€39.206.653	€35.362.155
4	€52.275.537	€45.555.111
5	€65.344.421	€55.018.249
6	€78.413.306	€63.789.275
7	€91.482.190	€71.904.174
8	€104.551.074	€79.397.294
9	€117.619.959	€86.301.407
10	€130.688.843	€92.647.779
NPV		**€567.002.272**

Table 9.39: NPV of Reduced beneficiaries' work absence due to illness for Enterprises

Outcome 2: Reduced need for full-time professional caregivers

- Annual wage in Lombardy Region for a full-time professional caregiver: €17.940;
- Annual loss with the virtual coach: (reduced number of newly hired professional caregivers * annual wage = Loss in (n)) €570.248;
- NPV: (in n, value to be discounted, *Total loss (n) = Total loss (n-1)+Loss (n)*).

n (year)	Value to be discounted	**Discounted losses**
1	€570.248	€550.964
2	€1.140.496	€1.064.665
3	€1.710.743	€1.542.992
4	€2.280.991	€1.987.752
5	€2.851.239	€2.400.667
6	€3.421.487	€2.783.381
7	€3.991.734	€3.137.467
8	€4.561.982	€3.464.422
9	€5.132.230	€3.765.676
10	€5.702.478	€4.042.594
NPV		**€24.740.580**

Table 9.40: NPV of Reduced need for full-time professional caregivers for Enterprises

It now becomes possible to **display the value for the SROI ratio**[6] .
To compute the result, the reduced need for full-time professional caregivers has been neglected on both sides (beneficiaries and enterprises). In fact, the two outcomes, one as a loss and the other one as a saving, combined with each other, provide a total value equal to 0.
The **obtained SROI** is reported in Table 9.41 and it is **equal to 2,23**.
It is relevant to notice that, **neglecting the effects of attribution, the SROI ratio provides a result equal to 2,34**.

[6]It has to be noticed that the authors defined as base case the case in which risk reduction through prevention is estimated under an optimistic perspective (optimistic risk reduction) and monthly cost for NESTORE lies at its lower boundary (€50/month - optimistic input).

Stakeholder	Outcome		Impact	Input	**SROI**
Healthcare System	Reduced beneficiaries' morbidity	€1.182.345.936	€1.123.228.639		
	Reduced familiar caregivers' morbidity	€1.328.803	€1.262.363		
Beneficiaries	Reduced beneficiary's morbidity	€18.028.695.911	€17.127.261.116		
	Reduced need for full-time professional caregivers	€24.740.580	€23.503.551		
Familiar caregivers	Reduced need for full-time familiar caregivers	€252.064.766	€239.461.527		
Enterprises	Reduced need for full-time professional caregivers	- €24.740.580	- €23.503.551		
	Reduced beneficiaries' work absence due to illness	€567.002.272	€538.652.158		
Total		€20.031.437.687	€19.029.865.803	€8.551.160.116	**2,23**
Attribution		95%			

Table 9.41: SROI evaluation in optimistic scenario: optimistic risk reduction and optimistic cost of NESTORE

9.2.5 Sensitivity analysis

The authors decided to run a **sensitivity analysis considering two different variables: reduction in the risk of morbidity with the virtual coach (optimistic and pessimistic aforementioned scenarios) and monthly cost for NESTORE for the healthcare system (aforementioned optimistic and pessimistic scenarios)**.
The **first variable impacts all the outcomes, except from reduced beneficiary's morbidity estimated through WTP**. The **second variable impacts exclusively the input value**.
Considering the **three possible missing combinations** (optimistic outcome and input have been assumed as the base case), the following results are obtained:

- **Pessimistic outcome and optimistic input** (Table 9.42) reports a **SROI ratio of 2,18**.
  It is relevant to notice that, **neglecting the effects of attribution, the SROI ratio provides a result equal to 2,29**.

- **Optimistic outcome and pessimistic input** (Table 9.43) reports a **SROI ratio of 1,39**.
  It is relevant to notice that, **neglecting the effects of attribution, the SROI ratio provides a result equal to 1,46**.

- **Pessimistic outcome and pessimistic input** (Table 9.44) results in a **SROI ratio of 1,36**.
  It is relevant to notice that, **neglecting the effects of attribution, the SROI ratio provides a result equal to 1,43**.

It emerges that the SROI ratio for NESTORE project, along with a horizon of 10 years, varies between 1,36 and 2,23.

Stakeholder	Outcome		Impact	Input	**SROI**
Healthcare System	Reduced beneficiaries' morbidity	€981.037.354	€931.985.486		
	Reduced familiar caregivers' morbidity	€767.020	€728.669		
Beneficiaries	Reduced beneficiary's morbidity	€18.028.695.911	€17.127.261.116		
	Reduced need for full-time professional caregivers	€14.280.918	€13.566.872		
Familiar caregivers	Reduced need for full-time familiar caregivers	€145.498.465	€138.223.542		
Enterprises	Reduced need for full-time professional caregivers	- €14.280.918	- €13.566.872		
	Reduced beneficiaries' work absence due to illness	€463.848.571	€440.656.142		
Total		€19.619.847.321	€18.638.854.955	€8.551.160.116	**2,18**
Attribution			95%		

Table 9.42: SROI evaluation in pessimistic risk reduction and optimistic cost of NESTORE

Stakeholder	Outcome		Impact	Input	**SROI**
Healthcare System	Reduced beneficiaries' morbidity	€1.182.345.936	€1.123.228.639		
	Reduced familiar caregivers' morbidity	€1.328.803	€1.262.363		
Beneficiaries	Reduced beneficiary's morbidity	€18.028.695.911	€17.127.261.116		
	Reduced need for full-time professional caregivers	€24.740.580	€23.503.551		
Familiar caregivers	Reduced need for full-time familiar caregivers	€252.064.766	€239.461.527		
Enterprises	Reduced need for full-time professional caregivers	- €24.740.580	- €23.503.551		
	Reduced beneficiaries' work absence due to illness	€567.002.272	€538.652.158		
Total		€20.031.437.687	€19.029.865.803	€13.681.856.186	**1,39**
Attribution	95%				

Table 9.43: SROI evaluation in optimistic risk reduction and pessimistic cost of NESTORE

Stakeholder	Outcome		Impact	Input	**SROI**
Healthcare System	Reduced beneficiaries' morbidity	€981.037.354	€931.985.486		
	Reduced familiar caregivers' morbidity	€767.020	€728.669		
Beneficiaries	Reduced beneficiary's morbidity	€18.028.695.911	€17.127.261.116		
	Reduced need for full-time professional caregivers	€14.280.918	€13.566.872		
Familiar caregivers	Reduced need for full-time familiar caregivers	€145.498.465	€138.223.542		
Enterprises	Reduced need for full-time professional caregivers	- €14.280.918	- €13.566.872		
	Reduced beneficiaries' work absence due to illness	€463.848.571	€440.656.142		
Total		€19.619.847.321	€18.638.854.955	€13.681.856.186	**1,36**
Attribution			95%		

Table 9.44: SROI evaluation in pessimistic scenario: pessimistic risk reduction and pessimistic cost of NESTORE

9.2.6 Payback period

At last, it comes to the **definition of the payback period**[7].
The authors decided to **evaluate the year n = N, at which SROI ratio becomes higher than 1 by considering the time value of money**.
The result suggests the minimum time frame during which NESTORE should last in order to be value-for-money. This means that, if NESTORE technology is at risk of becoming obsolete before the threshold N, the entire project should not be invested in.

[7]The payback period is the time required to earn back the amount invested in an asset from its net cash flows. It is a simple way to evaluate the risk associated with a proposed project. An investment with a shorter payback period is considered to be better, since the investor's initial outlay is at risk for a shorter period of time. The calculation used to derive the payback period is called the payback method. The payback period is expressed in years and fractions of years.

	Year (n)	1	2	3	4	5
Healthcare system	Reduced beneficiaries' morbidity	€27.230.769	€50.840.428	€73.681.780	€94.920.167	€114.637.883
	Reduced familiar caregivers' morbidity					
Beneficiaries	Reduced beneficiary's morbidity	€2.094.487.978	€2.023.659.882	€1.955.226.939	€1.889.108.154	€1.825.225.269
	Reduced need for full-time professional caregivers	€550.964	€1.064.665	€1.542.992	€1.987.752	€2.400.667
Familiar caregivers	Reduced need for full-time familiar caregivers	€5.613.394	€10.847.138	€15.720.489	€20.251.838	€24.458.742
Enterprises	Reduced need for full-time professional caregivers	- €550.964	- €1.064.665	- €1.542.992	- €1.987.752	- €2.400.667
	Reduced beneficiaries' work absence due to illness	€10.329.745	€19.960.859	€28.928.782	€37.267.351	€45.008.879
	Impact	€2.030.778.791	€2.000.042.892	€1.969.880.091	€1.939.470.135	€1.908.864.234
Input	Cost of NESTORE	€993.433.033	€959.838.679	€927.380.366	€896.019.678	€865.719.495

Table 9.45: SROI ratio in each year - Part 1

	Year (n)	6	7	8	9	10
Healthcare system	Reduced beneficiaries' morbidity	€132.913.488	€149.821.967	€165.434.884	€179.820.526	€193.044.043
	Reduced familiar caregivers' morbidity	€97.008	€187.455	€271.674	€349.982	€422.684
Beneficiaries	Reduced beneficiary's morbidity	€1.763.502.676	€1.703.867.320	€1.646.248.618	€1.590.578.375	€1.536.790.700
	Reduced need for full-time professional caregivers	€2.783.381	€3.137.467	€3.464.422	€3.765.676	€4.042.594
Familiar caregivers	Reduced need for full-time familiar caregivers	€28.357.961	€31.965.496	€35.296.614	€38.365.885	€41.187.209
Enterprises	Reduced need for full-time professional caregivers	- €2.783.381	- €3.137.467	- €3.464.422	- €3.765.676	- €4.042.594
	Reduced beneficiaries' work absence due to illness	€52.184.207	€58.822.778	€64.952.688	€70.600.747	€75.792.536
	Impact	€1.878.202.573	€1.847.431.764	€1.816.594.253	€1.785.729.740	€1.754.875.313
Input	Cost of NESTORE	€836.443.957	€808.158.412	€780.829.384	€754.424.526	€728.912.585

Table 9.46: SROI ratio in each year - Part 2

Year (n)	1	2	3	4	5	6	7	8	9	10
SROI ratio	2,05	2,07	2,09	2,11	2,13	2,15	2,17	2,19	2,21	2,23

Table 9.47: SROI ratio in each year - Part 3

It results that **SROI ratio is higher than 1 from year 1**. This is due to the fact that the **healthcare system does not bear any initial investment but pays a monthly fee** to the providers of software, hardware and services it needs.

9.2.7 Discussion of results

Scenario analysis

A first relevant conclusion emerging from the analysis (Table 9.48) is given by the fact that the **SROI ratio assumes a final value higher than 1 in all the four designed scenarios** (combination of optimistic or pessimistic outcomes and input).

SROI (pessimistic outcome – pessimistic input)	Growth (%)	**SROI** (optimistic outcome - pessimistic input)	Growth (%)	**SROI** (pessimistic outcome – optimistic input)	Growth (%)	**SROI** (optimistic outcome – optimistic input)
1,36	2%	**1,39**	57%	**2,18**	2%	**2,23**

Table 9.48: SROI range

In detail, **SROI value oscillates between a minimum of 1,36 and a maximum of 2,23 (base case), with a percentage variation of 64%**. SROI ratio oscillation depends on the uncertainty range for the input, rather than that for the impact. In fact, the input varies between a monthly cost of €50,00 and €80,00 (60% growth), producing an NPV that spans between €8.551.160.116 and €13.681.856.186 (60% growth). Looking at the NPV of impact, it spans between a tighter range: €18.638.854.955 and €19.029.865.803 (2% growth).
The **project results to be value-for-money in any circumstance**. Even though monthly fee for the service or effect of a prevention path evolve in the worst possible direction configured by NESTORE Consortium, the final judgement regarding the entire project implementation does not mutate.
This element represents the strongest argument that the Consortium itself could employ to encourage the healthcare system towards the investment.

Time horizon analysis

Looking at the payback period, it emerges that **NESTORE project is value-for-money since year 1**.
This is a consequence of the fact that none of the stakeholders involved has to bear an initial investment for the implementation of the project. The healthcare system itself, that plays the role of payer and distributor, does not have to invest into any tangible or intangible asset for NESTORE. It simply proceeds adopting an outsourcing logic, acquiring from external providers, under a monthly cost, the resources that the entire project requires: hardware, software, technical assistance, courses for GPs. Also prescription fees for GPs happen under a monthly logic. This result suggests the need, for the Consortium, to clearly identify the outsourcers that the healthcare system should recur to and to promote the definition of favorable contracts with them, allowing to fall into the optimistic input scenario.

Dealing specifically with numbers, it emerges that the **SROI ratio increases as the adopted time horizon increases** (Table 9.49).

Year (n)	Impact (discounted value in n)	Input (discounted value in n)	NPV of impact (n assumed as time horizon)	NPV of input (n assumed as time horizon)	**SROI**
1	€2.030.778.791	€993.433.033	€2.030.778.791	€993.433.033	**2,05**
2	€2.000.042.892	€959.838.679	€4.030.821.683	€1.953.271.712	**2,07**
3	€1.969.880.091	€927.380.366	€6.000.701.774	€2.880.652.078	**2,09**
4	€1.939.470.135	€896.019.678	€7.940.171.909	€3.776.671.756	**2,11**
5	€1.908.864.234	€865.719.495	€9.849.036.143	€4.642.391.251	**2,13**
6	€1.878.202.573	€836.443.957	€11.727.238.716	€5.478.835.208	**2,15**
7	€1.847.431.764	€808.158.412	€13.574.670.480	€6.286.993.620	**2,17**
8	€1.816.594.253	€780.829.384	€15.391.264.733	€7.067.823.004	**2,19**
9	€1.785.729.740	€754.424.526	€17.176.994.473	€7.822.247.530	**2,21**
10	€1.754.875.313	€728.912.585	€18.931.869.786	€8.551.160.115	**2,23**

Table 9.49: SROI ratio along time horizon

This is due to the fact that, modifying the time horizon, the SROI numerator grows faster than its denominator.
In fact, the input value remains constant over time: the sum of the discounted inputs that occur over time to get the NPV differs from a simple multiplication between annual input and number of years (n) only due to the time value of money. Instead, the sum of discounted impacts (NPV of impacts) sees a steeper growth: it benefits of the fact that all discounted impacts, except from beneficiary's reduced morbidity measured through Willingness To Pay, increase over time. This derives from the fact that the effects of prevention are spread and increase over the selected time horizon: as time passes by, the number of beneficiaries who avoid contracting a disease increases, and, as a consequence, related savings grow. These two effects, when combined, ensure a rapid growth for the numerator of the SROI ratio (NPV of impacts) rather than for its denominator (NPV of inputs). The result is shown in Figure 9.1.

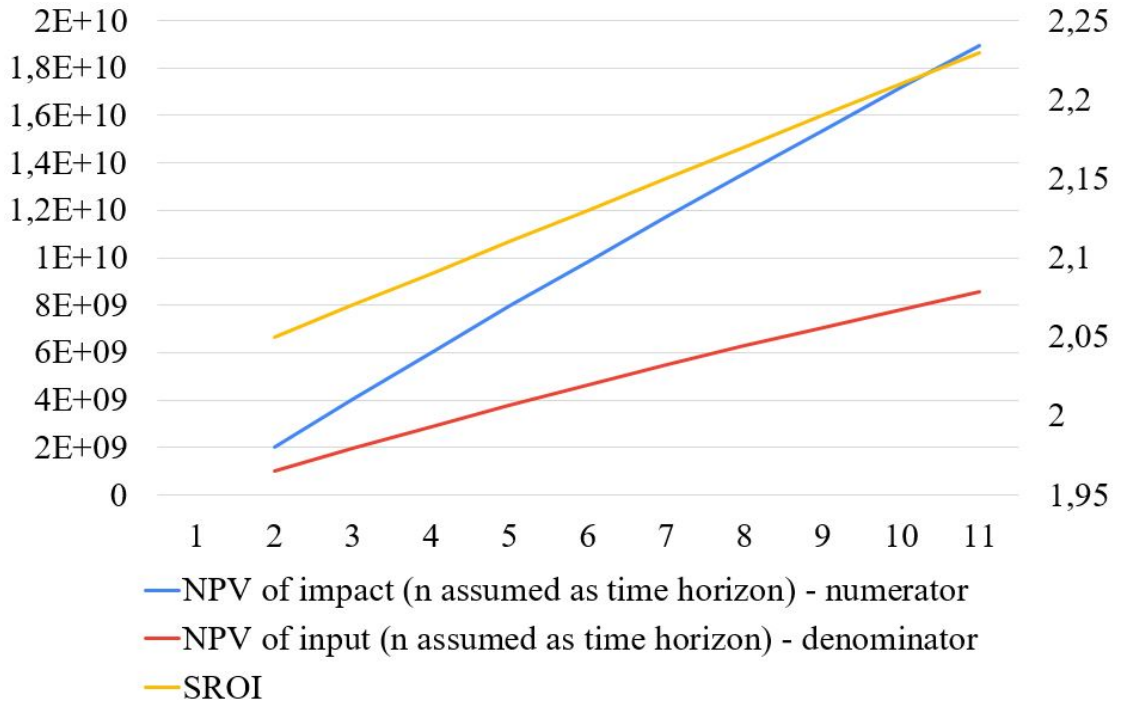

Figure 9.1: NPV and SROI trend over the time horizon

The graph allows to appreciate the **steeper growth of the numerator respect to the denominator**.

