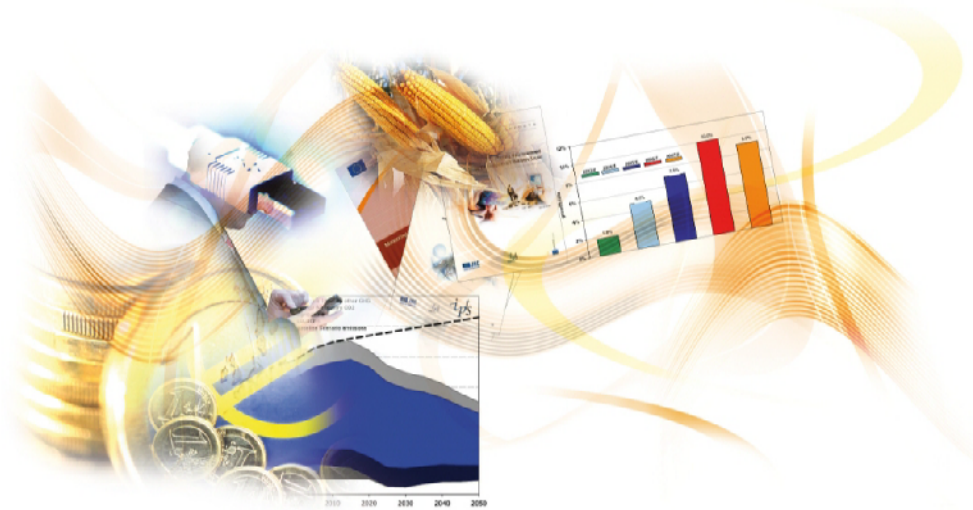# JRC Scientific and Technical Reports

Assessing the Impact of Integrated Personal Health and Care Services: The Need for Modelling

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Preface

This report contains the main findings of the scoping and exploratory research carried out in the course of 2010 by the SIMPHS research team (part of the TIESC Action within the Information Society Unit at IPTS[1]) on the broadly defined issue of assessing the micro and macro impact of Integrated Personal Health and Social Care Services (**IPHS**, see infra § 1.1 for the definition). SIMPHS, which stands for Strategic Intelligence Monitor of Personal Health Systems, is a three-year project collaboration between IPTS and Unit H1 (ICT for Health) of the European Commission's Directorate General Information Society. While this work is an integral part of ongoing research activities at IPTS, its strategic relevance has increased in the run up to the launch of the 2011 European Innovation Partnership on Active and Healthy Ageing, for which the SIMPHS project is expected to provide input during the impact assessment phase.

While one of the key results we present is the need for a modelling approach for the *ex ante* assessment of the potential impact of IPHS, the focus of this work was more broadly that of considering what evidence is available on the impacts of IPHS in particular and eHealth in general. In this respect, the material presented in this technical report represents a one-off contribution in terms of an updated, exhaustive, and interdisciplinary critical review of the state of the art. It is worth stressing that this report brings together, in a coherent framework, different strands of literature. It goes beyond the more specific sub-field dealing with the evaluation of eHealth and spans health economics, clinical studies, general approaches in economics, and general modelling and health-specific studies.

The initial driver to undertake this work came from the first year of research activities in the SIMPHS project, when we faced the challenge of analysing available evidence from evaluation studies to produce a preliminary extrapolation of the potential impacts of ICT-enabled Remote Monitoring and Treatment (RMT) of key chronic diseases such as Chronic Heart Failure (CHF), Type II Diabetes (henceforth simply Diabetes), and Chronic Obstructive Pulmonary Diseases (COPD). We were interested in three kinds of impact: a) improved health outcomes (i.e. improvement in key vital parameters, reduced mortality, delayed disease progression) and health-related quality of life for treated individuals (reduced burden of diseases on activities of daily living, increased convenience of being treated at home, etc); b) reduction in utilization of healthcare services (i.e. reduced hospitalisation); c) positive overspill in terms of market for the ICT industry and of increased productivity from fewer days lost to illness. To this end, we screened relevant sources (i.e. results of randomised control trials, meta analysis and reviews of these trials, general evaluation studies on the use of ICT in healthcare, etc) and we set out to gather at EU27 level all the relevant metrics (diseases prevalence, average costs per patient per disease, average costs of ICT-based RMT, ICT and personnel costs of RMT, etc). These activities were part of a broader focus on RMT innovation and market dynamics that is the object of the main deliverable of SIMPHS Phase 1.[2]

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[1] IPTS (Institute for Prospective Technological Studies) is one of the 7 research institutes of the European Commission's Joint Research Centre.

[2] See the core SIMPHS 1 Deliverable: Abadie, F., Codagnone, C., et al. (2010), *Strategic Intelligence Monitor on Personal Health Systems (SIMPHS): Market Structure and Innovation Dynamics*, JRC Scientific and Technical Report, Luxembourg: Publication Office of the European Union, ISBN 978-92-79-18947-0, (available at: http://ftp.jrc.es/EURdoc/JRC62159.pdf).

At the end of 2009, as a result of this preliminary work on issues of impact, we tentatively concluded that: a) the field of evaluation of ICT use in healthcare in general and of RMT in particular appeared fragmented and lacked conclusive shared evidence on impacts; b) there was a clear lack of EU-wide comparable data on key metrics (i.e. disease prevalence, disease costs, costs of ICT solutions); c) there was lack of evaluation of the potential macro-level overspills of using ICT in healthcare; d) there appeared to be no *ex ante* approaches and extrapolations available (if we do not consider very localised and limited business cases). Despite these evident limitations, we went ahead and delivered a very preliminary and static excel-based extrapolation to assess potential impacts.[3]

Against this background, in 2010 we set out to further scope and explore these issues to corroborate and/or rectify the tentative conclusions reached at the end of 2009. This activity was instrumental to both identifying new priorities for future research and to shaping the research activities foreseen for SIMPHS Phase 2. To this end, we launched the scoping and exploratory research, the main findings of which are the object of this report. This scoping and exploratory research was mainly based on desk research and on the re-elaboration of the gathered sources. It included:

1. A wide ranging critical review of health evaluation studies in general, that were selected irrespective of whether their focus was on ICT or non ICT-based interventions. The rationale was to identify approaches that could be applied to our specific focus.

2. A more in-depth and systematic critical analysis of evaluation studies focussed on the impact of using ICT in healthcare (so we selected not only those studies which strictly focussed on IPHS but also broader evaluations).

3. A monographic focus on modelling simulation approaches in general and on what specifically concerns healthcare.

Anticipating the main results of what follows in this report (further detailed in the body of the report), this scoping and exploratory research produced five key outputs:

1. First, it led us to conclude that in the short term a modelling simulation of IPHS impact is necessary in order to be able to support policy making with scientifically robust *ex ante* evaluation tools (see § 3.4.1).

2. As a result of this conclusion, it provided the theoretical and conceptual grounds to define a first pilot modelling exercise to be carried out by IPTS in the course of 2011 from which a longer-term modelling research agenda may be derived if the pilot is successful (see § 3.4.2and § 3.4.3).

3. It provided us with the insights on how to advance the agenda for building more robust evidence on the impacts of eHealth (see § 4.1).

4. It enabled us to identify and recommend Data Envelopment Analysis (DEA) as the most feasible way of conducting empirical *ex post* evaluations, not only of IPHS but also more generally of the ICT use in healthcare, or to put it better, of integrated ICT-based solutions (see § 4.2).

5. Finally, it contributed to shaping the research design of SIMPHS 2 to address the data constraints mentioned earlier and to be synergic with current and future modelling activities (see § 4.3).

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[3] The logic and results of this preliminary extrapolation are reported in full in Abadie, F., Codagnone, C., et al. (2010), *Strategic Intelligence Monitor on Personal Health Systems (SIMPHS), op. cit.*, pp. 45-55.

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1. Introduction: context and rationale

1.1. Healthcare in the twenty-first century: grand societal challenge

In the EU19 countries, for which data are provided in the OECD Health Data 2010, spending per capita rose on average by over 154% in real terms between 1990 and 2007 (with an average yearly real term growth of around 8%).

Figure 1: $[4] PPP per capita spending growth in EU19: 1990-2007[5]
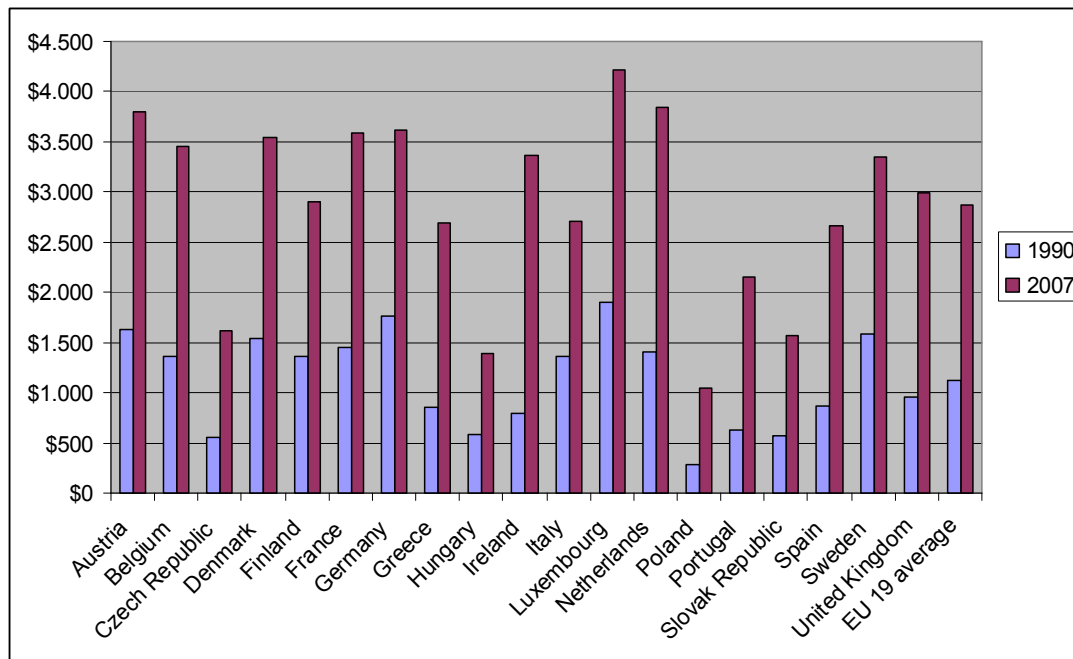
Source: OECD Health Data 2010.