Impact per stakeholder and impact item

The authors investigated how different stakeholders contribute to the total impact when selecting a time horizon of 10 years and a cost of capital equal to 3,5%. The investigation of the contribution of each actor to the input is not of interest, given that the healthcare system represents the only one payer in the project.

Firstly, it has been estimated the **impact value for each stakeholder** (Table 9.50 and Figure 9.2).

Stakeholder	**Impact**
Healthcare System	€1.124.491.001
Beneficiaries	€17.150.764.666
Familiar caregivers	€239.461.527
Enterprises	€542.261.692

Table 9.50: Impact per stakeholder

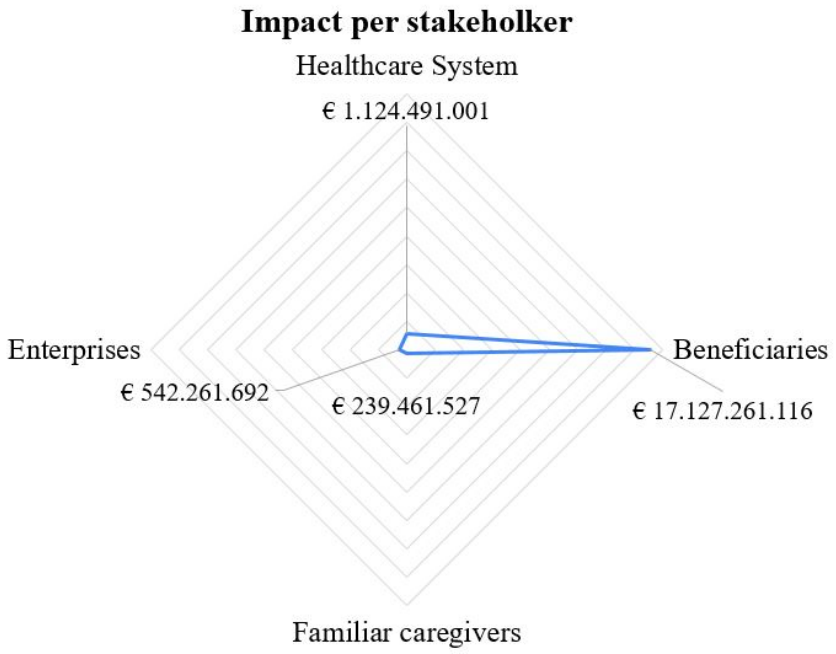

Figure 9.2: Impact value per stakeholder

Secondly, it has been computed their percentage contribution (Figure 9.3).

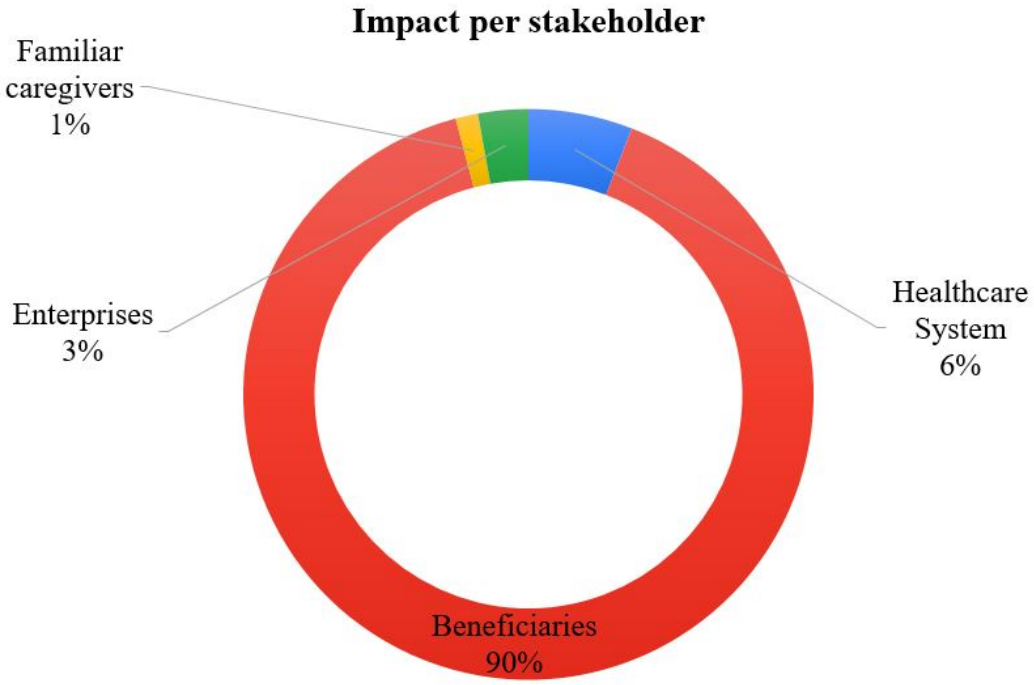

Figure 9.3: Contribution to total impact per stakeholder (%)

It clearly emerges that **beneficiaries are the actors that benefit the most from the implementation of the project**.

In detail, exploring the contribution of each specific impact item (Figure 9.4) and excluding the reduced need for full-time professional caregivers, it results that

beneficiaries' Willingness To Pay plays the major role.

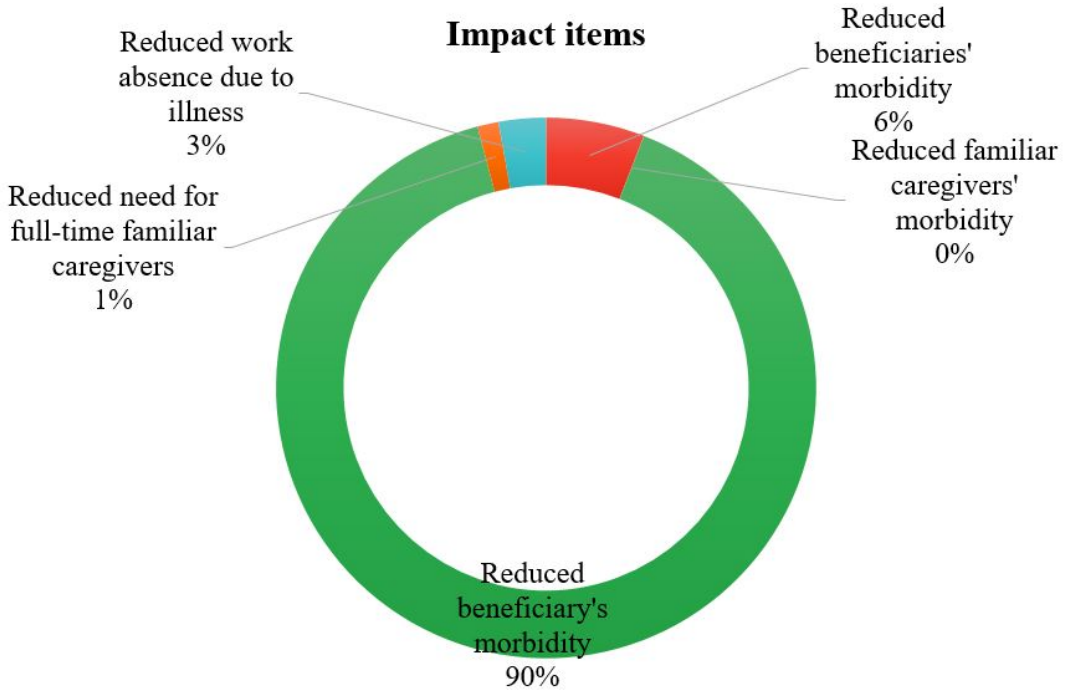

Figure 9.4: Contribution to total impact per impact item (%)

Having estimated WTP in terms of annual cost for a gym and a nutritionist, it derives that for NESTORE it is of paramount importance to provide a concrete support able to replace these two actors. Otherwise, most of the value of the project would be completely lost. NESTORE has to play the role of the most trustable actor available on the market for promoting both, physical activity and nutrition. It is not enough that it overcomes traditional hi-tech aids for a healthy lifestyle, proposing itself as a medical device, granting a continuous touch point with GPs, it has to become the cutting-edge revolution in professional care.

This result outlines the contribution that an SROI analysis can bring to the evaluation of a project.
In fact, a **traditional CBA from the point of view of the healthcare system, as shown in the literature, would have neglected the role of beneficiaries**, involving merely the payer for the project. In particular, CBA for NESTORE (from the payer perspective), assuming a time horizon of 10 years and a cost of capital equal to 3,5%, produces the following result (Table 9.51):

Benefit	€1.124.491.001
Cost	€8.551.160.116
CBA ratio	**0,13**

Table 9.51: CBA ratio

According to the CBA, the project is not value-for-money.

Impact per disease

Coming to the contribution that the preventive action against each disease provides to total impact, no relevant difference emerges.

Stakeholder	Impact	**Hypertension**	**Type 2 diabetes mallitus**	**Osteoporosis**
Healthcare system	Reduced beneficiaries' morbidity	€221.244.600	€286.579.367	€443.850.973
	Reduced familiar caregivers' morbidity	-	-	-
Beneficiaries	Reduced beneficiary's morbidity	€2.854.543.519	€2.854.543.519	€2.854.543.519
	Reduced need for full-time professional caregivers	-	-	-
Familiar caregivers	Reduced need for full-time familiar caregivers	-	-	-
Enterprises	Reduced need for full-time professional caregivers	- €144.128.483	- €83.574.583	- €286.558.079
	Reduced beneficiaries' work absence due to illness	-	-	-
Total impact		€3.219.916.603	€3.224.697.469	€3.584.952.571

Table 9.52: Impact of Hypertension, Type 2 diabetes mallitus and Osteoporosis

Stakeholder	Impact	**Heart failure**	**Stroke**	**Alzheimer**
Healthcare system	Reduced beneficiaries' morbidity	€8.369.566	€10.314.309	€152.869.823
	Reduced familiar caregivers' morbidity	-	€1.262.363	-
Beneficiaries	Reduced beneficiary's morbidity	€2.854.543.519	€2.854.543.519	€2.854.543.519
	Reduced need for full-time professional caregivers	-	- €23.503.551	-

Familiar caregivers	Reduced need for full-time familiar caregivers	-	€239.461.527	-
Enterprises	Reduced need for full-time professional caregivers	- €1.811.187	- €7.213.522	- €15.366.304
	Reduced beneficiaries' work absence due to illness	-	€23.503.551	-
Total impact		€2.864.724.273	€3.112.795.241	€3.022.779.646

Table 9.53: Impact of Heart failure, Stroke and Alzheimer

Four out of seven impacts are due only to stroke; while three out of seven impacts are due to all the considered diseases. In the first case, the allocation of the impact value to each disease was absolutely straightforward.
Looking at impacts influenced by more diseases:

- Reduced beneficiaries' morbidity (outcome 1 for the healthcare system): to define the contribution of each disease to total impact, the authors employed as allocation basis the annual cost for the healthcare system (Table 9.54).

Disease	Annual cost for the healthcare system	Contribution to the total annual cost for the healthcare system
Hypertension	€5.363.699	20%
Type 2 diabetes mellitus	€6.947.630	26%
Osteoporosis	€10.760.412	40%
Heart failure	€202.906	1%
Stroke	€250.053	1%
Alzheimer	€3.706.069	14%
Total	€27.230.769	100%

Table 9.54: Impact of each disease on the total annual cost for the healthcare system

- Reduced beneficiary's morbidity (outcome 1 for beneficiaries) has been uniformly distributed among diseases.
- Reduced beneficiaries' work absence due to illness has been distributed using as allocation basis the annual days of work absence (Table 9.55).

Disease	Annual cost for days of absence	Contribution to total annual days of absence
Hypertension	€99.884	27%
Type 2 diabetes mellitus	€57.919	16%
Osteoporosis	€198.590	53%
Heart failure	€1.255	0%
Stroke	€4.999	1%
Alzheimer	€10.649	3%
Total	€373.296	100%

Table 9.55: Impact of each disease on the annual cost for days of absence due to illness

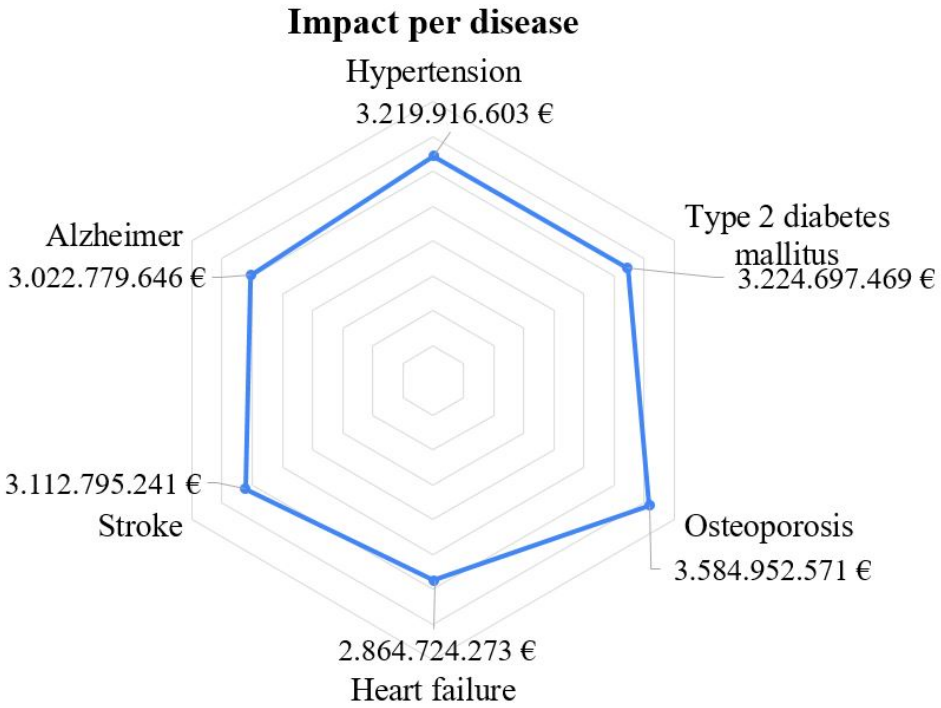

Figure 9.5: Impact value per disease

The **contribution of each disease to total impact depends on its related morbidity in the Lombardy Region, its annual cost for the Lombardy Region and the annual days of work absence due to illness it provokes**. In addition, **stroke is the only disease contributing to those impacts involving the need for a full-time caregiver**.

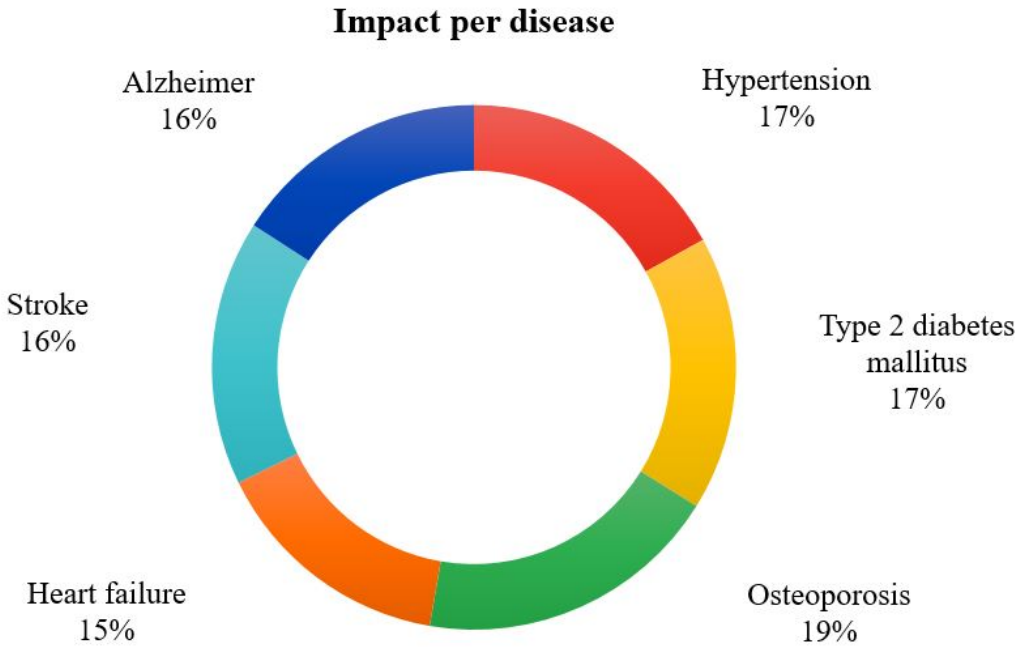

Figure 9.6: Contribution to total impact per disease (%)

It is evident that the **involved diseases play a uniform role in the total impact**. The authors expected that the heaviest contribution came from stroke, given its peculiarity in terms of required full-time assistance. Anyway, its costs, combined with its morbidity in the Lombardy Region, deaden its implications respect to hypertension, type 2 diabetes mellitus, osteoporosis, heart failure, and Alzheimer's.

Impact per age group Uniformity in the contribution to total impact emerges also when analysing different age ranges.

Stakeholder	Impact	40 - 64 (% contribution)	65 - 79 (% contribution)	40 - 64 impact	65 - 79 impact	**Total**
Healthcare system	Reduced beneficiaries' morbidity	49%	51%	€550.382.033	€572.846.606	€1.123.228.639
	Reduced familiar caregivers' morbidity	47%	53%	€593.310	€669.052	€1.262.363
Beneficiaries	Reduced beneficiary's morbidity	49%	51%	€8.392.357.947	€8.734.903.169	€17.127.261.116
	Reduced need for full-time professional caregivers	47%	53%	€11.046.669	€12.456.882	€23.503.551
Familiar caregivers	Reduced need for full-time familiar caregivers	47%	53%	€112.546.918	€126.914.610	€239.461.527
Enterprises	Reduced beneficiaries' work absence due to illness	100%	0%	€538.652.158	-	€538.652.158
	Reduced beneficiaries' work absence due to illness	47%	53%	€11.046.669	€12.456.882	€23.503.551
Impact				€9.616.625.704 9	€9.460.247.200	€19.076.872.90

Table 9.56: Impact per age group

Percentage contribution for each age range has been estimated by comparing morbidity of chronic diseases in Lombardy Region in the two age ranges: *Percentage contribution = number of people affected by chronic diseases in the Lombardy region in a specific age range / number of people affected by chronic diseases in the Lombardy region in both age ranges*

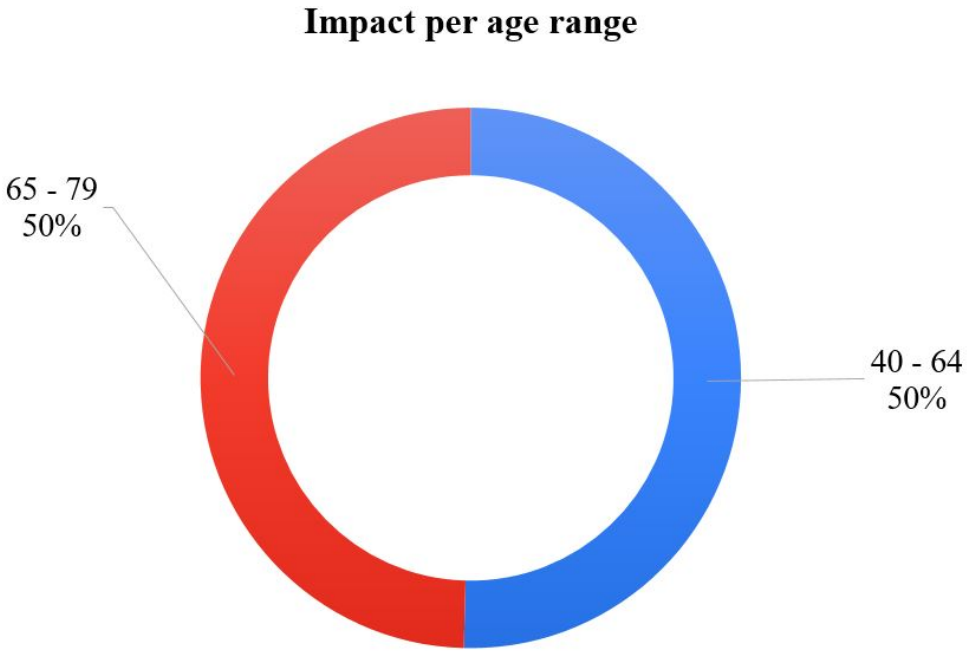

Figure 9.7: Contribution to total impact per age range (%)

The **uniform distribution can be explained in the light of the fact that, although chronic morbidity is higher for +65, their absolute number is lower than that of 40 – 64**.

This result reinforces the hypothesis of the authors according to which distributing NESTORE among 40+ could enhance its value. Anyway, the authors decided to verify the hypothesis by computing the SROI under the assumption of involving only 65 – 79. The contribution given to the input by 65 – 79 has been computed considering that they are the 28% of beneficiaries involved in the project (they account for 28% of the input).

65 - 79 impact	€9.616.625.704
65 - 79 input	€2.394.324.832
SROI ratio	**4,01**

Table 9.57: SROI under the hypothesis of involving only 65-79 years old beneficiaries

It results a higher value for the SROI ratio.
Making the service available for 40 – 64 provokes a steeper increase of costs rather than of impacts. Anyway, this computation does not consider the fact that part of the €9.616.625.704 achieved by 65+ are due to the promotion of a health path

in their 40s. For sure, excluding 40 – 64 from the program, this value should be corrected and lowered.
As a consequence, the authors decided not to employ this value to reinforce the idea of targeting only the eldest age range and encourage future researches to explore further implications.

Impact per gender Although no debate is ongoing regarding the possibility of distributing NESTORE only among males or females, the authors found it interesting to explore the contribution that different genders, characterized by different morbidities and numerosity, provide to the impact.

Stakeholder	Impact	Males (% contribution)	Females (% contribution)	Males impact	Females impact	**Total**
Healthcare system	Reduced beneficiaries' morbidity	41%	59%	€460.523.742	€662.704.897	€1.123.228.639
	Reduced familiar caregivers' morbidity	56%	44%	€706.923	€555.440	€1.262.363
Beneficiaries	Reduced beneficiary's morbidity	41%	59%	€7.022.177.057	€10.105.084.058	€17.127.261.116
	Reduced need for full-time professional caregivers	56%	44%	€13.161.988	€10.341.562	€23.503.551
Familiar caregivers	Reduced need for full-time familiar caregivers	56%	44%	€134.098.455	€105.363.072	€239.461.527
Enterprises	Reduced beneficiaries' work absence due to illness	41%	59%	€220.847.385	€317.804.773	€538.652.158
	Reduced beneficiaries' work absence due to illness	56%	44%	€13.161.988	€10.341.562	€23.503.551
Impact				€7.864.677.539 9	€11.212.195.365	€19.076.872.90

Table 9.58: Impact per gender

Percentage contribution for males and females has been computed considering the differences between the two in terms of morbidity of chronic diseases in the Lombardy Region.

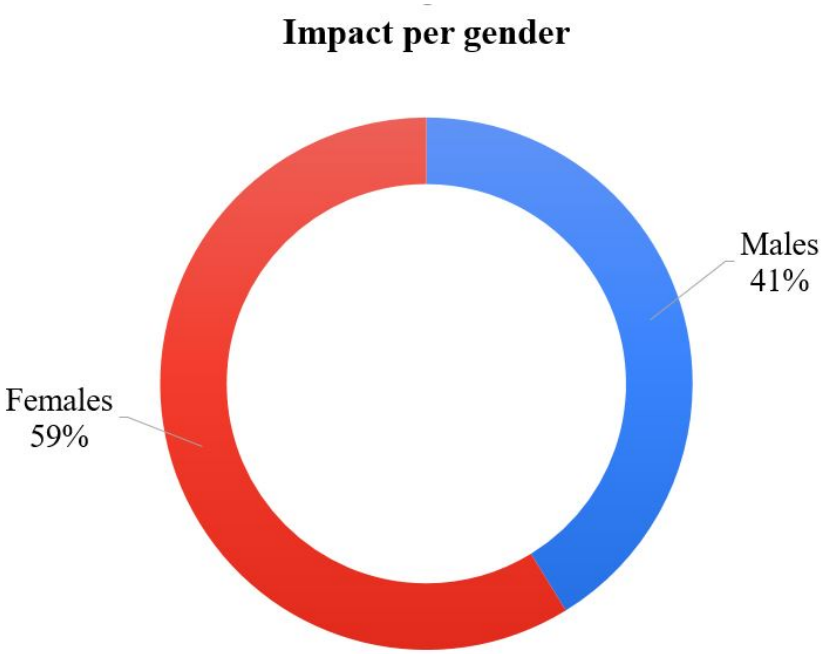

Figure 9.8: Contribution to total impact per gender (%)

It emerges that **females contribute the most to the result**. This result could be employed by NESTORE Consortium in order to provide guidelines to the healthcare system on the type of patients towards whom GPs should try to be more effective. Anyway, percentages do not justify any decision aimed at excluding males from the project.
In fact, even though numbers could prove an increase in the SROI, variables such as word of mouth, mutual influence and stimulation between members of a couple, trust in male GPs, could be negatively impacted by cutting off part of the target.

9.3 Validation

The authors' analysis has been presented to NESTORE Consortium and international reviewers during the "NESTORE review meeting", held on the 12th of November 2019. The actors present at the review meeting were all the members of the NESTORE Consortium:

- POLIMI (Design);
- CNR;
- FLEX;
- EURECAT;

- HES-SO;
- ROPARDO;
- FSIE;
- POLIMI DIG;
- POLIMI E UB.

and three external independent experts (Bulgaria, Italy and UK) and one project officer.

In particular, they have been presented with the range within which SROI ratio for NESTORE oscillates (as a consequence of having identified four different scenarios) and with a clear visualization of data regarding how different stakeholders contribute to the final ratio.
The purpose of the presentation was to **share with the NESTORE Consortium and the external independent experts the motivations that lay behind the willingness to estimate the SROI value for NESTORE and the methodology adopted to reach this objective**.
The reviewers have appreciated the decision to conduct an SROI analysis, since it has been recognized the relevance of considering the social impact of the outcomes resulting from project like NESTORE. Moreover, they considered of value the possibility to establish which is the impact (both in economic and social terms) for each stakeholder. As a matter of fact, having noticed that beneficiaries are those actors who benefit the most from the project, the reviewers have obtained relevant insights on the most suitable scenario for the exploitation strategy of NESTORE. In particular, some of the reviewers, relying on the awareness that beneficiaries are the most benefited actors, have suggested to turn NESOTRE into an out-of-pocket solution: it is not the healthcare system that has to pay to provide senior adults with NESTORE; they are the citizens who have to pay for a solution enabling such a relevant improvement of their health conditions.
On the other hand, other reviewers have interpreted the SROI result as a reinforcement of the need to have NESTORE as a freemium solution distributed by institutions (i.e. the healthcare system): in fact, a State that wishes to invest in its own country, should, first of all, improve the health conditions of its citizens. Politecnico di Milano, acting as project supervisor and coordinator, stands with this last faction, affirming that the success of the solution among senior adults depends exactly on its nature of medical device provided, free of charge, by the healthcare system. Therefore, the exploitation strategy suggested as hypothesis for the prospective development of the SROI model should remain the starting point for the implementation of the project.

Part IV

Conclusions and limitations

Chapter 10

Discussion and implications

10.1 Introduction

This study, for the methodological procedure adopted and for the results obtained, represents a significant contribution to both theory and practice.

In terms of theory, it offers original results to the existing literature on impact assessment through the SROI method on two different levels. On one level, **it contributes to the literature as an in-depth systematic analysis on the topics of SROI and CBA in healthcare**. On a second level, **given the lack of evidence on the adoption of the SROI method for assessing technologies, it represents a first attempt to adopt the SROI model for evaluating technologies in healthcare**.
Moreover, the study contributes to the **literature on virtual coaches for healthy ageing**, offering an **economic evaluation of these solutions for prevention**. Starting from the awareness of the technicalities and potentialities of a virtual coaching system, it explores the economic implications deriving from its adoption in the healthy ageing field.

In terms of practice, certain relevant managerial and policy implications are deducted.
In particular, **SROI analysis results in being a strategic tool to support promoters of a given initiative** (e.g. NESTORE Consortium) **in** (Social Value, UK, 2012):

- Ensuring that the initiative they are promoting is managing the most economic and social implications and risks;
- Managing unexpected outcomes, both positive and negative;
- Demonstrating to public services financing the initiative (e.g. the Lombardy Region healthcare system) that the solution is securing social value;
- Facilitating strategic discussions, creating a formal dialogue with stakeholders;
- Identifying common ground between what they want to achieve and what their stakeholders want to achieve.

10.2 Theoretical contribution

The research objective declared at the beginning of the current study was to define whether there is room for the application of the SROI method when evaluating technologies in the healthcare field, especially those promoting healthy ageing.
To meet this objective, an in-depth review of both, CBA (assessment method traditionally employed in healthcare) and SROI in healthcare, has been conducted.

Traditionally, cost-benefit analysis (CBA) is employed to assess the value-for-money of initiatives in healthcare (National Institute for Clinical Excellence, 2004). CBA has historically been under discussion. Critiques can be reduced to two major issues: firstly, CBA merely lists benefits that cannot be easily monetized; secondly, it evaluates costs and benefits from a unique perspective, neglecting comprehensive contributions from the complex network of actors that initiatives in healthcare typically involve (Ackerman (2008), Frank (2000), Sen (2000) and Self et al. (2015)).
The systematic exploration of the CBA literature confirms the fact that the majority of the authors, in the wake of tradition, limit themselves to adopting a single perspective of analysis. In detail, solely 4 out of 17 authors (Jeuland and Whittington (2009), Samson et al. (2018), Roudsari et al. (2016) and O'Reilly et al. (2011)) adopt multiple points of view when balancing costs and benefits.
Also the resistance to monetize (or even to list) the most complex benefits finds validity in the authors' search. Excluding benefits represented by cost savings, experts are resistant to proceed towards monetization of potential outcomes of a strategy, favoring, in case, Willingness to Pay or Human Capital method. As a matter of fact, 5 authors out of 17 do not even mention benefits in their analysis (Samson et al. (2018), Roudsari et al. (2016), O'Reilly et al. (2011), D. Greenberg et al. (2005) and Natafgi et al. (2018)). Dealing with the remaining 12 articles, experts claiming to adopt a certain perspective for the analysis, in reality, often overcome the limits of the single adopted perspective and involve benefits for different actors.

In recent times, the social return on investment (SROI) method has been promoted as a more holistic approach for demonstrating value-for-money of healthcare initiatives. According to Zappala and Lyons (2009), SROI, still being based on a rational choice logic and fundamentally being linked to the concept of CBA (Rotheroe and Richards, 2007), allows to overcome the CBA-related limit of unique perspective adoption (Ackerman, 2008). In fact, SROI refuses the adoption of a single perspective to conduct the evaluation. It consists in the drafting of a list of all the possible stakeholders directly or indirectly involved by the initiative, thus allowing to perform a broader evaluation, without getting stuck in the single-perspective-approach (Banke-Thomas et al., 2015).
The systematic exploration of the SROI literature confirms how this method enables the involvement of the point of view of multiple stakeholders. Retrieved papers can be categorized into three groups, corresponding to the level of involvement of stakeholders. Some papers (2 out of 10 articles, Akingbola et al. (2015) and Ricciuti and Bufali (2019)) include in the analysis

only beneficiaries, while other papers (5 out of 10 articles, Muyambi et al. (2017), Goudet et al. (2018), Banke-Thomas et al. (2015), Bosco et al. (2019) and Arvidson and McKay (2013)) consider also the role of promoters and implementers; in the end, other papers (3 out of 10 articles, Ramon et al. (2018), Bellucci et al. (2019) and Tanaree et al. (2019)) take into account a broader plethora of stakeholders that can be directly or indirectly touched by the health initiative.
As for the inclusion of social outcomes of a given project, authors dealing simply with beneficiaries mainly cite increased Quality of Life and average cost of a visit. Authors involving also promoters and implementers add donors' satisfaction. Broader analyses cite savings for the healthcare system and the State, staff satisfaction, lower criminality and increased productivity. As a matter of fact, **evidence from literature proves that SROI analysis includes social benefits (e.g. lower criminality and savings for the State) that a traditional CBA would have completely neglected**.
Focusing on monetization, 9 authors out of 10 (excluded Banke-Thomas et al. (2015)) **proceed towards a conversion of outcomes into monetary terms**. In particular, it emerges a predominant use of financial proxies, along with Cost Savings, Human Capital and Willingness to Pay. **This result confirms Banke-Thomas et al. (2015) praise to the SROI: the percentage of authors involving and monetizing outcomes increases respect to the CBA, as the identification of proper financial proxies enables a streamlined monetization**.
It is relevant to observe that no evidence emerges from the literature in terms of negative outcomes. **In contrast to expectations, no author cites negative outcomes in the analysis**.
Even the SROI has been criticized. Actually, **it results tough, in the assessment, to establish the counterfactual (what would have happened without the intervention)** (Brady, 2011). **This critique of the SROI is confirmed by the evidence**: only 4 authors out of 10 (Bellucci et al. (2019), Tanaree et al. (2019), Goudet et al. (2018) and Bosco et al. (2019)) involve deadweight, drop-off, attribution, and displacement. In addition, none of them provides satisfactory justification for the selected values.