Between 1960 and 2007, Life Expectancy at Birth (LEB) grew by more than 10 years and on average reached 79.1 years in OECD countries. Yet, a recent OECD efficiency frontiers-based forecast analysis shows that increasing spending by 10% a year in the next decade can at best produce a 3 to 4 month increase in LEB [1] [p. 61]. The same analysis also shows that there is no strong or statistically significant correlation between healthcare output (i.e. measured by number of hospital interventions and/or consultations with clinicians) and health outcomes such as LEB and several others [1] [p. 27].

Increased spending, however, is running up against a wall of decreasing returns and also budget constraints. As shown in Figure 2, total expenditure has reached on average almost 9% of GDP, and the part of this spending funded from the public budget is now at 6.6%. This is certainly a concern for EU27 countries where public deficits have climbed to 7% of GDP on average, and debt levels are over 80% of GDP, as stressed in the new EU 2020 strategy[2] [p. 5]. Just to provide a concrete volume figure to be used later, it can be estimated[6] that in 2008 total EU19 healthcare expenditure was about € 1 149 billion.

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[4] OECD Health Data 2010 provides expenditure data in purchasing power poverty terms only expressed in US $.

[5] Data for Hungary refer to 1991, for Luxembourg to 1995, and for Slovak republic to 1997 (instead of 1990). Data for Portugal and Luxembourg refer to 2006 instead of 2007.

[6] OECD health data provides total expenditure at US $ exchange rate in 2008 for all countries except Denmark, Greece, Luxembourg and Portugal. For these four countries we projected expenditure in 2008 using growth rates

Figure 2: Total and public healthcare expenditure as a % of GDP: 2007[7]
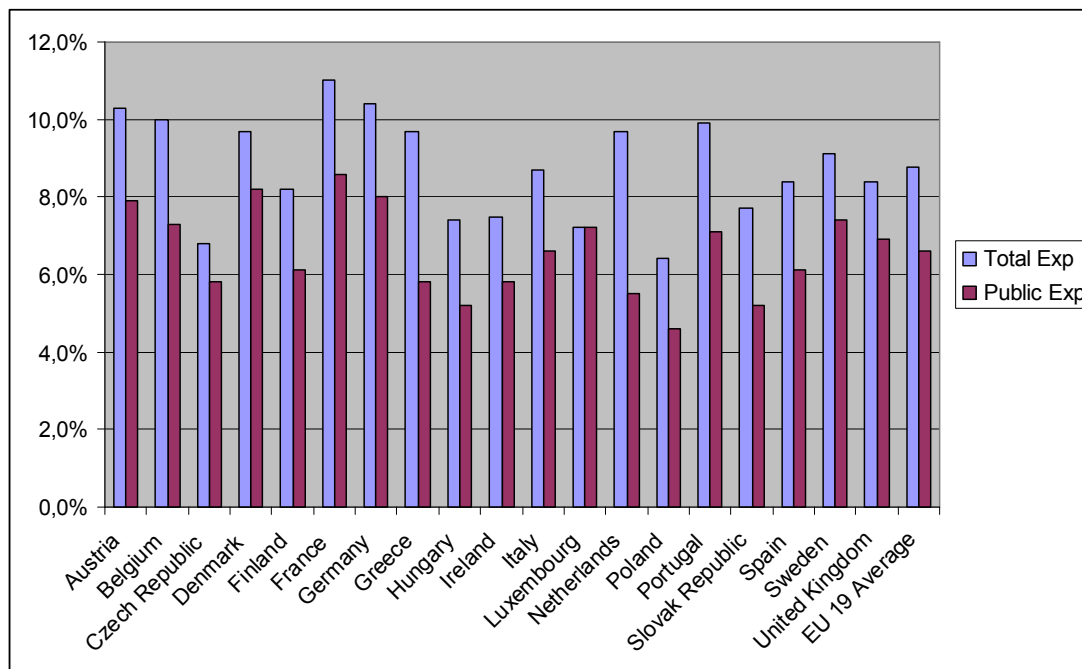
Source: OECD Health Data 2010

According to OECD projections[3], combined public expenditure for health and long-term care, starting from approximately 7% of GDP today, could grow by 3.5% (*cost containment scenario*) and 6% (*cost pressure scenario*) points of GDP by 2050.[8] The main drivers of rising costs are expensive developments in medical technologies, relative prices,[9] and ageing.

Apart from financial considerations, the ensuing demographic trends are challenging for the sustainability of health and long-term care and for society as a whole. Population ageing also has an impact on the old-age dependency ratio that will go from the current level of 0.25 (one elderly person to four active individuals) to 0.33 (one elderly person to three active individuals) in 2020 and could reach almost 0.5 (one elderly to two active) in the coming decades. This means that the pool of taxpayers will shrink at the same time as the numbers of individuals in need of healthcare and welfare assistance will increase. This is particularly worrying for Europe if we consider that today on

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in previous years (2005-2007). We, thus, obtained a total of US $ 1 494.6 billion, which we converted into Euro using the average exchange rate of 1 € = 1.3 US $.

[7]   Data for Portugal and Luxembourg refer to 2006, for the Netherlands to 2002, instead of 2007.

[8]   Although there are also less alarming forecasts such as those provided in the European Commission *Ageing Report 2009* [4]. Much of the variance in the forecasts depends on how the population ageing effect is factored in. Two possible opposing scenarios can be considered: a) increased longevity comes with rising disease and disability burden, as for instance affirmed by Olansky et al [5]; b) increased longevity will occur with increasing numbers of people living longer and healthier, as foreseen for instance by Fries [6]. Striking a balance between these two scenarios, Manton put forward the 'dynamic equilibrium' hypothesis where longevity gains are translated one-to-one into years in good health[7].

[9]   Healthcare costs have historically grown faster than income. This is generally held to be due to the effect of technology and relative-price movements in the supply of health services. Technical progress can be cost-saving and reduce the relative price of health products and services, but its impact on expenditure will depend on the price elasticity of the demand for healthcare. If it is high, a fall in prices will induce a more than proportionate rise in demand, increasing expenditures. Even if prices do not fall, new technologies may increase demand by increasing the variety and quality of products. In the case of long–term, care its relative price may increase in line with average productivity growth in the economy because the scope for productivity gains in long-term care is more limited.

average only 46% of older workers (55-64) are employed in the EU27 as compared to 62% in the US and Japan[2]. Additionally, we should not forget the expected shortages of healthcare professionals [8], long-term care workers[9], and informal carers.[10]

In addition to all these pressures, we should not forget the new wave of poor health, which can be seen for instance in the rising prevalence worldwide of obesity and Type II Diabetes across all age groups (including children and adolescents), caused by the unintended consequences of modern lifestyles[10].

The use of ICT in healthcare or eHealth is a possible solution which could contribute to successfully coping with this societal challenge. In the descriptive and non taxonomic definition provided in 2004 by the European Commission Action Plan, eHealth is defined as referring to "*the application of information and communications technologies across the whole range of functions that affect the health sector' and including 'products, systems and services that go beyond simply Internet-based applications*"[11][11] [p. 4]. So, it more or less coincides with what in the US context and in many scientific journal articles is referred to as Health Information Technology (HIT).[12] A particularly promising subset of eHealth comprises what we call **IPHS**, which stands for extramural (outside of institutionalised care) Integrated Personal Health and Social Care Systems that we define as follows:

"*IPHS address the health and/or social care needs of individuals outside care institutions and support the work of care providers in an integrated fashion: 1) they can integrate social assistance, remote monitoring of chronic diseases, prevention, wellness and fitness; 2) they are produced as a result of integration of different institutional and information systems. They are personal and possibly personalised in the way they gather, process and communicate data (for feed-back/action). They are supported by the following technological layers: a) ambient and/or body (wearable, portable or implantable) sensor devices, which acquire, monitor and communicate physiological parameters and other health and social relevant context of an individual (e.g., vital body signs, biochemical markers, activity, emotional and social state, environment); b) intelligent processing of the acquired information to derive insights about individual's health and social status and support/trigger the activity of professionals; c) active feedback to the users, either from professionals or directly from the devices (i.e. through persuasive technologies and serious gaming)*".