As a literature gap, it emerged that **SROI analysis is new to the evaluation of technologies in healthcare**: none of the identified articles refers to the evaluation of a technology, but they all concern a health process or intervention.
Starting from the awareness of this gap, the authors aimed at developing and validating a model for performing an SROI analysis when evaluating technologies in healthcare. In detail, stated the urgent social and economic implications deriving from population ageing (World Health Organization, 2017), the authors decided to focus on technologies fostering healthy ageing. In sum, **this thesis represents a first attempt, in literature, to employ the SROI method for assessing technologies in healthcare**.
Traditionally, SROI studies are performed within the non-profit sector and there has not been a significant application of the methodology amongst academia(Husereau et al., 2013). However, considering the field of application selected by the authors, that of healthy ageing, they clearly emerge the social and humanitarian implications

of an initiative willing to work in that direction. The social impact of healthy ageing has been declared by WHO (2015). Moreover, as stated by Dyakova et al. (2017), SROI can be relevant in the context of advocacy for investments for health and sustainable development. As a consequence, **it has been confirmed the eligibility of the SROI methodology when dealing with technologies for healthy ageing**: healthy ageing is, by definition, a social issue; therefore, SROI, with its purpose of capturing social facets of projects, represents a valuable candidate to assess its consequences.

When developing the model, following the guideline of Social Value, UK (2012), seven sub-objectives have been formulated:

1. The definition of the stakeholders who revolve around the figure of the senior and sick adults and that, as consequence, could be both positively and negatively affected by the launch of initiatives promoting a healthy ageing path;
2. The definition of the inputs necessary to promote an initiative for healthy ageing;
3. The identification of the outcomes resulting from an initiative for healthy ageing and the investigation of the consequent impacts for each of the addressed stakeholders;
4. The definition of relevant indicators that allow the measurement of the detected outcomes;
5. The definition of monetizing criteria to convert the highlighted outcomes into monetary terms;
6. The definition of the most suitable time horizon to capture all the relevant impacts of the healthy ageing promoting initiative with a certain degree of confidence;
7. The definition of a proper discount rate to actualize impacts that would be generated on a long-term horizon.

Following Crowe et al. (2011) suggestion to adopt an **inductive approach**, authors focused on **NESTORE case study**. This allowed to provide an answer to each sub-question:

1. When performing an SROI analysis of a virtual coach for healthy ageing (conceived as a medical device distributed by the healthcare system itself), aiming at the highest exhaustiveness, it is necessary to **involve as stakeholders beneficiaries (the target for the device), the healthcare system (including GPs), familiar caregivers, broader Regional/National (depending on the magnitude of the project) economic system**:
    - Beneficiaries: they are the target for the virtual coach;

- Healthcare system: it economically benefits from the reduction in beneficiaries' morbidity;
- Familiar caregivers: they are the relatives of the beneficiaries that cover the role of caregivers in case of beneficiaries' morbidity. Reduced beneficiaries' morbidity encourages their reintegration into the labor market;
- Broader Regional/National economic system: conceived as professional caregivers and enterprises in which both beneficiaries and their familiar caregivers are employed.

A more detailed analysis can consider including pharmaceutical and biomedical companies, NPOs and NGOs, municipalities, family and friends, influencers.

2. When performing an SROI analysis of a virtual coach for healthy ageing (conceived as a medical device distributed by the healthcare system itself), there is one **major input to consider: the cost for the healthcare system itself**. It acts as payer, promoter and distributor of the project, bearing its entire costs.

3. When performing an SROI analysis of a virtual coach for healthy ageing (conceived as a medical device distributed by the healthcare system itself), all the **outcomes to involve are strictly related to beneficiaries' reduced morbidity achieved through prevention**.
   More in detail, the following outcomes have to be involved:

   - Beneficiaries:
     1) Reduced beneficiary's morbidity (risk of contracting the disease);
     2) Reduced need for full-time professional caregivers.
   - Healthcare system:
     1) Reduced beneficiaries' morbidity (rate of illness);
     2) Reduced familiar caregivers' morbidity.
   - Familiar caregivers:
     1) Reduced need for full-time familiar caregivers.
   - Economic system:
     1) Reduced beneficiaries' work absence due to illness;
     2) Reduced need for full-time professional caregivers.

4. When performing an SROI analysis of a virtual coach for healthy ageing (conceived as a medical device distributed by the healthcare system itself), the **indicators identified as suitable for expressing the outcomes** are the following:

   - Beneficiaries:
     1) Reduced beneficiary's morbidity (risk of contracting the disease): Percentage reduction in beneficiary's morbidity;
     2) Reduced need for full-time professional caregivers: Reduction in the number of employed full-time professional caregivers.

- Healthcare system:
  1) Reduced beneficiaries' morbidity (rate of illness): Reduction in the number of unhealthy beneficiaries;
  2) Reduced familiar caregivers' morbidity: Reduction in the number of unhealthy familiar caregivers.
- Familiar caregivers:
  1) Reduced need for full-time familiar caregivers: Reduction in the number of needed full-time familiar caregivers.
- Economic system:
  1) Reduced beneficiaries' work absence due to illness: Reduction in beneficiaries' annual work absence days due to illness;
  2) Reduced need for full-time professional caregivers: Reduction in the number of employed full-time professional caregivers.

5. It follows the **definition of proper monetizing criteria** (financial proxies):

- Beneficiaries:
  1) Reduced beneficiary's morbidity (risk of contracting the disease): Percentage reduction in beneficiary's morbidity - Willingness to Pay for reduced morbidity.
  2) Reduced need for full-time professional caregivers: Reduction in the number of employed full-time professional caregivers - Cost saving equal to the annual wage for a full-time professional caregiver.
- Healthcare system:
  1) Reduced beneficiaries' morbidity (rate of illness): Reduction in the number of unhealthy beneficiaries - Cost saving equal to the annual healthcare system cost for a given disease;
  2) Reduced familiar caregivers' morbidity: Reduction in the number of unhealthy familiar caregivers - Cost saving equal to the annual healthcare system cost for a given disease.
- Familiar caregivers:
  1) Reduced need for full-time familiar caregivers: Reduction in the number of needed full-time familiar caregivers - Income increase equal to yearly average income.
- Economic system:
  1) Reduced beneficiaries' work absence due to illness: Reduction in beneficiaries' annual work absence days due to illness – Cost saving equal to the cost of a day of work absence;
  2) Reduced need for full-time professional caregivers: Reduction in the number of employed full-time professional caregivers - Annual loss equal to the annual wage for a full-time professional caregiver.

In sum:

Stakeholder	**Input**	**Outcome**	**Indicator**	**Financial proxy**
Beneficiaries		Reduced beneficiary's morbidity (risk of contracting the disease)	Percentage reduction in beneficiary's morbidity	Willingness to Pay for reduced morbidity
		Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Cost saving equal to the annual wage for a full-time professional caregiver
Healthcare system	Cost of the project	Reduced beneficiaries' morbidity (rate of illness)	Reduction in the number of unhealthy beneficiaries	Cost saving equal to the annual healthcare system cost for a given disease
		Reduced familiar caregivers' morbidity	Reduction in the number of unhealthy familiar caregivers	Cost saving equal to the annual healthcare system cost for a given disease
Familiar caregivers		Reduced need for full-time familiar caregivers	Reduction in the number of needed full-time familiar caregivers	Income increase equal to yearly average income
Enterprises		Reduced beneficiaries' work absence due to illness	Reduction in beneficiaries' annual work absence days due to illness	Cost saving equal to the cost of a day of work absence
		Reduced need for full-time professional caregivers	Reduction in the number of employed full-time professional caregivers	Annual loss equal to the annual wage for a full-time professional caregiver

6. The definition of the most suitable **time horizon for the research definitely depends on the nature of the technology involved**.
   Generalizing, it should be identified considering the **maximum time horizon beyond which the technology becomes obsolete**. As this happens, regardless of its effectiveness, the Intention To Use could drop-off, generating losses for the financer of the project.

7. As regards the choice of the discount rate, the authors suggest following the **guidelines coming from the British Treasury Minister's Green Book** and to adopt a rate equal to 3,5%.

Having defined a suitable model, the authors' purpose was that of showing that, even in this field, SROI can represent a valuable alternative to CBA.
CBA methodology, in fact, not involving multiple stakeholders and lacking the adoption of a triple-bottom-line perspective(Ackerman, 2008), can underestimate the benefits from a given initiative.
As a matter of fact, **the study on NESTORE case has revealed that a traditional CBA performed from the point of view of the payer (the healthcare system), would lead to a refusal of the entire project as a non-value-for-money initiative** (refer to Chapter 9.2.7).

Even if the study represents a first attempt to adapt SROI to technology in healthcare, it is relevant to observe how the building blocks of the **designed model fit with the results coming from the SROI literature concerning healthcare processes**.

As regards stakeholders' involvement, the current study confirms what emerges from the literature (Krlev et al., 2013): when dealing with public projects, executives, target groups, funders and society as a whole have to be considered.
Differently from Akingbola et al. (2015) and Ricciuti and Bufali (2019), who adopted a single-perspective approach (considering only beneficiaries as stakeholders for the SROI analysis), **this study aligns with all the other authors that entered the SROI literature analysis** (Muyambi et al. (2017), Bosco et al. (2019), Banke-Thomas et al. (2015), Goudet et al. (2018), Arvidson and Salisbury (2014), Bellucci et al. (2019), Ramon et al. (2018), Tanaree et al. (2019)) and **embraces a broader plethora of stakeholders**.
The authors' study confirms how **this trend actually represents a strict need to achieve completeness and engagement of stakeholders** (Banke-Thomas et al., 2015). As a matter of fact, neglecting part of these players would penalize the analysis, reducing it to an incomplete attempt of embracing all the positive and negative consequences of a project.
Focusing on the type of stakeholders involved, the list proposed by the authors finds similarities with that designed by Tanaree et al. (2019). In evaluating the impact of an alcohol intervention program, they consider, alongside local communities and legal authorities, the beneficiaries, their families, the healthcare system and the labor market.

As regards the inputs necessary to run the initiative, huge differences emerged between the model proposed by the authors (that focuses on

the costs to acquire and distribute the virtual coach) and those presented in the literature. This is not a surprise since the literature-related studies concern the evaluation of processes, to whom staff cost is a relevant input. As a matter of fact, 8 out of 10 authors (Bellucci et al. (2019), Akingbola et al. (2015), Ramon et al. (2018), Tanaree et al. (2019), Goudet et al. (2018), Ricciuti and Bufali (2019), Arvidson and Salisbury (2014) and Bosco et al. (2019)) include staff as the main source of input.

Focusing on the nature of the outcomes involved, from the literature it resulted that **SROI analysis has the major purpose of enriching traditional economic outcomes with social ones** (Nicholls and Lawlor, 2012). **The authors' study reinforces such feature especially when involving Willingness to Pay of beneficiaries** (same monetization criteria adopted by 2 out of 10 authors (Muyambi et al. (2017) and Ricciuti and Bufali (2019))) and benefits related to a reduction in stress and lack of sleep of familiar caregivers, moving beyond traditional economic implications.
The inclusion of health-related implications for familiar caregivers in an SROI analysis represents a novelty in literature. Recurring to the SROI allowed not only to involve them, but also to monetize aspects they benefit from in an agile way through proper financial proxies (Banke-Thomas et al., 2015).
In conclusion, the authors' analysis represents a clear example of the statement of Brady (2011) according to which SROI allows to monetize complex outcomes with financial proxies.

Differently from the guideline from Banke-Thomas et al. (2015) (that states that the time horizon to implement an SROI analysis should vary between a range of 4 months to 5 years), authors decided, relying mainly on the contribution resulting from the CBA literature analysis applied to technologies (in particular Harat et al. (2012)), to enlarge it, proposing a time horizon of 10 years.
The decision emerges from the awareness that the available studies on SROI refer to process/intervention initiatives, that, logically, have an impact more limited in time; a virtual coach, or any technology, instead, can offer a longer-lasting support to the beneficiaries.

The authors' model contributes to the theory by involving in the analysis a negative outcome (loss for the Regional economic system). In fact, in contrast to what has been sustained by Banke-Thomas et al. (2015), no evidence comes from the literature in terms of negative outcomes inclusion.

As above mentioned, **the current study on NESTORE represents a contribution to the literature on virtual coaches for healthy ageing**.
In particular, it offers a **prospective analysis of the effectiveness and potential economic implications of a coaching system for senior adults**.
The investigation of the literature regarding virtual coaches for healthy ageing revealed the scarcity of practical studies in this field. Once again, the authors' research acts as the first building block in a reality where SROI is slightly adopted.

10.3 Managerial contribution

Any entity willing to propose health-related solutions to decision-makers should provide clear evidence of the effectiveness of the outcome-of-usage benefits. The same concept applies to the promoters and developers of a virtual coaching system for healthy ageing purposes (e.g. NESTORE Consortium). On the other hand, there is the need to sensitize decision-makers, redirecting their decisions and educating them towards a more holistic approach. In a reality in which economic aspects are not exhaustive and self-sufficient anymore, social and environmental implications can make the difference and light up the proper direction for public initiatives.

The adoption of technologies for healthy ageing is an urgent need nowadays (World Health Organization, 2015).
SROI represents a valuable tool for assessing their potential impact, by highlighting both the positive and negative effects for all the actors impacted by the solution, not only the payer: population, healthcare system, State.

The promoters and developers of a project, in particular, have to guarantee three points, when proposing such a solution (Social Value, UK, 2012):

1. **The overall positive impact, not only for the target but for the whole society**;

2. **The positive impact according to the strategic objective of the entity they represent**;

3. **The economic sustainability of the initiative for the payer (the SROI analysis has to guarantee that the entity in charge of the payment would return on the investment).**

SROI analysis allows to meet each of these points, thus providing the decision-makers (the healthcare system that plays as the payer in the scenario designed by the authors) **with all the necessary information to make the most proper decision**.
NESTORE Consortium, for example, could employ the authors' research to encourage the healthcare system to approve the initiative.
As a matter of fact, the computation of SROI, in its complete and general form, offers an overview of the general impact of an initiative, clearly stating which is the value generated for all the stakeholders involved.
Moreover, since the final SROI ratio is the result of the sum of the impacts deriving from any single stakeholder, it becomes easy to evaluate whether there is any actor that would be negatively affected by the solution implementation. In this way, decision-makers can have certainty that they would benefit from the implementation of the solution, independently from the overall positive or negative impact generated.

The **SROI definition embodies the sustainability of the promoted initiative**: a positive value of SROI means that the project is value-for-money, thus guaranteeing the financial solidity of the solution proposed.

The current study has already demonstrated to be a supportive tool for decision-makers. In fact, during the sharing of the thesis' results with the NESTORE Consortium, it emerged a discussion about which stakeholder, considering the benefits obtained, should have the burden of NESTORE cost.
SROI cannot provide a final and definitive answer, but **can offer a new and innovative perspective to provide decision-makers with all the relevant information that can support them in their onerous duty of making decisions**.

The possibility to estimate the broader socio-economic outcomes of the technological solution proposed results, as a further advantage, in the possibility of **fostering the acceptance of the solution among its potential users**. As a matter of fact, citizens expected to be the users of the virtual coach (the beneficiaries) may be reluctant to the idea of entrusting their ageing process to a technological device. Thanks to the **SROI analysis, they can be provided with the evidence of the benefits, expressed into monetary terms, that they can obtain from adopting the solution**. Moreover, looking at NESTORE case, the sensitivity analysis boosts the potency of the communication. It allows to report that the positive outcomes for direct users emerge also in the pessimistic scenario, characterized by a reduced effectiveness of the preventive intervention.

Chapter 11

Limitations and further developments

Project limitations (and thus future developments) can be drafted retracing, step by step, the route followed by the authors to build the model.

1. Establishing scope and identifying stakeholders.
   As regards the scope, the authors designed a model in which the National/Regional healthcare system plays the role of the payer and the virtual coach is presented as a medical device. Of course, as NESTORE case itself envisions, this is not the only viable alternative. **The virtual coach could be conceived as a "peace of mind" device (not a medical device) and thus be distributed by health insurance companies, enterprises (as part of welfare programs) or paid directly by its target. The authors invite future researchers to explore in-depth these alternatives**, thus offering a more complete value-for-money evaluation of virtual coaches for healthy ageing.
   Moreover, since the SROI result highlights beneficiaries as the stakeholder that benefits the most from the NESTORE program, **future researchers can conduct the SROI analysis considering NESTORE as an out-of-pocket solution**. In this way, it will be possible to study whether they owe their privileged to the fact of receiving the solution for free.
   As regards the stakeholders, the authors made the decision to not involve in the analysis: pharmaceutical and biomedical companies, family and friends and influencers. Dealing with pharmaceutical and biomedical companies, it has already been underlined the complexity of estimating their loss caused by the fall of sales in a restricted geographical area. For family and friends, merely the implications for familiar caregivers have been taken into account, neglecting psychological consequences for those individuals who, even not caring for the senior adult, are part of his/her life. As it comes to influencers, their role has been completely neglected by the authors. Anyway, a proper communication campaign for a potential virtual coach should for sure involve them and imply higher costs for the payer. Once again, the authors invite future researches to **analyse and involve these further stakeholders and aspects in their analyses**.