IPHS can contribute to better monitoring of diseases (i.e. remote monitoring and treatment), provide support for dignified and independent living (i.e. telecare and Ambient Assisted Living, AAL), help prevent the onset of diseases and produce wellness

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[10] As explained in both of the two OECD studies cited in the previous footnotes, the increasing predominance of nuclear families, work force feminisation, and work force mobility, are all factors reducing the pool of informal carers (family and friends) and adding to the already strong demand side pressures on both healthcare and LTC.

[11] An equally illustrative but more organized definition can be found in the report drafted by the eHealth task force in support of the Lead Market Initiative [12]. In this source, the various items of the action plan definition are grouped into four categories: 1) Clinical information systems (specialized tools for health professionals within care institutions, tools for primary care and/or for outside the care institutions); 2) Telemedicine and homecare systems and services; 3) Integrated regional/national health information networks and distributed electronic health record systems and associated services; 4) Secondary usage non-clinical systems (systems for health education and health promotion of patients/citizens; specialised systems for researchers and public health data collection and analysis; support systems for clinical processes not used directly by patients or healthcare professionals.

[12] Actually neither expression reflects what it really intends to include well. eHealth indeed may suggest only online applications, whereas HIT seems to exclude them. ICT for Health would be a better expression, yet we stick to eHealth, given its more widespread usage.

(i.e. mobile health, persuasive technologies, serious gaming). These contributions can, at the same time, improve quality of life and health outcomes, contain costs, and create market opportunities in very innovative industries such as those producing sensors, nanotechnologies, data processing software, etc.

1.2. Two extra years of healthy life by 2020: the evidence gap

Sustainability and public budget issues are only part of the picture and should not be pursued as objectives at the expense of the quality of health outcomes in the Members States. At least, this is not the vision of the new EU Strategy 2020 where ageing and healthcare figure prominently as a societal grand challenges that can be turned into an opportunity for smart, innovative, and inclusive growth. EU2020 includes the acceleration of demographic ageing and the low workforce participation of older workers (55-64 age group) as sources of structural weakness in Europe, and considers ageing among the long-term global challenges that the European social market model is facing. On the other hand, the strategy stresses innovation as a source of potential inclusion and growth and singles out the potential of Information and Communication Technology (ICT)-enabled innovation in general and in particular in the field of active and healthy ageing. A topic also included in the new Digital Agenda for Europe [13]. As a matter of fact, the European Innovation Partnership (EIP) on Active and Health Ageing is the first, among the innovation flagship initiatives envisaged in EU2020 Strategy, to be launched in 2011. IPHS clearly constitute one of the key components that the upcoming EIP on Active and Health Ageing aims to mobilise and, particularly, it can contribute to the declared target of adding two years of healthy life for all Europeans. The targets, the areas of focus, and the triple-win sought by the upcoming EIP (see more on these below) perfectly reflect the discussion conducted so far and *de facto* place innovations such as the widespread introduction of IPHS centre stage. So far, however, despite the existence of clear pressures and drivers and the availability of all the technological solutions, adoption of IPHS remains very limited, which brings us to address the evidence gap.

This promising context suffers, in fact, from an important gap in our scientific understanding of the phenomena at hand. In this report, we scope and analyse this gap in depth.

As shown in more detail later (Section 3 and especially § 3.3), we are still faced with inconclusive and fragmented *ex post* evaluation evidence on the cost effectiveness of adopting eHealth applications in general and IPHS services in particular. Moreover, there are practically no sophisticated *ex ante* tools, leaving aside rudimentary and static business case calculations, to simulate the potential impact of alternative interventions and investments in eHealth or IPHS. It is a fact that the lack of more sophisticated evidence on the micro and macro economic impacts of IPHS can hinder the diffusion and adoption of such services at national, regional, and local level. As policy makers have no evidence, they do not see the incentives and have no arguments to overcome traditional resistance to innovation. Alternatively, policy and investments can drift away in unintended directions when they are based on poor evaluation. Evaluation in its pristine sense means identifying cause and effect relations and assigning them a value (the measurement side of evaluation). This entails having a theoretical understanding of a phenomenon in order to make a hypothesis about cause and effect and then gather relevant data to test and prove it scientifically.

Let us further illustrate the implications of lacking evidence by looking more closely at the proposed target and areas of focus of the EIP on Active and Health Ageing, and the benefits it seeks. The EIP is still in the public consultation phase at the time of writing and its goals and contents, still preliminary, can be obtained from the consultation website[13] and from the website dedicated to the innovation union concept.[14] Combining the information from these two websites, we can sketch the following brief summary:

- Main Target: add 2 years to the average healthy lifespan in the EU by 2020.
- Areas of focus:
   o Prevention and health promotion - medical technology, medicines and treatment for age-related chronic diseases and others;
   o Integrated health and social care for the elderly, improving home-based care and self-care; and new large-scale, innovative solutions for long-term care of the elderly;
   o Independent, active living for elderly people, supported by innovative products, devices and services.
- Triple wins sought:
   o Enabling EU citizens to lead healthy, active and independent lives while ageing;
   o Improving the sustainability and efficiency of social and healthcare systems;
   o Boosting and improving the competitiveness of the markets for innovative products and services, responding to the ageing challenge at both EU and global level, thus creating new opportunities for businesses.

Yet, what do we know about the Last Years of Life (LYOL) and especially about how ICT-enabled services and innovation such IPHS can contribute to increasing healthy life while containing cost and boosting economic opportunities? Figure 3, which includes only a very selective list of scientific contributions from the vast literature surrounding the debate on LYOL, provides some interesting but not univocal insights. As argued [14-16], the idea that dying people at the end of their lives receive large and expensive 'doses of care' should still be considered a widely-held belief that is not fully confirmed by evidence. Additionally, the large variation observed in the costs of LYOL across several dimensions suggests that a single general population model may not be capable of fully capturing the phenomenon[17]. The only non-contradictory evidence, reported by different studies, is that LYOL costs tend to be higher for relatively younger cohorts than for older ones. Additionally, LYOL raise an important issue of quality of care with respect to emotional need, regardless of medical treatment. Finally, the very specific conditions of the individual and of the disease or impairment he or she is affected by clearly make a difference to both the costs and the kind of care needed during his or her LYOL. Last but not least, we should also recall that, in the literature, there is a clear variance in the forecasts about the impact of ageing on healthcare costs. Much of this variance depends on how the population ageing effect is factored in. Two possible opposing scenarios can be considered: a) increased longevity will come with rising disease and disability burden, as for instance affirmed by Olansky et al [5]; b) increased longevity will occur with increasing numbers of people living longer and healthier, as foreseen for instance by Fries [6]. Striking a balance between these two scenarios, Manton put forward the 'dynamic equilibrium' hypothesis where longevity gains are translated one-to-one into years in good health[7].

Against this background, let us put forward some logical and hypothetical reasoning on the target, areas of focus, and triple-win of the EIP in relation to the potential contribution of IPHS.

First, the earlier-cited OECD study[1] shows that investing more money only on the supply side of healthcare (where we include eHealth application aimed only at helping professionals to provide better care) can add a maximum of three to four extra months increase in life expectancy in the next 10 years. Second, illness or wellness in LYOL are determined mostly through trillions of small lifestyle choices made by individuals every day long before they could conventionally be considered elderly (65 and above age group). Third, once chronic and other age-related diseases have emerged, they cannot be reversed - they can only be managed.

Figure 3: End of Life Years: Illustrative examples from the scientific literature

Evidence on cost at end of life:

- **Data on Medicare enrolees who died in 1978**. Only 6% of people who died had more than $ 15 000 in Medicare expenses in their last year of life.[14]
- **Longitudinal US hospital study (1992-1997)**. This study shows: a) great variation in hospital-intensive use at end-of-year point, but also that this is mostly low; b) last hospital stay was infrequently resource intensive; c) type of use not explained in statistically significant way by age, gender, or illness[16];
- **Random sample of aged Medicare beneficiaries who died 1996 to 1999**. Older beneficiaries have higher expenditures in the second and third years before death but lower expenditures in the last year of life (LYOL). On average, the youngest cohort spent $ 8 017 more in the LYOL than the oldest cohort, whereas in the third year before death, the oldest cohort's expenditures were $ 5 270 more than those for the youngest cohort [5]
- **2006 Dutch study using health insurance data on 2.1 million people**. On average, costs for younger decedents were higher than for people who died at higher ages. Costs per decedent were 13.5 times higher than average costs for the whole population and were approximately 14 906 Euro in the last year of life. The decline of costs in the last year of life with increasing age will have a moderate lowering effect on the growth of healthcare expenditure. The projection from this study shows a 10% decline in the growth rate of future health expenditure compared to conventional projection methods[15];
- **2006 Australian study**. Older decedents were not more likely to be hospitalised than younger decedents in the final three years of life. Moreover, once hospitalised, their in-patient costs were lower. In-patient costs were heavily concentrated in the three last quarters of life[18]
- **2008 Australian study**. Prior to the last 5 months of life, the mean cost of hospitalisation was positively associated with age. However, the magnitude of the cost increase in the last 5 months of life was inversely related to age in such a way that the cost in the last month of life was similar across age groups. The finding that increased costs are associated with proximity to death, but that the magnitude of the increase is inversely associated with age, has implications for the ongoing debate about whether proximity to death or age is the dominant driver of healthcare costs. [17]