2. Mapping outcomes.
   This step is concerned with identifying inputs, valuing inputs, clarifying outputs, describing outcomes.
   Looking at the inputs and their valuation, the authors envisioned a model in which the healthcare system oversees a monthly cost covering the whole service provision. Anyway, when coming to NESTORE case study, the quantification of this value could not be precisely defined. Given the prospective and approximative nature of their study, the authors invite **future researchers, aware of the real cost for implementing the project, to correct the data** and, if necessary, the whole consideration on the NESTORE initiative.
   Coming to the outcomes for a generic model, when dealing with the National/Regional healthcare system, the authors neglected some secondary aspects. The availability of a full-time virtual aid and an improvement in the health conditions of beneficiaries could generate, in fact, a loss for those physicians and specialists (especially nutritionists) that in Italy operate and work as private or public entities. Analogously, the authors, describing outcomes for the economic system, did not mention some relevant elements. On the one hand, **losses for entities that, even not as healthcare professionals, play a fundamental role in healthy ageing were neglected. An example is represented by losses for gyms and wellness centres**. On the other hand, **it was not considered that healthier adults heavily contribute to profits in the service sectors** (ex. theatres, cinemas, restaurants, travel agencies, airline companies, hotels, etc.). Future analysis should quantify these implications and define how they affect the overall SROI ratio for a virtual coach for healthy ageing.

3. Evidencing outcomes and giving them a value.
   There are four steps to follow for evidencing and valuing outcomes: developing outcome indicators, collecting outcomes data, establishing the duration of outcomes, valuing outcomes.
   The main difficulty, concerning this step, derives from the fact that the authors' model derives from a prospective analysis. The choice of indicators has been suggested by the literature, as well as the choice of financial proxies. Anyway, the **impossibility to directly experience the outcomes provided by a virtual coach and to collect data regarding them represents the major limitation of the current study**. This consideration becomes particularly relevant when considering that beneficiaries' Willingness To Pay for reduced morbidity enabled by the virtual coach builds up 90% of the result. The estimation of WTP has been defined by considering which role a virtual coach could play in the life of beneficiaries (nutrition and physical activity aid, replacing gyms and nutritionists' role), anyway, only a retrospective study can reveal its appropriateness.
   Another limitation of the current research is represented by the decision of the authors to involve the consequences and benefits resulting from only two (physical activity and nutrition) out of the four domains of healthy ageing covered by NESTORE (physical activity, nutrition, social sphere, and cognitive ability). Future analysis could try to **estimate how the introduc-**

tion and consideration of social and cognitive related outcomes for beneficiaries vary the SROI ratio and the impact for the different stakeholders.

4. Establishing impact.
   This step requires to define deadweight, displacement, attribution, and drop-off.
   As already evidenced by a literature review on the SROI, their estimation results to be really complex. This becomes particularly true when dealing with a prospective study. In fact, while the authors found it reasonable to assume a value equal to 0% for both displacement and drop-off, it was more challenging to quantify deadweight and attribution. As it comes to **deadweight, it requires the definition of comparison groups or benchmarks whose trends can be observed only in case of retrospective studies**. Therefore, future researchers are invited to define control groups and to involve ex-post and proven-in-the-field values for deadweight.

5. Calculating the SROI.
   This step is mainly concerned with the choice of a proper time horizon and discount rate.
   For the time horizon, the authors underlined how its selection is mainly related to the nature of the technology in place and its risk of obsolescence. This observation can be assumed as a major guideline for the model. Anyway, when it comes to NESTORE case study, once again, it was possible to merely define an approximation of this value.

6. Reporting, using and embedding.
   This step becomes crucial when dealing with the real implementation of a project.
   The authors make their results available for NESTORE Consortium, encouraging them to use it to engage all stakeholders in their initiative.

An interesting aspect that rotates around mHealth solutions is that of using the **data from users for improving the solution itself and for selling them to third parties. The authors decided to neglect this aspect** in drafting a generic model for healthy ageing solutions because of its complex technicalities and privacy implications; anyway, its involvement could reinforce the idea of SROI as a complete and holistic methodology. The use of data to improve the solution could enhance its potentialities and possibly delay the date for its obsolescence. On the other hand, selling data to third parties could represent the proper incentive for the healthcare system: it could increase incomes from the project and, maybe, be positively impacted by it.

The last limitation to be underlined is represented by the **weak validation that the model has obtained so far**. In fact, having shown the SROI model for NESTORE to the NESTORE Consortium represents just an initial approval step, without proving its definitive effectiveness. To overcome this limit, future researchers could try to **adapt the SROI model developed by the authors to other**

contexts such as other technologies operating in the healthcare field, in order to verify its robustness and versatility.

Bibliography

Abdullah, Mohammad MH, Collin L Gyles, Christopher PF Marinangeli, Jared G Carlberg, and Peter JH Jones

2015 "Cost-of-illness analysis reveals potential healthcare savings with reductions in type 2 diabetes and cardiovascular disease following recommended intakes of dietary fiber in Canada", *Frontiers in pharmacology*, 6, p. 167. (Cit. on pp. xviii, 23, 26.)

Abramson, Beth L and Rochelle G Melvin

2014 "Cardiovascular risk in women: focus on hypertension", *Canadian Journal of Cardiology*, 30, 5, pp. 553-559. (Cit. on pp. 156, 165.)

Ackerman, Frank

2008 "Critique of cost-benefit analysis, and alternative approaches to decision-making", *Friends of the Earth England, Wales and Northern Ireland, London*. (Cit. on pp. xvii, xxiii, xxvii, 7, 119, 123, 226, 232.)

Akingbola, Kunle, Suwimon Phaetthayanan, and Joyce Brown

2015 "A-Way Express Courier: Social Enterprise and Positive Psychology", *Nonprofit Management and Leadership*, 26, 2, pp. 173-188. (Cit. on pp. xxii, 94, 98, 99, 101-104, 106, 107, 112-115, 226, 232, 233.)

Akiyama, Miki and Chon Abraham

2017 "Comparative cost-benefit analysis of tele-homecare for community-dwelling elderly in Japan: Non-Government versus Government Supported Funding Models", *International journal of medical informatics*, 104, pp. 1-9. (Cit. on pp. xx, xxi, 47, 54, 57, 60, 61, 64, 65, 69, 71, 72, 75-78.)

Albaina, Inaki Merino, Thomas Visser, Charles APG Van Der Mast, and Martijn H Vastenburg

2009 "Flowie: A persuasive virtual coach to motivate elderly individuals to walk", in *2009 3rd International Conference on Pervasive Computing Technologies for Healthcare*, IEEE, pp. 1-7. (Cit. on p. 135.)

Alessi, Cathy A, Eun J Yoon, John F Schnelle, Nahla R Al-Samarrai, and Patrice A Cruise

1999 "A randomized trial of a combined physical activity and environmental intervention in nursing home residents: do sleep and agitation improve?", *Journal of the American Geriatrics Society*, 47, 7, pp. 784-791. (Cit. on pp. xviii, 22, 26.)

Alexander, Gina K, Kim E Innes, Terry K Selfe, and Cynthia J Brown

2013 ""More than I expected": perceived benefits of yoga practice among older adults at risk for cardiovascular disease", *Complementary therapies in medicine*, 21, 1, pp. 14-28. (Cit. on pp. xviii, 22, 26.)

Aranceta, J, C Perez-Rodrigo, J Gondra, and J Orduna

2001 "Community-based programme to promote physical activity among elderly people: the GeroBilbo study." *The journal of nutrition, health & aging*, 5, 4, pp. 238-242. (Cit. on pp. xviii, 21, 26.)

Arokiasamy, Perianayagam, Uttamacharya Uttamacharya, Kshipra Jain, Richard Berko Biritwum, Alfred Edwin Yawson, Fan Wu, Yanfei Guo, Tamara Maximova, Betty Manrique Espinoza, Aaron Salinas Rodriguez, et al.

2015 "The impact of multimorbidity on adult physical and mental health in low-and middle-income countries: what does the study on global ageing and adult health (SAGE) reveal?", *BMC medicine*, 13, 1, p. 178. (Cit. on pp. xviii, 18.)

Arvidson, Malin and Stephen McKay

2013 "Valuing the social? The nature and controversies of measuring social return on investment (SROI)", *Voluntary sector review*, 4, 1, pp. 3-18. (Cit. on pp. xvii, xxii, xxvii, xxviii, 8, 227.)

Arvidson, Malin and David Salisbury

2014 "The social return on investment in community befriending", *International Journal of Public Sector Management*, 27, 3, pp. 225-240. (Cit. on pp. 95, 99, 100, 102-104, 107, 109, 111-116, 232, 233.)

Assistere.net

n.d. *Quanto costa una badante*, https://www.assistere.net/quanto-costa-una-badante/. (Cit. on pp. 161, 175, 187.)

Audouin, M and K Govender

2004 *Strategic environmental assessment: Integrated environmental management*, Department of Environmental Affairs and Tourism. (Cit. on p. 29.)

Banke-Thomas, Aduragbemi Oluwabusayo, Barbara Madaj, Ameh Charles, and Nynke van den Broek

2015 "Social Return on Investment (SROI) methodology to account for value for money of public health interventions: a systematic review", *BMC Public Health*, 15, 1, p. 582. (Cit. on pp. xvii, xx-xxiii, xxvii, xxviii, 8, 81, 82, 95, 96, 99, 100, 113, 114, 116, 226, 227, 232, 233.)

Banos, Oresti and Chris Nugent

2018 "M-Coaching: Towards the Next Generation of Mobile-Driven Healthcare Support Services", *Computer*, 51, 8, pp. 14-17. (Cit. on p. 135.)

Bartholomew, L Kay, Guy S Parcel, Gerjo Kok, and Nell H Gottlieb

2001 *Intervention mapping: designing theory-and evidence-based health promotion programs*, Mayfield Mountain View, CA. (Cit. on p. 134.)

Bartlett II, James E, Robert V Boylan, Jimmie E Hale, et al.

2014 "Executive coaching: An integrative literature review", *Journal of Human Resource and Sustainability Studies*, 2, 04, p. 188. (Cit. on p. 132.)

Bassuk, Shari S and JoAnn E Manson

2005 "Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease", *Journal of applied physiology*, 99, 3, pp. 1193-1204. (Cit. on pp. 156, 165.)

Batra, Priya and Anil K Sharma

2013 "Anti-cancer potential of flavonoids: recent trends and future perspectives", *3 Biotech*, 3, 6, pp. 439-459. (Cit. on pp. 24, 26.)

Battistoni, Giuseppe, Mario Genco, Marta Marsilio, Chiara Pancotti, Sandro Rossi, and Silvia Vignetti

2016 "Cost–benefit analysis of applied research infrastructure. Evidence from health care", *Technological Forecasting and Social Change*, 112, pp. 79-91. (Cit. on pp. xx, 48, 54, 57, 59, 61, 63-65, 70-78.)

Beard, John R, Alana Officer, Islene Araujo De Carvalho, Ritu Sadana, Anne Margriet Pot, Jean-Pierre Michel, Peter Lloyd-Sherlock, JoAnne E Epping-Jordan, GMEE Geeske Peeters, Wahyu Retno Mahanani, et al.

2016 "The World report on ageing and health: a policy framework for healthy ageing", *The Lancet*, 387, 10033, pp. 2145-2154. (Cit. on pp. 17, 18.)

Bellucci, Marco, Carmela Nitti, Serena Franchi, Enrico Testi, and Luca Bagnoli

2019 "Accounting for social return on investment (SROI) The costs and benefits of family-centred care by the Ronald McDonald House Charities", *Social Enterprise Journal*, 15, 1, pp. 46-75. (Cit. on pp. xxii, xxiii, 94, 98, 100-104, 106, 107, 110, 112-116, 227, 232, 233.)

Bettany-Saltikov, Josette

2012 *How to do a systematic literature review in nursing: a step-by-step guide*, McGraw-Hill Education (UK). (Cit. on pp. 35, 85.)

Bizzarri, Dr. Lelio

2015 *Psicoterapia Integrata e Psicologia di Comunità*, https://bizzarrilelio.wordpress.com/. (Cit. on p. 172.)

Bloom, David E, Somnath Chatterji, Paul Kowal, Peter Lloyd-Sherlock, Martin McKee, Bernd Rechel, Larry Rosenberg, and James P Smith
2015 "Macroeconomic implications of population ageing and selected policy responses", *The Lancet*, 385, 9968, pp. 649-657. (Cit. on p. 3.)

Boardman, Anthony E, David H Greenberg, Aidan R Vining, and David L Weimer
2017 *Cost-benefit analysis: concepts and practice*, Cambridge University Press. (Cit. on p. 34.)

Bootman, J Lyle, Clayton Rowland, and Albert I Wertheimer
1979 "Cost-benefit analysis: a research tool for evaluating innovative health programs", *Evaluation & the health professions*, 2, 2, pp. 129-154. (Cit. on p. 30.)

Bosco, Alessandro, Justine Schneider, and Emma Broome
2019 "The social value of the arts for care home residents in England: A Social Return on Investment (SROI) analysis of the Imagine Arts programme", *Maturitas*, 124, pp. 15-24. (Cit. on pp. xxii, xxiii, 96, 99, 100, 102-104, 107-109, 112, 114-116, 227, 232, 233.)

Brady, R
2011 "The True Cost of Stigma: Evaluating the Social Return on Investment of the Stigma and Discrimination Component of the Alliance's Africa Regional Programme II", *International HIV/AIDS Alliance: Hove, United Kingdom*. (Cit. on pp. xvii, xxii, xxiii, 8, 119, 227, 233.)

Brandenburgh, Arjen, Ward van Breda, Wim van der Ham, Michel Klein, Lisette Moeskops, and Peter Roelofsma
2014 "Increasing physical and social activity through virtual coaching in an ambient environment", in *International Conference on Active Media Technology*, Springer, pp. 487-500. (Cit. on pp. 126, 135, 136.)

Brest, Paul
2010 "The power of theories of change", *Stanford Social Innovation Review*, 8, 2, pp. 47-51. (Cit. on p. 79.)

Brzozowska, Krystyna et al.
2007 "Cost-benefit analysis in public project appraisal", *Engineering economics*, 3 (53), pp. 78-83. (Cit. on pp. xix, 29.)

Budgen, David and Pearl Brereton
2006 "Performing systematic literature reviews in software engineering", in *Proceedings of the 28th international conference on Software engineering*, ACM, pp. 1051-1052. (Cit. on p. 82.)

Burke, Gregory L, Alice M Arnold, Diane E Bild, Mary Cushman, Linda P Fried, Anne Newman, Cathy Nunn, John Robbins, and CHS Collaborative Research Group

2001 "Factors associated with healthy aging: the cardiovascular health study", *Journal of the American Geriatrics Society*, 49, 3, pp. 254-262. (Cit. on pp. xviii, 19.)

Butterworth, Susan, Ariel Linden, Wende McClay, and Michael C Leo

2006 "Effect of motivational interviewing-based health coaching on employees' physical and mental health status." *Journal of occupational health psychology*, 11, 4, p. 358. (Cit. on p. 133.)

Callejas, Zoraida, David Griol, Michael F McTear, and Ramon Lopez-Cozar

2014 "A virtual coach for active ageing based on sentient computing and m-health", in *International workshop on ambient assisted living*, Springer, pp. 59-66. (Cit. on pp. 126, 135.)

Castorina, Jose Antonio, Emilia Ferreiro, Delia Lerner, and Marta Kohl de Oliveira

2010 "Piaget-Vygotsky: novas contribuiccoes para o debate". (Cit. on p. 138.)

Cecchini, Michele, Franco Sassi, Jeremy A Lauer, Yong Y Lee, Veronica Guajardo-Barron, and Daniel Chisholm

2010 "Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness", *The Lancet*, 376, 9754, pp. 1775-1784. (Cit. on p. 134.)

Cerbino, Dr. Nicola

2019 "Osservatorio nazionale sulla salute nelle regioni italiane", *Rapporto Osservasalute*. (Cit. on pp. 170, 175, 192.)

Chaput, Jean-Philippe, Jean-Pierre Després, Claude Bouchard, and Angelo Tremblay

2007 "Short sleep duration is associated with reduced leptin levels and increased adiposity: results from the Quebec family study", *Obesity*, 15, 1, pp. 253-261. (Cit. on p. 174.)

Chase, Nancy L, Xuemei Sui, Duck-chul Lee, and Steven N Blair

2009 "The association of cardiorespiratory fitness and physical activity with incidence of hypertension in men", *American journal of hypertension*, 22, 4, pp. 417-424. (Cit. on pp. 156, 165.)

Chatterji, Somnath, Julie Byles, David Cutler, Teresa Seeman, and Emese Verdes

2015 "Health, functioning, and disability in older adults—present status and future implications", *The lancet*, 385, 9967, pp. 563-575. (Cit. on p. 18.)