Quality of life considerations:

- **Qualitative analysis of Medicare claims in the last 3 years of life**. In 75% of cases, people lacked continuity of care that could have improved their quality of life and the way they died, and in 13% of cases a medical error was identified by the analysis[19].
- **Old age-based rationing of healthcare and its implications**. Old age-based rationing of healthcare takes places both implicitly and explicitly. Its effects show on an emotional level and it affects medical practice. A distinction is made between explicit and implicit healthcare rationing. For example, performing fewer human organ transplants can be regarded as explicit rationing. Implicit or soft rationing may arise through either an undersupply of medical and nursing staff or through an oversupply of medical care as a consequence of the DRG bonus system. In this way, an underlying and misleading incentive for an oversupply of diagnoses and treatments is created while at the same time the pressure is increased to reduce the length of hospital stay. Consequently, patients miss out on what they need most at this late stage of life: care and time to

Fourth, LYOL costs vary depending on whether one gets there with co-morbid chronic conditions (requiring costly interventions to alleviate suffering before death) or after a relatively healthy life. One of the reasons why LYOL costs are higher for relatively younger cohorts (i.e. those dying around the age of 65 compared to those dying around the age of 80) is that in many cases longevity is not necessarily associated with the prevalence of acute chronic conditions but rather with age-related functional frailties (in this case, fortunately, there is no need for either management or prevention and ICT applications can possibly be of help for independent living). Fifth, and we provide evidence for this later, the better chronic diseases are managed, the longer individuals will live, which means prevalence increases and costs cannot decrease, since chronic diseases cannot be reversed and the continuation of life ensured by good management cannot restore good health. Indeed, only prevention can ensure longer and healthier lives and lower healthcare costs at the same time.

These five considerations raise some issues if we consider jointly the EIP target, areas of focus, and the first two of the triple wins. Longer and healthier lives do not seem to depend exclusively on management and prevention addressing the elderly. Either healthy longevity does not require management of chronic conditions but only assistance of a dignified and independent life, or if chronic conditions are present they cannot really be prevented in the true sense of the word (only secondary and tertiary prevention can be applied, which can be considered part of management). This points to the issue of where the beginning of ageing is set, considering that the process of ageing starts the very same day we are born. It also reminds us of the importance of keeping older workers (55-64) active in the labour force for longer. In this respect, it is worth noting that expenditure for prevention and management among relatively younger cohorts (such as the 55-64 age group) would more than compensate not only in terms of reduced medical costs but also in terms of gained or retained productivity. If ageing concerns only the very elderly, then for some people the two extra years of life will not be healthy and will require a lot of management (chronic co-morbidities cannot be prevented), while for others, they may only require assistance. In both cases, it seems unlikely that healthier and more independent lives and system sustainability and efficiency will be achieved at the same time.

Yet, all the above speculative reasoning could radically change, if we had evidence on how IPHS innovations could modify some of the parameters used in such reasoning. Remote monitoring and treatment could, for instance, reduce hospitalisation costs while at the same time increase life-span at objectively and subjectively defined higher levels of health-related quality of life. In this scenario, it would no longer be true that better disease management cannot be matched by containment of costs. Mobile health applications for wellness and primary/secondary prevention, which address at-risk people aged 55-64, could increase their productivity and working lives while avoiding current and future costs. Integration of remote-monitoring with telecare/ AAL,

depending on the profiles of the elderly, could create synergies between health and social care and ease the burden carried by the shrinking pool of professionals. The market opportunities generated for innovative industries and their spill-over on GDP growth may justify public investments even in a scenario where gains in medical cost reduction are modest: improved health outcomes and quality of life gains plus economic growth in several industries would make the business case even if medical costs did not decrease (public budget gains from increased tax revenues would compensate for the lack of net savings in healthcare spending).

Having all of the above evidence would greatly help the Commission and the Member States when they come to operationalise the EIP on Active and Healthy Ageing: a) to define the specific target; b) to allocate scarce resources to alternative courses of action; c) to use more holistic evidence including cross-sectoral spill-over effects going beyond the simple comparison between, on the one hand the costs of intervention, and the medical savings and health outcomes on the other. Unfortunately, this kind of evidence is still fragmented or totally lacking and this is why we set out to scope and analyse the field. Having carried out this exercise, we conclude that an exploratory modelling of IPHS impacts is urgently needed.

1.3. Scope and structure of this report

Before illustrating the scope and structure of this report, we still need to make a final terminological and conceptual clarification.

Evaluation, like any other science, can be only empirical (simply descriptive or inductive using results of experiment), analytical and theoretical (models and hypotheses tested through empirical data), or computational (where the dynamic of complex systems are simulated with the support of computer software). We can group for simplicity the first two approaches and call them 'observational', while we call the third 'computational':

- observational approaches collect empirical data (through observation, surveys, and various other method) analyse them and in some case use the data to solve analytically a model and estimate its parameters;

- computational approaches start with a theoretical understanding of a phenomenon. A model is then derived from it and the phenomenon's dynamics are simulated (using empirical parameters calibrated into the model and imposed 'what if' policy shocks) to better understand processes or causal relations[22]. As a general rule, scientists move to computational approaches when systemic complexity makes the theoretical models too complex to solve analytically with empirical data. Computational approaches in evaluation are the best-suited and most sophisticated tools for *ex ante* analysis, where they should use input from *ex post* observational studies. Henceforth, we will use the term "modelling" to refer only to computational approaches, whereas the term 'model' will be used to refer to analytical approaches solved with empirical data.

As anticipated in the Preface, during the course of the 2010 scoping and exploration activities whose findings are the basis of this report, while we looked at the field of healthcare evaluation generally (regardless of whether or not the focus is on ICT or non-ICT interventions), we also devoted a specific focus to the issue of modelling approaches in healthcare, and we went further and deeper into the study of eHealth evaluation than

we had done earlier in 2009, as reported in SIMPHS Phase 1 core deliverable.[15] Accordingly, in **Section 2** we discuss evaluation and modelling in healthcare in general, focussing on approaches and examples that do not consider ICT as a separate treatment variable. This was done, both to gain important methodological insights and to compensate for the lack of a consolidated approach in the field of eHealth (particularly for what concerns modelling). In this section, we also establish a general framework to map the kinds of evaluation that are possible and the key concepts and variables to be considered. Next, in **Section 3**, we critically review the state of the art in evaluation of eHealth, with a short introduction on what is done in the broader field of the economics of ICT (to extract also from this field some insights and to assess the suitability of a general economic approach to ICT in the field of eHealth). In § 3.4, we reach the conclusion that there is a short term need for a pilot modelling exercise on the micro and macro impacts of IPHS. In this same paragraph, we present the rationale and design for the exploratory modelling that will be carried out by IPTS during 2011. Finally in Section 4, we present our conclusions on the implications of our findings, further illustrating the outputs anticipated in the Preface (the last three, as the first two are presented in § 3.4).

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[15]   See Abadie, F., Codagnone, C., et al. (2010), *Strategic Intelligence Monitor on Personal Health Systems (SIMPHS), op. cit.*, pp. 45-55, and Chapter 9.

2. Evaluation within the health ecosystem: framework and examples

2.1. What is evaluated and how

While a more systematic approach with an economic flavour is the specific domain of health economics,[16] the study and evaluation of the interaction between input, output, and outcomes within the health ecosystem is a multidisciplinary undertaking involving, among others, public health and epidemiological studies, clinical studies, broader economic analysis, and market studies.

Figure 4: Framework of evaluation in the health ecosystem
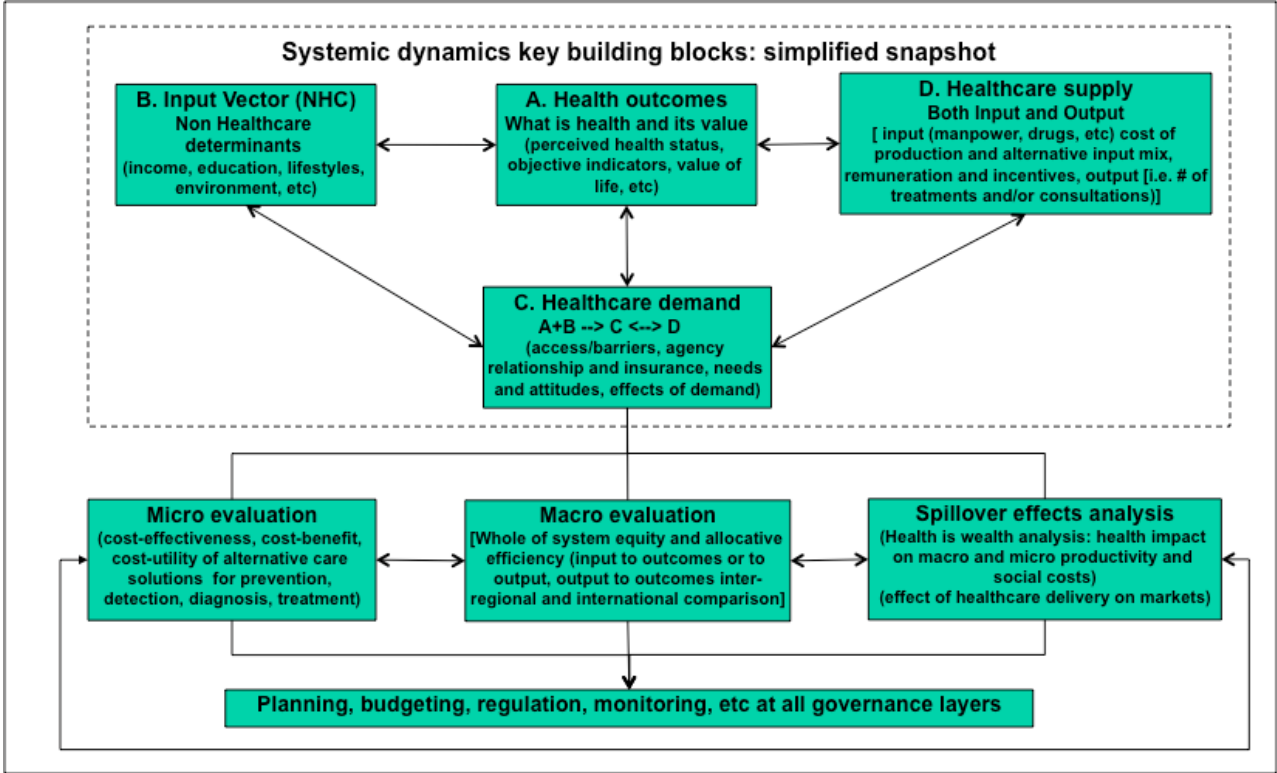
Source: Authors' re-elaboration from Culyer and Newhouse[24].[17]