Chen, Jiu-Chiuan, Mark A Espeland, Robert L Brunner, Laura C Lovato, Robert B Wallace, Xiaoyan Leng, Lawrence S Phillips, Jennifer G Robinson, Jane M Kotchen, Karen C Johnson, et al.
2016 "Sleep duration, cognitive decline, and dementia risk in older women", *Alzheimer's & Dementia*, 12, 1, pp. 21-33. (Cit. on p. 174.)

Christensen, Kaare, Gabriele Doblhammer, Roland Rau, and James W Vaupel
2009 "Ageing populations: the challenges ahead", *The lancet*, 374, 9696, pp. 1196-1208. (Cit. on p. 17.)

Christie, Gregory J, Tara Hamilton, Bradley D Manor, Norman AS Farb, Faranak Farzan, Andrew Sixsmith, Jean-Jacques Temprado, and Sylvain Moreno
2017 "Do lifestyle activities protect against cognitive decline in aging? A Review", *Frontiers in aging neuroscience*, 9, p. 381. (Cit. on pp. xviii, xix, 21, 26.)

Clarke, PM, JL Wolstenholme, and S Wordsworth
2010 *Applied Methods of Cost-effectiveness Analysis in Healthcare (Band 3 von Handbooks in Health Economic Evaluation)*, Oxford, UK: Oxford University Press. (Cit. on p. 34.)

Clutterbuck, David and Zulfi Hussain
2010 *Virtual coach, virtual mentor*, IAP.

Colditz, Graham A
1992 "Economic costs of obesity", *The American journal of clinical nutrition*, 55, 2, 503S-507S. (Cit. on p. 21.)

Consolvo, Sunny, David W McDonald, Tammy Toscos, Mike Y Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, Anthony LaMarca, Louis LeGrand, Ryan Libby, et al.
2008 "Activity sensing in the wild: a field trial of ubifit garden", in *Proceedings of the SIGCHI conference on human factors in computing systems*, ACM, pp. 1797-1806. (Cit. on p. 138.)

Consortium, York Health Economics
2016 *Cost of Illness [online]*. (Cit. on p. 74.)

Cook, Nancy R, Jeffrey A Cutler, Eva Obarzanek, Julie E Buring, Kathryn M Rexrode, Shiriki K Kumanyika, Lawrence J Appel, and Paul K Whelton
2007 "Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP)", *Bmj*, 334, 7599, p. 885. (Cit. on pp. 156, 165.)

Cooper, Chris, Andrew Booth, Jo Varley-Campbell, Nicky Britten, and Ruth Garside
2018 "Defining the process to literature searching in systematic reviews: a literature review of guidance and supporting studies", *BMC medical research methodology*, 18, 1, p. 85. (Cit. on pp. 32, 76, 83.)

Courtney, Paul and Colin Baker

2017 "Assessing the value of community health programmes using a Social Return on Investment frameworkColin Baker", *European Journal of Public Health*, 27, suppl 3. (Cit. on pp. 89, 92.)

Craik, Fergus IM, Ellen Bialystok, and Morris Freedman

2010 "Delaying the onset of Alzheimer disease: bilingualism as a form of cognitive reserve", *Neurology*, 75, 19, pp. 1726-1729. (Cit. on pp. xviii, 25, 27.)

Crimmins, Eileen M and Hiram Beltran-Sanchez

2010 "Mortality and morbidity trends: is there compression of morbidity?", *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 66, 1, pp. 75-86. (Cit. on p. 18.)

Cropper, Maureen L, Mark C Freeman, Ben Groom, and William A Pizer

2014 "Declining discount rates", *American Economic Review*, 104, 5, pp. 538-43.

Crossan, Mary M and Marina Apaydin

2010 "A multi-dimensional framework of organizational innovation: A systematic review of the literature", *Journal of management studies*, 47, 6, pp. 1154-1191. (Cit. on pp. 33, 84.)

Crowe, Sarah, Kathrin Cresswell, Ann Robertson, Guro Huby, Anthony Avery, and Aziz Sheikh

2011 "The case study approach", *BMC medical research methodology*, 11, 1, p. 100. (Cit. on pp. xxiii, 126, 228.)

D'Andrea, A.M.

2019 *Stipendi medi in Italia: differenze tra Nord e Sud, ecco chi guadagna di più*, https://www.money.it/Stipendi-medi-in-Italia-1-570-euro-differenze-Nord-Sud. (Cit. on pp. 180, 184.)

Davalos, Maria E, Michael T French, Anne E Burdick, and Scott C Simmons

2009 "Economic evaluation of telemedicine: review of the literature and research guidelines for benefit–cost analysis", *Telemedicine and e-Health*, 15, 10, pp. 933-948. (Cit. on p. 51.)

Davis, Fred D, Richard P Bagozzi, and Paul R Warshaw

1989 "User acceptance of computer technology: a comparison of two theoretical models", *Management science*, 35, 8, pp. 982-1003. (Cit. on p. 154.)

Dennis, Alan R, Viswanath Venkatesh, and V Ramesh

2003 "Adoption of collaboration technologies: Integrating technology acceptance and collaboration technology research", *Working Papers on Information Systems*, 3, 8, pp. 3-8. (Cit. on p. 154.)

Diaz Abrahan, Veronika, Favio Shifres, and Nadia Justel
2019 "Cognitive benefits from a musical activity in older adults", *Frontiers in psychology*, 10, p. 652. (Cit. on p. 25.)

Doll, Timothy M, Victor L Fulgoni III, Yiduo Zhang, Kristin J Reimers, Patricia T Packard, and James D Astwood
2009 "Potential health benefits and medical cost savings from calorie, sodium, and saturated fat reductions in the American diet", *American Journal of Health Promotion*, 23, 6, pp. 412-422. (Cit. on p. 23.)

Donnan, Peter T, Graham P Leese, Andrew D Morris, Diabetes Audit, et al.
2000 "Hospitalizations for people with type 1 and type 2 diabetes compared with the nondiabetic population of Tayside, Scotland: a retrospective cohort study of resource use." *Diabetes Care*, 23, 12, pp. 1774-1779. (Cit. on p. 183.)

Dyakova, Mariana, Christoph Hamelmann, Federica Turatto, and Volker Then
2017 *Social return on investment - Accounting for value in the context of implementing Health 2020 and the 2030 Agenda for Sustainable Development*. (Cit. on pp. 79, 228.)

Ebert, Philip and Wolfgang Freibichler
2017 "Nudge management: applying behavioural science to increase knowledge worker productivity", *Journal of Organization Design*, 6, 1, p. 4. (Cit. on p. 134.)

EuroHealthNet, Healthy Ageing
2012 *European Policies and Initiatives*. (Cit. on pp. 6, 20, 23.)

European Commission & Economic Policy Committee
2014 *The 2012 ageing report: underlying assumptions and projection methodologies*, European Commission Directorate-General for Economic and Financial Affairs. (Cit. on pp. xvii, 3.)

Eurostat, Statistics Explained
2017 *Waste statistics (2018)*. (Cit. on p. 138.)

Fasola, Juan and Maja J Mataric
2013 "A socially assistive robot exercise coach for the elderly", *Journal of Human-Robot Interaction*, 2, 2, pp. 3-32. (Cit. on pp. 126, 136.)

Fattore, Giovanni
2009 "Proposta di linee guida per la valutazione economica degli interventi sanitari in Italia", *PharmacoEconomics Italian Research Articles*, 11, 2, pp. 83-93. (Cit. on p. 51.)

Federconsumatori
2017 *Sport: Indagine Federconsumatori sui costi delle palestre in Italia*. https://www.federconsumatori.it/Showdoc.php?nid=20170907113855. (Cit. on p. 159.)

Felsen, Gidon, Noah Castelo, and Peter B Reiner

2013 "Decisional enhancement and autonomy: public attitudes towards overt and covert nudges." *Judgment & Decision Making*, 8, 3. (Cit. on p. 134.)

Ferrari, Rossella

2015 "Writing narrative style literature reviews", *Medical Writing*, 24, 4, pp. 230-235. (Cit. on pp. 32, 83.)

Fiatarone, Maria A, Evelyn F O'Neill, Nancy Doyle Ryan, Karen M Clements, Guido R Solares, Miriam E Nelson, Susan B Roberts, Joseph J Kehayias, Lewis A Lipsitz, and William J Evans

1994 "Exercise training and nutritional supplementation for physical frailty in very elderly people", *New England Journal of Medicine*, 330, 25, pp. 1769-1775. (Cit. on p. 22.)

Fisher, Marc, Kennedy Lees, and J David Spence

2006 "Nutrition and stroke prevention", *Stroke*, 37, 9, pp. 2430-2435. (Cit. on pp. 156, 165.)

Fogg, BJ

2003 "How to Motivate & Persuade Users", *CHI 2003: New Horizons*. (Cit. on p. 136.)

For Clinical Excellence, National Institute et al.

2004 "NICE guide to the methods of technology appraisal", *NICE, London*.

Ford, Amasa B, Marie R Haug, Kurt C Stange, Atwood D Gaines, Linda S Noelker, and Paul K Jones

2000 "Sustained personal autonomy: a measure of successful aging", *Journal of aging and health*, 12, 4, pp. 470-489. (Cit. on pp. xviii, 19.)

Frank, Robert H

2000 "Why is cost-benefit analysis so controversial?", *The Journal of Legal Studies*, 29, S2, pp. 913-930. (Cit. on pp. xvii, 7, 226.)

Frew, Emma

2010 *Applied methods of cost-benefit analysis in health care*, Oxford University Press, vol. 4. (Cit. on p. 30.)

Gangwisch, James E, Steven B Heymsfield, Bernadette Boden-Albala, Ruud M Buijs, Felix Kreier, Thomas G Pickering, Andrew G Rundle, Gary K Zammit, and Dolores Malaspina

2006 "Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey", *hypertension*, 47, 5, pp. 833-839. (Cit. on p. 174.)

Gargani, John

2017 "The leap from ROI to SROI: Farther than expected?", *Evaluation and program planning*, 64, pp. 116-126. (Cit. on pp. xxi, 80.)

Giuliani, Giancarlo

2018 *Chi è il Caregiver: i Dati ISTAT*, https://www.formazione-sanitaria.com/2018/01/23/caregiver-dati-istat-2018/. (Cit. on pp. 173, 178.)

Goudet, Sophie, Paula L Griffiths, Caroline W Wainaina, Teresia N Macharia, Frederick M Wekesah, Milka Wanjohi, Peter Muriuki, and Elizabeth Kimani-Murage

2018 "Social value of a nutritional counselling and support program for breastfeeding in urban poor settings, Nairobi", *BMC public health*, 18, 1, p. 424. (Cit. on pp. xxii, xxiii, 95, 99, 102-104, 106, 110, 112-116, 227, 232, 233.)

Greenberg, Dan, Yitzhak Peterburg, Daniel Vekstein, and Joseph S Pliskin

2005 "Decisions to adopt new technologies at the hospital level: insights from Israeli medical centers", *International journal of technology assessment in health care*, 21, 2, pp. 219-227. (Cit. on pp. xvii, 9, 226.)

Greenspoon, Jeffrey Noah, Anthony Whitton, Timothy Whelan, Waseem Sharieff, James Wright, Jonathan Sussman, and Amiram Gafni

2013 "Robotic radiosurgery for the treatment of 1–3 brain metastases: a pragmatic application of cost-benefit analysis using willingness-to-pay", *Technology in cancer research & treatment*, 12, 6, pp. 517-523. (Cit. on pp. xx, xxi, 50, 51, 56, 57, 60-65, 77, 78.)

Gregg, Edward W, Jane A Cauley, Dana G Seeley, Kristine E Ensrud, and Douglas C Bauer

1998 "Physical activity and osteoporotic fracture risk in older women", *Annals of internal medicine*, 129, 2, pp. 81-88. (Cit. on pp. 156, 165.)

Grundy, Emily and Ann Bowling

1999 "Enhancing the quality of extended life years. Identification of the oldest old with a very good and very poor quality of life", *Aging & Mental Health*, 3, 3, pp. 199-212. (Cit. on p. 19.)

Hackney, Madeleine E, Svetlana Kantorovich, and Gammon M Earhart

2007 "A study on the effects of Argentine tango as a form of partnered dance for those with Parkinson disease and the healthy elderly", *American Journal of Dance Therapy*, 29, 2, pp. 109-127. (Cit. on p. 25.)

Hamari, Juho, Jonna Koivisto, Harri Sarsa, et al.

2014 "Does Gamification Work?-A Literature Review of Empirical Studies on Gamification", in *HICSS*, 2014, vol. 14, pp. 3025-3034. (Cit. on p. 138.)

Hansen, Pelle Guldborg and Andreas Maaloe Jespersen

2013 "Nudge and the manipulation of choice: A framework for the responsible use of the nudge approach to behaviour change in public policy", *European Journal of Risk Regulation*, 4, 1, pp. 3-28. (Cit. on p. 135.)

Harat, Aleksandra, Pawel Sokal, Piotr Zielinski, Marek Harat, Teresa Rusicka, and Leszek Herbowski

2012 "Assessment of economic effectiveness in treatment of neuropathic pain and refractory angina pectoris using spinal cord stimulation", *Adv Clin Exp Med*, 21, 5, pp. 653-663. (Cit. on pp. xx, 48, 54, 57, 67, 71-77, 233.)

Harvey, Jack

1996 "Public-sector Development: Cost–benefit Analysis", in *Urban Land Economics*, Springer, pp. 119-146. (Cit. on p. 29.)

Hayes, Eileen and Karen A Kalmakis

2007 "From the sidelines: Coaching as a nurse practitioner strategy for improving health outcomes", *Journal of the American Academy of Nurse Practitioners*, 19, 11, pp. 555-562. (Cit. on p. 132.)

Heath, John M and Marian R Stuart

2002 "Prescribing exercise for frail elders." *The Journal of the American Board of Family Practice*, 15, 3, pp. 218-228. (Cit. on pp. xviii, 21, 22, 26, 155, 156, 164, 182.)

Helbostad, Jorunn, Beatrix Vereijken, Clemens Becker, Chris Todd, Kristin Taraldsen, Mirjam Pijnappels, Kamiar Aminian, and Sabato Mellone

2017 "Mobile health applications to promote active and healthy ageing", *Sensors*, 17, 3, p. 622. (Cit. on p. 137.)

HM Treasury

2003 "The Green Book: Appraisal and Evaluation in Central Government: London: HM Treasury", *British Government*. (Cit. on pp. xxv, 75, 114, 145, 190.)

Hogan, David B, Tak S Fung, and Erika M Ebly

1999 "Health, function and survival of a cohort of very old Canadians: results from the second wave of the Canadian Study of Health and Aging", *Canadian journal of public health*, 90, 5, pp. 338-342. (Cit. on p. 19.)

Horvath, Adam O and Leslie S Greenberg

1989 "Development and validation of the Working Alliance Inventory." *Journal of counseling psychology*, 36, 2, p. 223.

Howard, Virginia J and Michelle N McDonnell

2015 "Physical activity in primary stroke prevention: just do it!", *Stroke*, 46, 6, pp. 1735-1739. (Cit. on pp. 155, 156, 164, 165, 171, 178, 182, 186.)

Hsiao, Ya-Hsin, Chih-Hua Chang, and Po-Wu Gean

2018 "Impact of social relationships on Alzheimer's memory impairment: mechanistic studies", *Journal of biomedical science*, 25, 1, p. 3. (Cit. on pp. xviii, 24, 27.)

Hu, Nan, Jin-Tai Yu, Lin Tan, Ying-Li Wang, Lei Sun, and Lan Tan

2013 "Nutrition and the risk of Alzheimer's disease", *BioMed research international*, 2013. (Cit. on pp. 156, 165.)

Hudlicka, Eva

2013 "Virtual training and coaching of health behavior: Example from mindfulness meditation training", *Patient education and counseling*, 92, 2, pp. 160-166. (Cit. on p. 137.)

Husereau, Don, Michael Drummond, Stavros Petrou, Chris Carswell, David Moher, Dan Greenberg, Federico Augustovski, Andrew H Briggs, Josephine Mauskopf, and Elizabeth Loder

2013 "Consolidated health economic evaluation reporting standards (CHEERS) statement", *Cost Effectiveness and Resource Allocation*, 11, 1, p. 6. (Cit. on pp. 82, 227.)

Hwang, Kwangseon

2016 "Cost-benefit analysis: its usage and critiques", *Journal of Public Affairs*, 16, 1, pp. 75-80. (Cit. on p. 7.)

Inouye, Sharon K, Stephanie Studenski, Mary E Tinetti, and George A Kuchel

2007 "Geriatric Syndromes: Clinical, Research, and Policy Implications of a Core Geriatric Concept: (See Editorial Comments by Dr. William Hazzard on pp 794–796)", *Journal of the American Geriatrics Society*, 55, 5, pp. 780-791. (Cit. on pp. xviii, 19.)

Ives, Yossi

2008 "What is' coaching'? An exploration of conflicting paradigms." *International Journal of Evidence Based Coaching & Mentoring*, 6, 2. (Cit. on p. 132.)

Jeuland, Marc and Dale Whittington

2009 "Cost–benefit comparisons of investments in improved water supply and cholera vaccination programs", *Vaccine*, 27, 23, pp. 3109-3120. (Cit. on pp. xx, 48, 54, 57, 66, 67, 70, 71, 73, 74, 77, 226.)