The top of Figure 4 provides a simplified snapshot of the key blocks of factors interacting within the ecosystem, whereas the bottom part shows the kind of evaluation and analysis that can be applied to this interaction, and an indication of the usage of such evidence (for planning, budgeting and decisions on public health investments, regulation, monitoring, etc.). In a way, blocks A to D are the 'engine room' for evaluation and analysis. They need to be conceptually defined, a hypothesis must be developed regarding their interactions, and above all they must be measured (indicators defined and data gathered to measure them).

The starting point within the systemic dynamic is that of health outcomes or health status, **Block A,** which also points to the conceptual and measurement foundations for any subsequent analysis and evaluation. The key questions are how health outcomes or

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[16]   Health economics is itself a multidisciplinary form of applied economics grounded in four traditional areas of economics: finance and insurance, industrial organisation, labour and public finance[23].

[17]   They further developed a framework originally elaborated by Williams [25].

status can be measured, what objective and subjective (self-perceived status) measures are needed and possibly integrated, and what the value of life is. There are quite a large number of consolidated objective indicators of health outcomes at aggregate level, such as: Life Expectancy at Birth (LEB); Life Expectancy at 65 (LE65); Potential Years of Life Lost (PYLL); Infant Mortality (IM); Health Adjusted Life Expectancy (HALE) at birth; Amenable Mortality (AM). More specific metrics, entailing more difficulties for the gathering of robust data (especially at the level of international comparisons), include prevalence (a stock) and incidence (a flow) of diseases or of other relevant parameters such as obesity. At the more micro level of, for instance Randomised Control Trials (RCT) assessing the impact of intervention on treated and non-treated groups, there are objective clinical parameters to measure the health outcomes (for instance Haemoglobin A1c for Diabetes; forced expiratory volume in 1 second for COPD; or Ejection Fraction (Ef) for CHD).

It is, however, of great importance to also have measurements of self-perceived health status in general and after receiving a treatment. This is so for at least two reasons. First, because ethically the real usefulness to the end user must guide any intervention and medical professional decisions should be assessed against the user perspective. Second, since in many instances there is no charge for healthcare services (that would measure individuals' willingness to pay directly and, indirectly, their appreciation of the quality of received services), we need ways to measure the benefits associated with alternative allocations of scarce resources from the perspective of the recipients of healthcare services. For this purpose, health economics has developed Health-Related Quality of Life (HRQoL) indexes that are used to calculate Quality Adjusted Life Years (QALY). In short, through surveys of both users and experts, indexes are built as to how much having a particular disease at a particular level of intensity subtracts from the full quality of life one would enjoy without such a condition. QALY indexes vary from 1= perfect health and 0= death. So, assume having asthma at a moderate level is associated with an index of 0.70, this means that an individual with moderate asthma every year loses 0.3 QALY, or that each additional year of life with asthma is worth 0.7 QALY.[18] The related and controversial issue is about the monetary value of a QALY. In this respect, the monetary value of life is a much-debated issue, from the perspective of the ethics

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[18]   The body of literature on QALY is vast and we have selectively reviewed it to provide the basic understanding illustrated here [26-73]. One standardised and widely-used HRQoL index is the 15-D index [66], which includes 15 dimensions (i.e. breathing, mental functioning, vision, speech, etc). The development of 15-D entails two steps. First, subjects are asked to rate each dimension on 1-5 scale, assessing how they feel about them. Within each dimension each point on the scale is assigned a value that represents the functioning level. Second, the 15-D investigators assign a second set of weights to each of these 15 dimensions using responses from community surveys to reflect the importance of each dimension. Naturally, 15-D is not the only HRQoL index available. Much used by economists is the new and simplified Euroqol 5D index (see for instance illustration in Williams [72]). Allegedly, compared to other indexes, Euroqol has been developed with a view to constructing an index that reflects the evaluation of the general public rather than the views of healthcare professionals. To further illustrate how can QALY be used, it is worth comparing it with the Disability Adjusted Life Years (DALY) measure elaborated by World Bank experts such as Murray and Lopez [74]. The DALY measure has been developed in order to calculate the loss, expressed in terms of years of life in full health, associated with premature mortality or with being sick (morbidity). DALY measures health status in terms of losses from a normative benchmark, and in this sense differs from QALY that measures gains. So, the latter is a measure to assess the impacts of an intervention, whereas the former is mostly used to assess the disease burden situation. Therefore, QALY is the tool to measure the health-related quality of life outcome of an intervention (e.g. RMT) in terms of gains in health. QALY can be used as an indicator in Randomised Clinical Trials, in addition to the classical ones on "reduced mortality" and "reduced hospitalisation". Once all the information about the cost of an intervention has been tested in RCT, one could calculate the cost-per-QALY ratios as a measure of cost-effectiveness. It is worth noting that in none of the articles reporting results of RCT on telemonitoring of chronic patients is a cost-per-QALY ratio used.

and philosophy of health economics.[19] One position in this debate is that healthcare policies and programmes should be assessed primarily from the perspective of their effect on life expectancy and of HRQoL, whereas the monetary value of these measures is only of secondary importance. On the other hand, from the perspective of healthcare funding authorities, having a monetary measure of QALY to include in Cost-Effectiveness Analysis is useful when allocating scarce financial resources to alternative investment possibilities. In the UK, for instance, the National Institute for Health and Clinical Excellence (NICE) must decide how much it can afford to pay for a gain of one QALY while operating on a fixed budget. So the argument goes that, assuming that QALY values reflect the preferences of consumers, having this value would enable policy makers to make informed decisions on budget allocations that at least proxy the market mechanism. In this context, the NICE has established the following thresholds: a new medical technology can cost a maximum of GBP 30 000 (€ 35 800) per produced QALY[55]. Finally, it must be noted that ready-made and comparable QALY measures exist only for a few diseases and for a few countries[1] [pp. 48-49].

Block B concerns the Non-Health Care (NHC) determinants of health status including among others, the following: a) *income and education* (but also gender, age, ethnicity, level of embeddedness into networks of social relations and support); b) *lifestyle variables* such as: food consumption (Kcal per capita per year, grams of fat intake per capita per year, kilograms of sugar consumption per capita per year; kilograms of fruit and vegetable consumption per capita per year[20]); alcohol and tobacco consumption; Physical Activity Levels (PALs); c) *environmental conditions* such as air pollution and level of water sanitation. In Figure 4, we have called this the "Input Vector" since a large number of such factors are generally included in regression equations on the independent variables size as in the last analysis carried out by the OECD [1]. They are not input in the stricter sense from the perspective of policy and/or specific healthcare and public health interventions, yet policies can also be affected by them (i.e. agricultural policy to change the relative price of food so that the cost of fruit and vegetables is comparable with that of junk food). Data and analysis on most of these variables come from other disciplinary fields and, although they are not always granular, they are widely available, with the exception of lifestyle parameters where the comparability of international data is not always high.

Block C concerns the demand for healthcare, shaped in interaction with the variables of Block A and Block B. This demand interacts in turn in various ways with the supply of healthcare. It includes both issues studied from the strict perspective of health economics (especially the agency relation and its implications under the assumption of a third party payer in terms of the well known concepts of *moral hazard* and *adverse selection*)[21] and other softer issues tackled in all social science fields and in public and

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[19] See, for instance, Chapter 32 and especially Chapters 34 and 35 in the Handbook of Health Economics edited by A. J. Culyer and J. P. Newhouse[75]. A key debate is about the relations between the value of a QALY and the social value of health status [36, 73]. Critics argue that the social value of health status and life cannot be measured simply by the mere sum or un-weighted averages of individual preferences and should better reflect social context and differences among different groups of individuals. Another critiques concerns the fact that QALY assumes that a value of treatment is higher the younger the age of the treated person. Indeed, restoring a younger individual to full active life and economic activity has a higher Return on Investment than applying the same treatment to an already retired old person, yet the ethical implications of this choice (if used to allocate scarce resources) it is straightforward and requires no further comments.

[20] Just to name a few indicators for which fairly comparable international data are provided in the OECD Health Data 2010 dataset.

[21] For an illustration and application of the concepts of 'adverse selection' and 'moral hazard' in the context of healthcare financing see for instance [76]. The presence of a 'third party payer' (private insurance or the National

community health promotion: access and barriers and related matters of equity, emergence and construction of needs, attitudes toward health (consumerism, passivity, worrying well, etc). The more economic perspective looks at the effects of demand on the supply of healthcare especially with regard to relative prices, the phenomenon of induced demand, and unnecessary consumption (fuelled by asymmetric price elasticity and by moral hazard and adverse selection). The softer perspective also looks at user acceptance of particular treatments and technologies, which is in principle an issue of great relevance from the perspective of IPHS. In this domain, however, there is a dearth of internationally-comparable data, with possibly two exceptions: a) the EU27-wide Eurobarometer surveys provide a direct source of data, from which the attitudes of the general population and of specific socio-economic groups toward health and healthcare could be inferred; b) the EU27 data gathered through Eurostat's survey of households on the usage of Internet for health purposes (information search and other more transactional functionalities), which can be used as an indirect source to derive attitudes (where survey data are lacking) and to assess the extent to which the online medium either reduces or induces the utilization of the healthcare system.

Block D concerns the supply of provision of healthcare and in a certain sense can be considered, together with **Block A,** to be part of the real core of evaluation in the health context, if seen from the perspective of policy and investments addressing the healthcare system. The supply of healthcare is where inputs are used and outputs produced. The input side includes total expenditure in monetary value at different levels, manpower used, current consumption items (drugs and other consumables), remuneration/incentives, and, in synthetic terms, the cost of production and of alternative input mix. Health capital equipment is also part of the input side and it is generally measured when carrying out macro-level international comparisons using as proxies the number of hospital beds and scanners, although this variable can be measured more granularly in micro-level analyses. Whereas aggregate and internationally-comparable monetary measures of expenditure (and how it is financed) and manpower input are widely available,[22] more specific measures of input are not. A case in point is that the direct medical costs per disease, for which the various editions OECD Health Data do not report figures (though they do report disease-specific metrics such as average length of stay in hospital). The reason is that medical costs (per disease and/or treatment) show great country variations shaped by country-specific medical practices and disease classifications. This is a great challenge for any attempt at evaluations with an international comparison scope. Where the outputs of healthcare are concerned, we must remember that for a long time in the public sector, including the public part of healthcare systems, the convention has been used whereby input =

Health System), means that users/patients pay less or nothing when they use services and this can increase their demand for services to a point at which their marginal cost far exceeds the marginal benefits they receive. Because individuals know their health status better and their propensity to use health services, those who expect to make heavy use of hospital services buy insurance that offers full hospital coverage and, if such an insurance plan raises its premium rates to cover these expected higher risks, consumers who expect to use fewer hospital services would abandon this plan and only the higher-risk enrolees would remain in it. This is 'adverse selection'. Moral hazard can also characterize the behaviour of healthcare providers: a) GPs, knowing that their patients do not pay for it, may over-prescribe to please them and/or reduce the time needed for each consultation (in the worst cases, over-prescription by GPs is intentionally done to favour vested interests); b) intentional 'moral hazard' can also be enacted in hospitals when unnecessary interventions and cure are prescribed because of advantages in reimbursement schemes. It is worth noting that the danger of over-consumption, favoured by 'adverse selection' and 'moral hazard', besides inflating costs can also endanger the appropriateness of the cure and have further negative impacts on both health status and healthcare costs of patients.

[22] They are fully reported in the various editions of the OECD Health Data dataset.

output; i.e. output is measured by expenditure and basically there can be no productivity growth[77]. In recent years, countries have started to measure healthcare output in volume [78, 79] (see also Box 1.2 on page 28 in [1]). These new measurement efforts are still in the initial stages and mostly focus on "number of consultations with doctors" and "number of hospital treatments". These measurements also vary considerably by country and this may still reflect measurement problems (as well as, of course, institutional and organisational differences between countries). Other measurement indicators concerning the supply side, which are available in OECD Health Data, include:

Indirect output efficiency indicators

- Average Length of Stay (ALOS) in patient care in general and by specific diseases;
- Occupancy rate of acute care beds;
- Turn over rate of acute care beds.

Health Care Quality indicators (HCQIs)

- Avoidable admissions for chronic obstructive pulmonary diseases;
- Avoidable admissions for asthma;
- Avoidable admissions for congestive heart failure.[23]

Moving now from the 'engine room' to the bottom part of Figure 4 we have indentified, (also with a conceptual simplification with respect to the more nuanced set of possible approaches), three broad groups of evaluation and analysis.

Micro-level evaluations producing Cost-Effectiveness Analysis (CEA) and/or Cost-Benefit Analysis (CBA) and/or Cost-Utility Analysis (CUA) of clearly identified alternative ways of delivering care (mode, place, timing, amount) across all the possible phases of healthcare (detection, diagnosis, treatment, after care) to which we add prevention and health promotion (though they are generally considered separately from healthcare supply, as part of public health). These approaches traditionally consider outcomes for the treated groups using data from Randomised Control Trials (RCT) and Longitudinal Cohorts Studies (LCS). Such studies tend to use survival rates, levels of clinical parameters, and various measures of HRQoL (most often QALY) to be contrasted against the costs or more broadly defined input. If we consider hospitals or primary care units as the equivalent of firms in microeconomics, then input/output studies across comparable samples of healthcare-producing units such as the two mentioned could also be considered part of micro-level evaluation. On the other hand, what we group under the heading of micro-level as opposed to macro-level approaches are sometimes distinguished also as 'disease-level approaches' focussing on health and the treated individuals and " sub-sectoral approaches" focussing on producing units output indicators as, for instance, in [1].

Macro-level whole system approaches are by definition comparative (across different sub-territorial units within a country or across countries) and aim to measure the level of equity (access by different societal groups) and allocative efficiency. The latter can compare input to output, input to outcomes, and output to outcomes. They are generally carried out through panel and/or cross-sectional regression and other statistical techniques, such as Data Enveloped Analysis (see Section 2.2). When the end focus is on outcomes, these approaches naturally control for other variables and particularly for the

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[23] This indicator and the other two in this list were reported in OECD Health Data 2009 but are no longer available in the 2010 edition.

vector of NHC determinants of health in order to produce robust causal attributions of health outcomes to input or output.

Spill-over effect analyses do not properly fall into the domain of health evaluation but can be used to reinforce the evidence to support the evaluation of all the impacts that the introduction of an innovation in the delivery of care can have. The best example is the use of health status inside the macroeconomics of growth as a factor which contributes to increasing productivity and GDP growth and reducing aggregate social costs. At a more micro level, one can look at studies on the effects that employees' health status have on their firms' productivity and insurance costs (in systems where employers contribute to health insurance). Spill-over effect studies can also focus on how the delivery of care influences market opportunities and functioning mechanisms.

In view of the above, it is clear that evaluation of health tackles both the costs (input) and the consequences (output and/or outcomes) of routine care provision, or of ad hoc evaluated interventions and treatment. Such evaluations also tend to be explicitly or implicitly comparative with respect to the public policy needs they should service. Explicit comparison is mostly at the micro level between well-defined and circumscribed (in time and space) alternative courses of actions, whereas macro-level international comparisons are implicitly comparative from the perspective of policy (identify and understand gaps vis-à-vis shaping policy changes and system reforms). The matrix below summarises these considerations and help distinguishing three cases of partial evaluation from full evaluation (bottom right quadrant).

Figure 5: Typology of healthcare evaluations
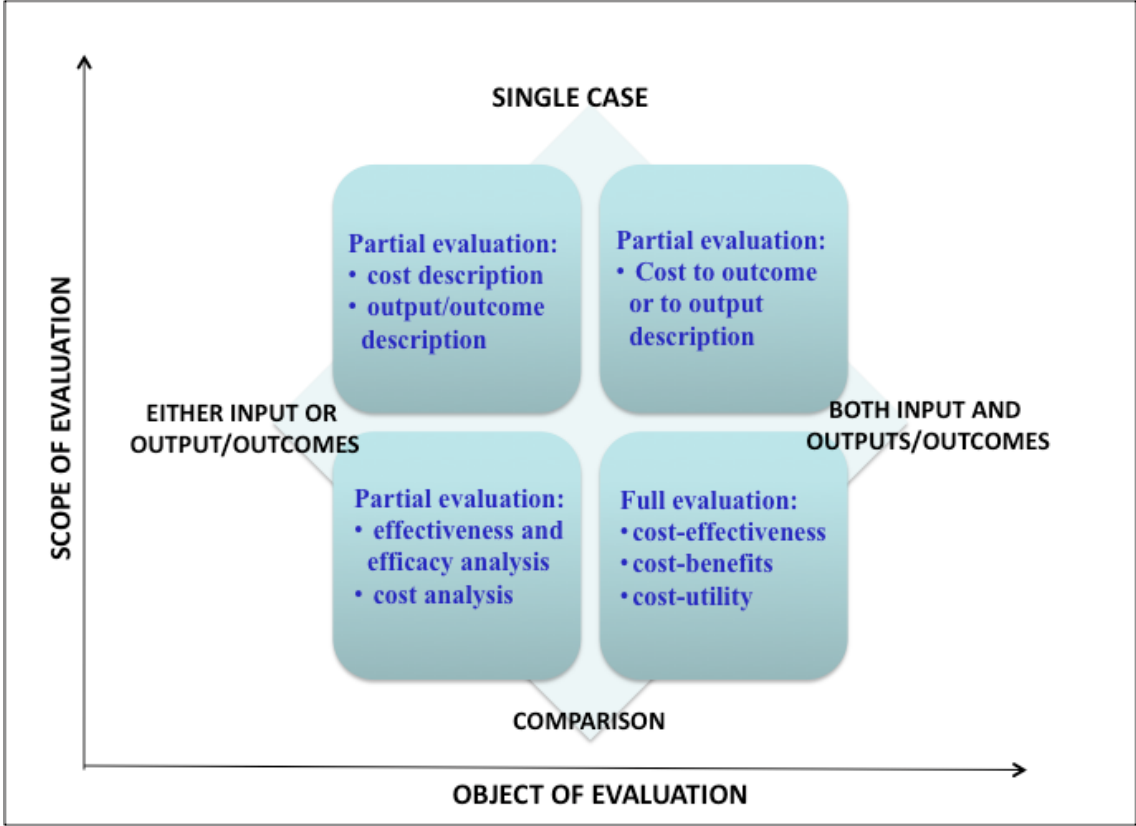
Source: adapted from Drummond et al[80].