Joglekar, Prafulla N

1984 "Cost-benefit studies of health care programs: Choosing methods for desired results", *Evaluation & the health professions*, 7, 3, pp. 285-303. (Cit. on p. 30.)

Jones, Timothy F and Charles B Eaton

1994 "Cost-benefit analysis of walking to prevent coronary heart disease." *Archives of family medicine*, 3, 8, pp. 703-710. (Cit. on p. 21.)

Jordan, Meg, Ruth Q Wolever, Karen Lawson, and Margaret Moore

2015 *National training and education standards for health and wellness coaching: the path to national certification.* (Cit. on p. 133.)

Kable, Ashley K, Jacqueline Pich, and Sian E Maslin-Prothero
2012 "A structured approach to documenting a search strategy for publication: A 12 step guideline for authors", *Nurse education today*, 32, 8, pp. 878-886. (Cit. on pp. xix, xxii, 32, 83.)

Kahneman, Daniel
2011 *Thinking, fast and slow*, Macmillan. (Cit. on p. 134.)

Kamphorst, Bart A
2017 "E-coaching systems", *Personal and Ubiquitous Computing*, 21, 4, pp. 625-632. (Cit. on p. 136.)

Kattan, Michael W
2009 *Encyclopedia of medical decision making*, Sage, vol. 1. (Cit. on p. 73.)

Katzmarzyk, Peter T and Ian Janssen
2004 "The economic costs associated with physical inactivity and obesity in Canada: an update", *Canadian journal of applied physiology*, 29, 1, pp. 90-115. (Cit. on p. 21.)

Kim, Sang Mi, Sung Wan Hwang, Eun-Hwan Oh, and Jung-Kyu Kang
2013 "Determinants of the length of stay in stroke patients", *Osong public health and research perspectives*, 4, 6, pp. 329-341. (Cit. on p. 183.)

Klarman, Herbert E
1967 "Present status of cost-benefit analysis in the health field." *American Journal of Public Health and the Nations Health*, 57, 11, pp. 1948-1953. (Cit. on p. 31.)

Klein, Michel, Nataliya Mogles, and Arlette Van Wissen
2014 "Intelligent mobile support for therapy adherence and behavior change", *Journal of biomedical informatics*, 51, pp. 137-151. (Cit. on p. 136.)

Koren, Marina
2013 *Being a Lifelong Bookworm May Keep You Sharp in Old Age*. (Cit. on p. 25.)

Krlev, Gorgi, Robert Munscher, and Katharina Mulbert
2013 "Social Return on Investment (SROI): state-of-the-art and perspectives-a meta-analysis of practice in Social Return on Investment (SROI) studies published 2002-2012". (Cit. on pp. 80, 124, 232.)

Kruger, J, Sandra A Ham, Harold W Kohl III, et al.
2005 "Trends in leisure-time physical inactivity by age, sex, and race/ethnicity-United States, 1994-2004." *Morbidity and Mortality Weekly Report*, 54, 39, pp. 991-994. (Cit. on p. 21.)

Kujala, Urho M, Jaakko Kaprio, Pekka Kannus, Seppo Sarna, and Markku Koskenvuo
2000 "Physical activity and osteoporotic hip fracture risk in men", *Archives of Internal Medicine*, 160, 5, pp. 705-708. (Cit. on pp. 156, 165.)

Kulyk, Olga, Hendrikus JA op den Akker, Randy Klaassen, and JEWC van Gemert-Pijnen

2014 "Personalized virtual coaching for lifestyle support: principles for design and evaluation", *International journal on advances in life sciences*, 6, 3-4, pp. 300-309. (Cit. on p. 127.)

Laing, Catherine M and Nancy J Moules

2017 "Social Return on Investment: A New Approach to Understanding and Advocating for Value in Healthcare", *Journal of Nursing Administration*, 47, 12, pp. 623-628. (Cit. on p. 97.)

Lee, Ronald and Andrew Mason

2010 "Some macroeconomic aspects of global population aging", *demography*, 47, 1, S151-S172. (Cit. on p. 4.)

Lin, Mau-Roung, Hei-Fen Hwang, Yi-Wei Wang, Shu-Hui Chang, and Steven L Wolf

2006 "Community-based tai chi and its effect on injurious falls, balance, gait, and fear of falling in older people", *Physical therapy*, 86, 9, pp. 1189-1201. (Cit. on p. 22.)

Liotta, Giuseppe, Helena Canhao, Fabian Cenko, Rita Cutini, Ercole Vellone, Maddalena Illario, Przemyslaw Kardas, Andrea Poscia, Rute Dinis Sousa, Leonardo Palombi, et al.

2018 "Active ageing in Europe: adding healthy life to years", *Frontiers in medicine*, 5, p. 123. (Cit. on pp. xviii, 5, 20.)

Lloyd-Sherlock, Peter, Martin McKee, Shah Ebrahim, Mark Gorman, Sally Greengross, Martin Prince, Rachel Pruchno, Gloria Gutman, Tom Kirkwood, Desmond O'Neill, et al.

2012 "Population ageing and health", *The Lancet*, 379, 9823, pp. 1295-1296. (Cit. on p. 18.)

Lordos, Emilia Frangos, Francois R Herrmann, Jean-Marie Robine, Mireille Balahoczky, Sandra V Giannelli, Gabriel Gold, and Jean-Pierre Michel

2008 "Comparative value of medical diagnosis versus physical functioning in predicting the 6-year survival of 1951 hospitalized old patients", *Rejuvenation research*, 11, 4, pp. 829-836. (Cit. on pp. xviii, 19.)

Maartensson, Johan, Johan Eriksson, Nils Christian Bodammer, Magnus Lindgren, Mikael Johansson, Lars Nyberg, and Martin Lovden

2012 "Growth of language-related brain areas after foreign language learning", *NeuroImage*, 63, 1, pp. 240-244. (Cit. on p. 25.)

Maas, Karen and Kellie Liket

2011 "Social impact measurement: Classification of methods", in *Environmental management accounting and supply chain management*, Springer, pp. 171-202. (Cit. on p. 80.)

MacKie-Mason, Jeffrey K and Hal R Varian

1995 "Pricing congestible network resources", *IEEE journal on Selected Areas in Communications*, 13, 7, pp. 1141-1149. (Cit. on p. 74.)

Marengoni, Alessandra, Sara Angleman, Rene Melis, Francesca Mangialasche, Anita Karp, Annika Garmen, Bettina Meinow, and Laura Fratiglioni

2011 "Aging with multimorbidity: a systematic review of the literature", *Ageing research reviews*, 10, 4, pp. 430-439. (Cit. on p. 18.)

Martin-Sanchez, Francisco Javier, Virginia Carbajosa, Pere Llorens, Pablo Herrero, Javier Jacob, Oscar Mirò, Cristina Fernandez, Hector Bueno, Elpidio Calvo, and Josè Manuel Ribera Casado

2016 "Tiempo de estancia prolongado en los pacientes ingresados por insuficiencia cardiaca aguda", *Gaceta Sanitaria*, 30, 3, pp. 191-200. (Cit. on p. 183.)

Mastropietro, Alfonso, Christina Roecke, Simone Porcelli, Josep del Bas, Noemi Boquè, Laura Fernandez Maldonado, and Giovanna Rizzo

2018 "Multi-domain Model of Healthy Ageing: The Experience of the H2020 NESTORE Project", in *Italian Forum of Ambient Assisted Living*, Springer, pp. 13-21. (Cit. on p. 126.)

McIntosh, Emma, Cam Donaldson, and Mandy Ryan

1999 "Recent advances in the methods of cost-benefit analysis in healthcare", *Pharmacoeconomics*, 15, 4, pp. 357-367. (Cit. on p. 31.)

McKenzie, Joanne E, Patricia Priest, Rick Audas, Marion R Poore, Cheryl R Brunton, and Lesley M Reeves

2010 "Hand sanitisers for reducing illness absences in primary school children in New Zealand: a cluster randomised controlled trial study protocol", *Trials*, 11, 1, p. 7. (Cit. on pp. xx, 50, 51, 56, 57, 67, 77, 78.)

Merom, Dafna, Anne Grunseit, Ranmalee Eramudugolla, Barbara Jefferis, Jade Mcneill, and Kaarin J Anstey

2016 "Cognitive benefits of social dancing and walking in old age: the dancing mind randomized controlled trial", *Frontiers in aging neuroscience*, 8, p. 26. (Cit. on pp. xviii, 25, 27.)

Millar, Ross and Kelly Hall

2013 "Social return on investment (SROI) and performance measurement: The opportunities and barriers for social enterprises in health and social care", *Public Management Review*, 15, 6, pp. 923-941. (Cit. on p. 79.)

Miller, Gregory E, Michael LM Murphy, Rosemary Cashman, Roy Ma, Jeffrey Ma, Jesusa MG Arevalo, Michael S Kobor, and Steve W Cole

2014 "Greater inflammatory activity and blunted glucocorticoid signaling in monocytes of chronically stressed caregivers", *Brain, behavior, and immunity*, 41, pp. 191-199. (Cit. on p. 174.)

Mishan, Ezra J
1971 "Evaluation of life and limb: a theoretical approach", *Journal of Political Economy*, 79, 4, pp. 687-705.

Moretti, Francesca, Diana De Ronchi, Virginia Bernabei, Lucia Marchetti, Barbara Ferrari, Claudia Forlani, Francesca Negretti, Cleta Sacchetti, and Anna Rita Atti
2011 "Pet therapy in elderly patients with mental illness", *Psychogeriatrics*, 11, 2, pp. 125-129. (Cit. on p. 25.)

Morris, Martha Clare, Christy C Tangney, Yamin Wang, Frank M Sacks, Lisa L Barnes, David A Bennett, and Neelum T Aggarwal
2015 "MIND diet slows cognitive decline with aging", *Alzheimer's & dementia*, 11, 9, pp. 1015-1022. (Cit. on pp. xviii, 24, 26.)

Muyambi, Kuda, Bruce Gurd, Lee Martinez, May Walker-Jeffreys, Kari Vallury, Pauline Beach, and Shaun Dennis
2017 "Issues in using social return on investment as an evaluation tool", *Evaluation Journal of Australasia*, 17, 3, pp. 32-39. (Cit. on pp. xxii, xxiii, xxviii, 95, 96, 99, 106, 112, 114-116, 227, 232, 233.)

Natafgi, Nabil, Dan M Shane, Fred Ullrich, A Clinton MacKinney, Amanda Bell, and Marcia M Ward
2018 "Using tele-emergency to avoid patient transfers in rural emergency departments: An assessment of costs and benefits", *Journal of telemedicine and telecare*, 24, 3, pp. 193-201. (Cit. on pp. xx, xxi, 50, 51, 56, 57, 60, 64, 65, 76-78, 226.)

National Institute for Clinical Excellence
2004 "NICE guide to the methods of technology appraisal", *NICE, London*. (Cit. on pp. xvii, 6, 29, 31, 123, 226.)

National Research Council
2010 *Review of the Department of Homeland Security's approach to risk analysis*, National Academies Press. (Cit. on p. 74.)

Newcomer, Kathryn E, Harry P Hatry, and Joseph S Wholey
2015 *Handbook of practical program evaluation*, Wiley Online Library. (Cit. on p. 76.)

Nicholls, Jeremy
2007 "Why measuring and communicating social value can help social enterprise become more competitive", *London: Cabinet Office, Office of the Third Sector*. (Cit. on p. 82.)

Nicholls, Jeremy and Eilis Lawlor
2009 *A guide to social return on investment*, Office of the Third Sector, Cabinet Office. (Cit. on p. 15.)
2012 "A guide to social return on investment: The SROI network", *Accounting for Value*. (Cit. on pp. xvii, xxiii, xxiv, xxviii, 8, 143, 233.)

OECD

2017 *Health at a Glance 2017: OECD Indicators*, https://www.oecd.org/italy/Health-at-a-Glance-2017-Key-Findings-ITALY-in-English.pdf. (Cit. on p. 183.)

Office of Best Practice Regulation

2008 *Best practice regulation guidance note: value of statistical life.*

Oinas-Kukkonen, Harri

2010 "Behavior change support systems: A research model and agenda", in *International Conference on persuasive technology*, Springer, pp. 4-14. (Cit. on pp. 126, 135.)

O'Reilly, Daria, Jean-Eric Tarride, Ron Goeree, Cynthia Lokker, and K Ann McKibbon

2011 "The economics of health information technology in medication management: a systematic review of economic evaluations", *Journal of the American Medical Informatics Association*, 19, 3, pp. 423-438. (Cit. on pp. xx, xxi, 49, 51, 56, 57, 59, 62, 64, 65, 75-78, 226.)

Organization, World Health

2013 *Transforming and scaling up health professionals' education and training: World Health Organization guidelines 2013*, World Health Organization. (Cit. on p. 137.)

Orji, Rita, Julita Vassileva, and Regan L Mandryk

2014 "Modeling the efficacy of persuasive strategies for different gamer types in serious games for health", *User Modeling and User-Adapted Interaction*, 24, 5, pp. 453-498. (Cit. on p. 138.)

Palmer, Stephen

2008 "The PRACTICE model of coaching: Towards a solution-focused approach", *Coaching Psychology International*, 1, 1, pp. 4-8. (Cit. on p. 133.)

Peel, Nancye, Helen Bartlett, and Roderick McClure

2004 "Healthy ageing: how is it defined and measured?", *Australasian Journal on Ageing*, 23, 3, pp. 115-119. (Cit. on p. 20.)

Penedo, Frank J and Jason R Dahn

2005 "Exercise and well-being: a review of mental and physical health benefits associated with physical activity", *Current opinion in psychiatry*, 18, 2, pp. 189-193. (Cit. on pp. xviii, 21, 26.)

Pfister, Roman, Stephen J Sharp, Robert Luben, Nick J Wareham, and Kay-Tee Khaw

2011 "Plasma vitamin C predicts incident heart failure in men and women in European Prospective Investigation into Cancer and Nutrition–Norfolk prospective study", *American heart journal*, 162, 2, pp. 246-253. (Cit. on pp. 156, 165.)

Poder, Thomas G, Jihane Erraji, Lucien P Coulibaly, and Kouame Koffi
2017 "Percutaneous coronary intervention with second-generation drug-eluting stent versus bare-metal stent: Systematic review and cost–benefit analysis", *PloS one*, 12, 5, e0177476. (Cit. on pp. xx, xxi, 49, 55, 57, 60-62, 65, 69, 70, 72, 73, 75-78.)

Popay, Jennie, Helen Roberts, Amanda Sowden, Mark Petticrew, Lisa Arai, Mark Rodgers, Nicky Britten, Katrina Roen, Steven Duffy, et al.
2006 "Guidance on the conduct of narrative synthesis in systematic reviews", *A product from the ESRC methods programme Version*, 1, b92. (Cit. on pp. 45, 92.)

Preston, Samuel H, Patrick Heuveline, and Michel Guillot
2001 "[BOOK REVIEW] Demography, measuring and modeling population processes", *Population and Development Review*, 27, 2, pp. 365-367. (Cit. on p. 4.)

Quah, Euston and Edward Joshua Mishan
2007 *Cost-benefit analysis*, Routledge. (Cit. on p. 30.)

Quigley, Muireann
2013 "Nudging for health: on public policy and designing choice architecture", *Medical Law Review*, 21, 4, pp. 588-621. (Cit. on p. 134.)

Quotidiano sanità
2018 *I caregiver sono circa 8,5 milioni, 7,3 milioni lo fanno per i propri familiari. E chi aiuta di più sono spesso proprio gli anziani*, https://www.quotidianosanita.it/studi-e-analisi/articolo.ph.articolo_id=58181. (Cit. on pp. 159, 160, 171, 178, 186.)

Rajgopal, Radhika, Ruby H Cox, Michael Lambur, and Edwin C Lewis
2002 "Cost-benefit analysis indicates the positive economic benefits of the Expanded Food and Nutrition Education Program related to chronic disease prevention", *Journal of nutrition education and behavior*, 34, 1, pp. 26-37. (Cit. on pp. xviii, 23, 26.)

Ramon, Ismaila, Sajal K Chattopadhyay, W Steven Barnett, and Robert A Hahn
2018 "Early childhood education to promote health equity: a community guide economic review", *Journal of public health management and practice: JPHMP*, 24, 1, e8. (Cit. on pp. xxii, xxiii, 94, 98, 100, 101, 103, 107, 108, 111-114, 116, 227, 232, 233.)

Ricciuti, Elisa and Maria Vittoria Bufali
2019 "The health and social impact of Blood Donors Associations: A Social Return on Investment (SROI) analysis", *Evaluation and program planning*, 73, pp. 204-213. (Cit. on pp. xxii, xxviii, 95, 99, 102-104, 106, 108, 109, 111-116, 226, 232, 233.)

Roberts, A, G Holmes, C Thac, and P Oppenheim

1987 "The Economic Benefits of Participation in Regular Physical Activity Recreation Ministers Council of Australia". (Cit. on p. 22.)