Before concluding this overview we need to consider the pros and cons of micro and macro approaches when international comparison is the only choice, as is the case in the EU27 context.

Micro level disease-specific evaluations have the clear advantage of constructing more granular and relevant measures of health outcomes. On the other hand, it is unfeasible to conduct RCT and LCS in a large number of countries (unless one has a very long time frame for research) and the data from already-conducted country studies are hardly comparable. Already compiled and internationally comparable data on costs and health outcomes by disease are not yet available.

Sub-sectoral hospital studies can be carried out at the international level if the focus is only on input/output, for it is hardly possible to attribute outcomes of a given community population to the output of a given hospital. In this respect, good health outcomes could be produced by coordinated and integrated delivery across hospitals, primary care units, and other healthcare establishments and it would be daunting to disentangle these different contributions to attribute such outcomes only to hospitals' output (unless one consider interventions tackling health conditions known to be addressed mainly by only one of the above-mentioned healthcare providers).

Macro approaches at system level have clear limitations in that they provide broad-brush pictures, using less granular data and at times far from perfect proxies. Yet, for international comparison they are considered the second best approach and have been used by both the WHO in the famous *2000 World Health Report* [81]and the OECD[1].

2.2. Selective examples of non modelling-based evaluations

Typical micro-level disease-specific evaluations. Randomised Control Trials (RCT) are typical micro-level and often disease-specific approaches. They qualify as full evaluation, since: a) they focus both on health outcomes (survival rates and clinical parameters) and cost measures (most often the cost of interventions and hospitalisation across the treated and controlled groups); b) they compare different courses of action (by comparing different treatments across the treated and the controlled group). They have been used widely in the evaluation of ICT-enabled remote monitoring and treatment [82-89]. They provide important insights, though they suffer from several limitations. First, they rarely include the elaboration of QALY measures. Second, they hardly consider spill-over benefits (i.e. re-gained productivity). These two factors combined can weaken their measure of cost-effectiveness as the costs of intervention may only barely be offset by reduction in hospitalisation. Third, at a more general methodological level, they represent a reductionist approach to real life complexities: for example in the case of multiple medication and co-morbidities [90, 91]. Longitudinal Cohort Studies have the advantage of following subjects over longer periods, but as a rule they can be considered less robust than RCT in terms of causality attribution (especially for short periods) and because they only implicitly compare alternative courses of action. Typical examples, in our field of interest, are the well-known studies on telemonitoring of various chronic diseases by the US Veteran Health Administration (VHA) [92-94].

Evaluation of hospitals efficiency through Data Envelopment Analysis (DEA). DEA[24] is a technique used to analyse the efficiency frontier of producing units in different industries. Basically, it processes input and output or outcomes data (data can be in

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[24] We explain here in simplified and in plain terms what DEA does using general and introductory sources [95-97].

different metrics) from a sample of comparable producing units and derives a virtual efficiency frontier.[25] The heart of the analysis lies in finding the 'best' virtual producer for each real producer. If the virtual producer is better than the original producer by either producing more output/outcome with the same input or making the same output/outcome with less input, then the original producer is inefficient. Thus, using sophisticated techniques, data from a relatively small sample of organisations (25 observations would be sufficient) can also be used to estimate an efficiency frontier virtually representing the maximum level of output that can be produced with the best combination of inputs. The hypothetical example illustrated in Figure 6 will clarify the results of DEA better. Hospital A and Hospital C are both on the efficiency frontier but Hospital B is not. A is output efficient compared to B (more output for the same amount of input) whereas C is input efficient compared to B (same level of output with a smaller amount of input).

Figure 6: DEA graphic exemplification
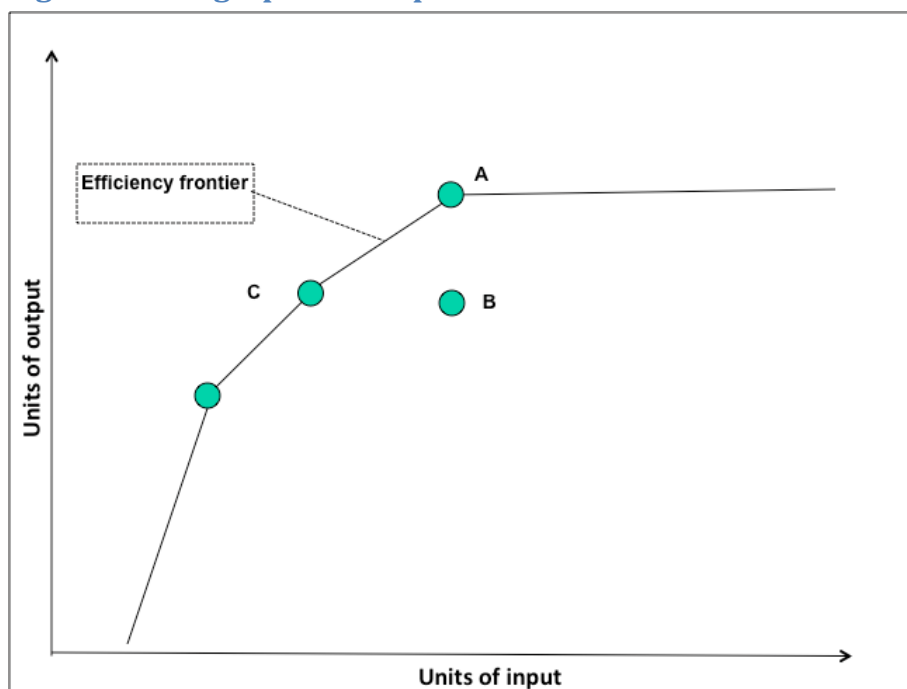
Source: Authors exemplificative elaboration (not based on real data).

Having received this kind of evaluation results, the management of hospital B can either try to move up (to produce more output with the same level of input) or left (to produce the same output with a substantially reduced amount of input).

This approach, which has its pros and cons compared to the similar technique of Stochastic Frontier Analysis[98], can be used to tackle different evaluation questions concerning hospitals or primary care units, as a few selected examples show[99-101].

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[25] Typical statistical approaches focus on the central tendency and, thus, evaluate existing and operating Producing Units (PUs) relative to an average PU. DEA, however, is an extreme point method and compares each PU with only the "best" PU. The overarching hypothesis behind this method is that if a given best producer, A, is capable of producing Y(A) units of output with X(A) inputs, then other producers should also be able to do the same if they operate efficiently. Similarly, if another best producer B is capable of producing Y(B) units of output with X(B) inputs, then other producers should also be capable of the same production schedule. Producers A, B, and others can then be combined to form a composite producer with composite inputs and composite outputs who will represent the best possible producer. This composite producer does not necessarily exist and it is sometimes called a virtual producer (i.e. a hypothetical concept made up of pieces from all the empirically-observed products).

Applying DEA to a sample of 85 public and private hospitals in Italy, researchers have demonstrated that: a) the imposition by healthcare authorities of constraint on acute care discharges, weighted by case-mix, reduced average hospital efficiency; and b) that past decisions by policy makers on hospital sizes and their role in provision of service also reduced their efficiency[99]. A study of hospitals in Thailand used DEA to evaluate whether the transition of the healthcare system to a capitation-based Universal Health Coverage affected the average efficiency of hospitals and found that efficiency did actually increase[101].

These two examples show how useful DEA is for assessing the impact of supply-side policy measures. On the other hand, in a US study DEA was first used to identify the most efficient hospitals and then to assess them against health quality measures (they are not exactly a measure of health outcomes but at least a good enough proxy)[100]. At any rate, one can also apply an input/output DEA while controlling for health outcomes and/or other relevant variables.

While DEA is mostly a micro-level technique, it has been applied for international country comparisons in the earlier cited WHO[81] and OECD[1] studies,[26] in which countries are considered as though they were producing units.