Roper, Kathy O, Arya Sedehi, and Baabak Ashuri

2015 "A cost-benefit case for RFID implementation in hospitals: adapting to industry reform", *Facilities*, 33, 5/6, pp. 367-388. (Cit. on pp. xx, 47, 51, 53, 57, 59, 63, 65, 69, 70, 72, 73, 76-78.)

Rose-Ackerman, Susan

2016 "The Limits of Cost/Benefit Analysis When Disasters Loom", *Global Policy*, 7, pp. 56-66. (Cit. on p. 30.)

Rotheroe, Neil and Adam Richards

2007 "Social return on investment and social enterprise: transparent accountability for sustainable development", *Social Enterprise Journal*, 3, 1, pp. 31-48. (Cit. on pp. 123, 226.)

Roudsari, Bahman, Justin McWilliams, Brian Bresnahan, and Siddharth A Padia

2016 "Introduction to cost analysis in IR: challenges and opportunities", *Journal of Vascular and Interventional Radiology*, 27, 4, pp. 539-545. (Cit. on pp. xx, xxi, 49, 51, 55, 57, 60-65, 75-78, 226.)

Rousseau, Denise M, Joshua Manning, and David Denyer

2008 "11 Evidence in management and organizational science: assembling the field's full weight of scientific knowledge through syntheses", *The academy of management annals*, 2, 1, pp. 475-515. (Cit. on pp. 16, 31.)

Rozin, Paul, Sydney E Scott, Megan Dingley, Joanna K Urbanek, Hong Jiang, and Mark Kaltenbach

2011 "Nudge to nobesity I: Minor changes in accessibility decrease food intake". (Cit. on p. 134.)

Salmeron, Jorge, Frank B Hu, JoAnn E Manson, Meir J Stampfer, Graham A Colditz, Eric B Rimm, and Walter C Willett

2001 "Dietary fat intake and risk of type 2 diabetes in women", *The American journal of clinical nutrition*, 73, 6, pp. 1019-1026. (Cit. on pp. 156, 165.)

Saltelli, Andrea, Marco Ratto, Terry Andres, Francesca Campolongo, Jessica Cariboni, Debora Gatelli, Michaela Saisana, and Stefano Tarantola

2008 *Global sensitivity analysis: the primer*, John Wiley & Sons. (Cit. on pp. 76, 115.)

Samson, Anne-Laure, Erik Schokkaert, Clemence Thebaut, Brigitte Dormont, Marc Fleurbaey, Stephane Luchini, and Carine Van de Voorde

2018 "Fairness in cost-benefit analysis: A methodology for health technology assessment", *Health economics*, 27, 1, pp. 102-114. (Cit. on pp. xx, 49, 51, 55, 57, 66, 67, 75, 77, 226.)

San Raffaele

n.d. *L'attività fisica può prevenire il rischio di un infarto*, http://www.sanraffaele.it/comunicazione/SRpedia/3127/l-attivita-fisica-puo-prevenire-il-rischio-di-un-infarto. (Cit. on pp. 156, 165.)

Schneider, M, D Stokols, SA Shumaker, JK Ockene, and KA Riekert

2009 "The handbook of health behavior change". (Cit. on p. 134.)

Scrafford, Carolyn G, Xiaoyu Bi, Jasjit K Multani, Mary M Murphy, Jordana K Schmier, and Leila M Barraj

2019 "Health economic evaluation modeling shows potential health care cost savings with increased conformance with healthy dietary patterns among adults in the United States", *Journal of the Academy of Nutrition and Dietetics*, 119, 4, pp. 599-616. (Cit. on pp. xviii, 23, 26, 155, 156, 164, 182.)

Self, Peter et al.

2015 *Econocrats & the Policy Process: The Politics & Philosophy of Cost-Benefit Analysis*, Macmillan International Higher Education. (Cit. on pp. xvii, 7, 226.)

Sen, Amartya

2000 "The discipline of cost-benefit analysis", *The Journal of Legal Studies*, 29, S2, pp. 931-952. (Cit. on pp. xvii, xxiii, xxvii, 7, 226.)

Sheeran, Paschal, Peter M Gollwitzer, and John A Bargh

2013 "Nonconscious processes and health." *Health Psychology*, 32, 5, p. 460. (Cit. on p. 134.)

Sherrington, Catherine, Nicola J Fairhall, Geraldine K Wallbank, Anne Tiedemann, Zoe A Michaleff, Kirsten Howard, Lindy Clemson, Sally Hopewell, and Sarah E Lamb

2019 "Exercise for preventing falls in older people living in the community", *Cochrane database of systematic reviews*, 1. (Cit. on pp. xviii, 22, 26, 155.)

Siewiorek, Daniel, Asim Smailagic, and Anind Dey

2012 "Architecture and applications of virtual coaches", *Proceedings of the IEEE*, 100, 8, pp. 2472-2488. (Cit. on p. 136.)

Snell, Michael

1997 *Cost–benefit analysis: For engineers and planners*, Thomas Telford Publishing. (Cit. on p. 29.)

Social Value, UK

2012 "A guide to social return on investment", *US ed. Accessed April*, 18, p. 2015. (Cit. on pp. xxviii, 80, 81, 124, 225, 228, 234.)

Soga, Masashi, Kevin J Gaston, and Yuichi Yamaura
2017 "Gardening is beneficial for health: A meta-analysis", *Preventive medicine reports*, 5, pp. 92-99. (Cit. on pp. xviii, 25, 27.)

Sommers, Benjamin D
2017 "State Medicaid expansions and mortality, revisited: a cost-benefit analysis", *American Journal of health economics*, 3, 3, pp. 392-421. (Cit. on pp. xx, 49-51, 55, 57, 66, 77.)

Stake, Robert E
1995 *The art of case study research*, Sage. (Cit. on p. 126.)

Staman, J, L Kool, J Timmer, R van Est, and FWA Brom
2013 "Aanbieding rapport'Op advies van de auto'Tweede Kamer der Staten Generaal". (Cit. on pp. 135, 138.)

Stewart, Anita L and Abby C King
1994 "Conceptualizing and measuring quality of life in older populations." (Cit. on p. 20.)

Strawbridge, William J, Richard D Cohen, Sarah J Shema, and George A Kaplan
1996 "Successful aging: predictors and associated activities", *American Journal of Epidemiology*, 144, 2, pp. 135-141. (Cit. on p. 19.)

Tanaree, Athip, Sawitri Assanangkornchai, Wanrudee Isaranuwatchai, Kednapa Thavorn, and Peter C Coyte
2019 "Integrated treatment program for alcohol related problems in community hospitals, Songkhla province of Thailand: A social return on investment analysis", *PloS one*, 14, 1, e0209210. (Cit. on pp. xxii, xxiii, xxviii, 95, 98, 100-104, 106, 108, 109, 111-116, 227, 232, 233.)

Testa, Americo, Andrea Francesconi, Rosangela Giannuzzi, Silvia Berardi, and Paolo Sbraccia
2015 "Economic analysis of bedside ultrasonography (US) implementation in an Internal Medicine department", *Internal and emergency medicine*, 10, 8, pp. 1015-1024. (Cit. on pp. xx, xxi, 48, 51, 54, 57, 60-62, 65, 69, 70, 72, 73, 75, 77, 78.)

Thaler, Richard and Cass Sunstein
2008 "Nudge: The gentle power of choice architecture", *New Haven, Conn.: Yale*. (Cit. on p. 134.)

Then, Volker, Christian Schober, Olivia Rauscher, and Konstantin Kehl
2018 *Social Return on Investment Analysis: Measuring the Impact of Social Investment*, Springer. (Cit. on p. 84.)

Thompson, P and M Fahrenbach
1994 "Risks of exercising: Cardiovascular including sudden death", *Bouchard, C. y cols.: physical activity fitness and health*, pp. 1019-1028. (Cit. on p. 23.)

Tranfield, David, David Denyer, and Palminder Smart

2003 "Towards a methodology for developing evidence-informed management knowledge by means of systematic review", *British journal of management*, 14, 3, pp. 207-222. (Cit. on pp. 16, 31, 33, 84.)

Tur-Kaspa, Ilan, G Aljadeff, S Rechitsky, HE Grotjan, and Y Verlinsky

2010 "PGD for all cystic fibrosis carrier couples: novel strategy for preventive medicine and cost analysis", *Reproductive biomedicine online*, 21, 2, pp. 186-195. (Cit. on pp. xx, 50, 51, 56, 66, 69, 72, 77.)

Umberson, Debra and Jennifer Karas Montez

2010 "Social relationships and health: A flashpoint for health policy", *Journal of health and social behavior*, 51, 1 suppl, S54-S66. (Cit. on pp. xviii, 24, 27.)

UNDESA

n.d. "United Nations Department of Economics and Social Affairs, 2007", *Indicators of Sustainable Development–Guidelines and Methodologies. United Nations, New York*. (Cit. on p. 17.)

United Nations

2017 *World Population Prospects: The 2017 Revision*. (Cit. on pp. xviii, 4, 5.)

United Nations Department of Economic and Social Affairs

2017 *World population ageing 2017: highlights*. (Cit. on pp. xvii, 3.)

University of York. Centre for Reviews and Dissemination and Akers, Jo

2009 *Systematic reviews: CRD's guidance for undertaking reviews in health care*, Centre for Reviews and Dissemination. (Cit. on pp. 35, 86.)

Vaillant, George E and Kenneth Mukamal

2001 "Successful aging", *American Journal of Psychiatry*, 158, 6, pp. 839-847. (Cit. on pp. xviii, 19.)

Van Dam, Rob M, Walter C Willett, Eric B Rimm, Meir J Stampfer, and Frank B Hu

2002 "Dietary fat and meat intake in relation to risk of type 2 diabetes in men", *Diabetes care*, 25, 3, pp. 417-424. (Cit. on pp. 156, 165.)

Van Bel, Daniel T, KCHJ Smolders, Wijnand A IJsselsteijn, Yvonne de Kort, et al.

2009 "Social connectedness: concept and measurement." *Intelligent Environments*, 2, pp. 67-74. (Cit. on pp. xviii, 24, 27.)

Vannieuwenborg, Frederic, Thomas Van der Auwermeulen, Jan Van Ooteghem, An Jacobs, Sofie Verbrugge, and Didier Colle

2016 "Evaluating the economic impact of smart care platforms: qualitative and quantitative results of a case study", *JMIR medical informatics*, 4, 4, e33. (Cit. on pp. xx, 48, 51, 55, 57, 64, 65, 70, 72, 73, 75, 77.)

Venkatesh, Viswanath and Hillol Bala

2008 "Technology acceptance model 3 and a research agenda on interventions", *Decision sciences*, 39, 2, pp. 273-315. (Cit. on p. 154.)

Venkatesh, Viswanath and Fred D Davis

2000 "A theoretical extension of the technology acceptance model: Four longitudinal field studies", *Management science*, 46, 2, pp. 186-204. (Cit. on p. 154.)

Verbeek, Jos, Christina Mischke, Rachel Robinson, Sharea Ijaz, Paul Kuijer, Arthur Kievit, Anneli Ojajärvi, and Kaisa Neuvonen

2017 "Occupational exposure to knee loading and the risk of osteoarthritis of the knee: a systematic review and a dose-response meta-analysis", *Safety and health at work*, 8, 2, pp. 130-142. (Cit. on p. 174.)

Visconti, F and E Volani

2018 "Engaging with a virtual coach for healthy ageing: an empirical investigation of the intention to use through a tam-extended framework", *Tesi di laurea presso Universita Politecnico di Milano*. (Cit. on p. 154.)

Vishwanath, SR

2007 *Corporate finance: Theory and practice*, SAGE Publications India. (Cit. on p. 79.)

Vivienne, McNiven

2012 "" BUMS OFF SEATS" WALKING INITIATIVE IN FIFE: ITS SOCIAL RETURN ON INVESTMENT", in *JOURNAL OF AGING AND PHYSICAL ACTIVITY*, HUMAN KINETICS PUBL INC 1607 N MARKET ST, PO BOX 5076, CHAMPAIGN, IL 6182, vol. 20, S59-S59. (Cit. on pp. 89, 92.)

Von Faber, Margaret, Annetje Bootsma–van der Wiel, Eric van Exel, Jacobijn Gussekloo, Anne M Lagaay, Els van Dongen, Dick L Knook, Sjaak van der Geest, and Rudi GJ Westendorp

2001 "Successful aging in the oldest old: who can be characterized as successfully aged?", *Archives of internal medicine*, 161, 22, pp. 2694-2700. (Cit. on pp. xviii, 19.)

Walia, Harneet K, Hong Li, Michael Rueschman, Deepak L Bhatt, Sanjay R Patel, Stuart F Quan, Daniel J Gottlieb, Naresh M Punjabi, Susan Redline, and Reena Mehra

2014 "Association of severe obstructive sleep apnea and elevated blood pressure despite antihypertensive medication use", *Journal of Clinical Sleep Medicine*, 10, 08, pp. 835-843. (Cit. on p. 174.)

Walwyn, David R and Adolph T Nkolele

2018 "An evaluation of South Africa's public–private partnership for the localisation of vaccine research, manufacture and distribution", *Health research policy and systems*, 16, 1, p. 30. (Cit. on pp. xx, 47, 51, 53, 57, 66, 69, 72, 77.)

Wang, Chenchen, Raveendhara Bannuru, Judith Ramel, Bruce Kupelnick, Tammy Scott, and Christopher H Schmid

2010 "Tai Chi on psychological well-being: systematic review and meta-analysis", *BMC complementary and alternative medicine*, 10, 1, p. 23. (Cit. on p. 22.)

Warner, Teri

2012 "E-coaching systems: Convenient, anytime, anywhere, and nonhuman", *Performance Improvement*, 51, 9, pp. 22-28. (Cit. on p. 135.)

Westall, Andrea

2004 *Social Return on Investment: Valuing what matters. Findings and recommendations from a pilot study. London: New Economics Foundation.* (Cit. on p. 80.)

Whelan, Gayle

2015 "Understanding the social value and well-being benefits created by museums: A case for social return on investment methodology", *Arts & Health*, 7, 3, pp. 216-230. (Cit. on pp. 89, 92.)

WHO

2015 *World Health Organization fact sheet: obesity and overweight.* (Cit. on p. 23.)

WHO Global Health Estimates

2013 "WHO methods and data sources for global burden of disease estimates 2000-2011", *Geneva: Department of Health Statistics and Information Systems.* (Cit. on pp. 17, 18.)

Williams, Patrick

2012 "Looking back to see the future: The influence of humanistic and transpersonal psychology on coaching psychology today", *International Coaching Psychology Review*, 7, 2, pp. 223-236. (Cit. on p. 133.)

Wolever, RQ, M Dreusicke, J Fikkan, TV Hawkins, S Yeung, J Wakefield, L Duda, P Flowers, C Cook, and E Skinner

2010 "Integrative health coaching for patients with type 2 diabetes", *The Diabetes Educator*, 36, 4, pp. 629-639. (Cit. on p. 133.)

Wolever, Ruth Q, Leigh Ann Simmons, Gary A Sforzo, Diana Dill, Miranda Kaye, Elizabeth M Bechard, Mary Elaine Southard, Mary Kennedy, Justine Vosloo, and Nancy Yang

2013 "A systematic review of the literature on health and wellness coaching: defining a key behavioral intervention in healthcare", *Global advances in health and medicine*, 2, 4, pp. 38-57. (Cit. on p. 134.)

Wooldridge, Michael and Nicholas R Jennings

1995 "Intelligent agents: Theory and practice", *The knowledge engineering review*, 10, 2, pp. 115-152. (Cit. on p. 136.)

Workshop on Healthy Aging (Online)
2001 (Cit. on p. 19.)

World Health Organization
2015 *World report on ageing and health*, World Health Organization. (Cit. on pp. xvii, xxiv, 4-6, 18, 20, 21, 124, 147, 228, 234.)
2017 *Global Diffusion of EHealth: Making Universal Health Coverage Achievable: Report of the Third Global Survey on EHealth*, World Health Organization. (Cit. on pp. xxiii, 124, 227.)

Yao, Liu H, You-Ming Jiang, John Shi, FA Tomas-Barberan, Nivedita Datta, Riantong Singanusong, and SS Chen
2004 "Flavonoids in food and their health benefits", *Plant foods for human nutrition*, 59, 3, pp. 113-122. (Cit. on p. 24.)

Yeung, Jerf WK, Zhuoni Zhang, and Tae Yeun Kim
2018 "Volunteering and health benefits in general adults: cumulative effects and forms", *BMC public health*, 18, 1, p. 8. (Cit. on p. 25.)

Yin, Robert K
2017 *Case study research and applications: Design and methods*, Sage publications. (Cit. on p. 126.)

York Health Economics Consortium
2016 *Cost-Benefit Analysis [online]*. (Cit. on p. 30.)

Zappala, Gianni and Mark Lyons
2009 *Recent approaches to measuring social impact in the Third sector: An overview*. (Cit. on pp. 123, 124, 226.)

Zenghelis, Dimitri
2006 "Stern Review: The economics of climate change", *London, England: HM Treasury*. (Cit. on p. 76.)