Macro-level International comparisons: input to outcomes efficiency evaluation. In 2000, the WHO published the first major attempt to compare 191 national healthcare systems regressing Disability Adjusted Life Expectancy (DALE) against several composite indicators measuring supply side and other effects[81]. Partly because of the politically sensitive nature of the ranking produced and partly because of some controversial methodological choices, this WHO report caused a public uproar and a methodological debate.[27] Ten years later, the OECD has published a less ambitious but probably methodologically less troublesome international comparison of its 30 countries: Life Expectancy at Birth (LEB, health outcome) was regressed (using a panel regression) against total spending (input), controlling for a vector of variables reflecting the non-healthcare determinants of health[1].[28] The main results of the panel regression (across the years 1990 to 2007 and almost all of the 30 countries) are the following:

• Hardly any correlation was found between healthcare outputs and LEB;
• Hardly any correlation was found between Healthcare Capital Equipment and LEB;
• Hardly any correlation was found between the type of institutional system and LEB;
• Total spending contributes in statistically significant ways to increasing in LEB in the period considered (but with persisting sizeable country variations);
• Socio-economic and lifestyle determinants also contribute in a statistically significant way, but less than spending.

While the first three results are in line with other studies, the second two are counter-intuitive compared to previous studies which found inconclusive results on the relation between spending and health outcomes and on average more robust correlations with lifestyle and socio-economic determinants.[29] A very simple descriptive analysis using OECD Health Data 2010 also produces counter intuitive results. Japan and Italy spend respectively only $ PPP 2 729 and $ PPP 2 870 per year per capita, but score better on

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[26] For a methodological review see the work of Hollingsworth and colleagues [102-104].
[27] See for instance [105] and [104].
[28] Naturally this is an extreme simplification of the methodological approach followed and of all alternative dependent and independent variables tested. It is, however, a precise synthesis of the final model specification, from which come the presented results.
[29] See for instance: [106-115].

many health outcomes than other countries which spend between $ PPP 3 500 and $ PPP 4 000 per capita (i.e. Austria, Germany, and the Netherlands). Measurement errors in accounting for the non-healthcare determinants of health possibly explain the higher explanatory power that the OECD results attribute to total spending. Yet, much more interesting from the perspective of healthcare system evaluation and improvement is the DEA performed by the OECD with the same data. This analysis concludes that, on average in the OECD area, LBE could be increased by 2.7 years while holding spending constant, or to put it differently a yearly increase of 10% in spending for a decade would only yield a 3 to 4 month increase in LEB on average for all the 30 OECD countries considered in aggregate. In other words, there is great scope for improving outcome efficiency without necessarily increasing spending. Yes, but how? If we had the evidence, we could use these findings and claim that moderate investments in remote monitoring and treatment and in Ambient Assisted Living could contribute to achieving outcome efficiency. Unfortunately, we cannot yet make this claim and it will take a while before we can.

Health is wealth: nations. The importance of the aggregate health status of a population has been recognised as contributing to economic growth in economic theory and it has been formally tested and documented empirically.[30] In the 1990s, economists started to include health as a factor in standard growth models, alongside capital deepening and technological growth.[31] Stated simply, empirical evidence has shown various channels through which good health has an impact. Besides reducing productivity losses (days of work lost due to illness or its disabling impacts), it increases the incentives to invest in education and lower human capital depreciation rates. So, it positively affects productivity directly (fewer days of work lost due to health problems) and indirectly (increased educational level). Moreover, improved health conditions and slower human capital depreciation can prolong the productive life of older workers (those aged 55-64) and reduce early retirement. Eventually these effects should reverberate positively on GDP. Evidently, if chronic diseases move in at an early age most of the above impacts are hampered and opportunity costs must be added to the growth of already large direct medical costs. Thus it is clear that improving the health status of the population should not only be on the public health agenda but also on a human capital agenda for more growth and jobs. Accordingly, the evaluation of new interventions in healthcare should also include consideration of these positive overspills. This, however, is not usually done.

Health is wealth: companies. The same kind of analysis can be done at company level considering that non-perfect health status (e.g. having a chronic condition or being obese) has been demonstrated to produce the following direct cash and opportunity costs for companies: a) increased costs for health insurance (in those countries where employers pay all or part of this insurance); b) productivity loss due to absenteeism and presenteeism; c) lower average productivity as reflected by wages due to lower capacities [122-141]. Even from this perspective there are large gains to be obtained through public health intervention and also through health promotion programmes for employees directly financed by the employers.

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[30] A state-of-the-art review concluded that correlation between health and economic performance is extremely robust across communities and over time. Many factors exogenous to income play an important role in determining health status, including a number of geographical, environmental, and evolutionary factors. This suggests the existence of simultaneous impacts of health on wealth and wealth on health. Potential health impacts on national economic performance are explored, and some important unanswered questions are identified[116].

[31] See only as a very selective and exemplificative list [117-121].

2.3. Modelling the impact of 'policy shocks' in the domain of chronic diseases

Before giving a few interesting examples, we need to make and explain the distinction between micro and macro-level modelling simulations.

Micro versus macrosimulation. Dynamic microsimulation "*starts with a large database describing a sample of individuals, households, or organisations and then uses rules to update the sample members as though time was advancing*"[22] (p. 17). They are variable-based and not agent-based simulations (and different from Agent-based Modelling) in the sense that they do not directly represent the agents. To put it differently, they deal with aggregates of individual units (i.e. households) and not with each individual agent within those aggregates. Compared to macro modelling, microsimulations have the advantage of looking more closely at individual units and at the more micro mechanisms through which interventions have an impact on these units. On the other hand, since they operate in closed systems, they fail to capture the interaction with other systems and the potential macro-level overspills and impacts. Macrosimulations capture the higher-level impacts but fail to provide any insight on how aggregate changes and new equilibrium affect individuals unit. To put it more concretely, we can refer to the IFs (international future) Computable General Equilibrium model[32] that was tested at IPTS during the spring of 2010. The health module included in this model is not sufficiently granular to input data and scenario parameters to simulate the impact of an intervention addressing a specific chronic disease. The theoretical relations and the data included in this model are very distant and inadequate proxies of the dynamic and mechanisms which affect a disease-specific policy shock. On the other hand, IFs CGE can test the potential spill-over impact of public health shock at higher levels (increased productivity and increased tax revenues), which micro simulations focussing on disease-specific shocks cannot account for.

Microsimulations in general. Going back to dynamic microsimulation, we can characterise them as computational approaches that use complex matrixes with several cells that enable us to produce granular projections of how a certain phenomenon may evolve, breaking it down to its various sub-components (as we show in Section ??? for diabetes modelling).[33] As illustrated in a relatively recent article, which reviewed research on building dynamic microsimulations of healthcare demand[145], the majority of microsimulation models have been developed and used mostly to simulate the distributional effect of policy interventions concerning social security, pensions, and personal tax. This article identified 24 microsimulation models, out of which only two were developed specifically for healthcare: HealthMod (NATSEM,[34] University of Canberra, Australia) and POHEM (Canada Statistics, Canada). Our own initial review, however, shows that there are also modelling tools on the market such as the CORE diabetes model[35] and that alternative simulation approaches such as System Dynamics are used especially for simulation of policy intervention in the domain diabetes and cardiovascular diseases (see below).

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[32] http://www.ifs.du.edu/introduction/index.aspx

[33] For reviews of opportunities and challenges of dynamic microsimulations in general from the perspective of policy making see for instance [142-144]. Interesting insights and documentation can also be found in the dedicated website http://www.microsimulation.org. Since 2007 the International Journal of Microsimulation has been launched and can be browsed as a way to review the range of different applications of such models. It is worth noting that several free and open source software exist that can be used to produce microsimulations.

[34] National Centre for Social and Economic Modelling.

[35] By Imshealth (www.imshealth.org)

Microsimulation of policy intervention scenarios for diabetes. Going to the specifics of chronic diseases, the most common form of dynamic microsimulations are those using diabetes models built ad hoc to project the future prevalence of this disease and direct medical costs in different policy interventions scenarios. This has been done in two recent US studies[146, 147], both of which build their simulation on the rich baseline data provided by the National Health and Nutrition Examination Survey (NHANES)[36] carried out periodically by the US Federal Centre for Disease Control and Prevention (henceforth CDC). This survey provides granular data on all parameters defining the likelihood of developing a disease or of an already-contracted disease progressing. They then apply scenarios of policy interventions to assess the impact on prevalence and medical costs. For the calculation of baseline and future medical costs, as well as for inputting the cost of the different intervention scenarios, country-based granular and robust data are used. Let us look, however, in more detail at an Australian simulation on diabetes carried out by researchers at the NATSEM of University of Canberra to both illustrate further the mechanisms through which this modelling works and to see how one can go beyond simple microsimulations [148]. The researchers started from the baseline data provided by a survey carried out as part of the Australian Diabetes, Obesity, and Lifestyle (AusDiab) Study [149, 150]. These data were entered into an *ad hoc* diabetes model comprising 3 456 different cells produced by the combination of eight key variables for diabetes risk: a) sex (2 variables); b) age (six groups); c) income (four categories); d) waist circumference (2 categories); e) blood pressure (2 categories); f) abnormal cholesterol (2 categories); g) physical activity (three categories); h) smoking history (three categories). It then proceeds to simulate prevalence of pre-diabetes and diabetes for the 3 456 different population cells over a 45 year period comprising 15 three year cycles, under a no action baseline scenario and under a policy shock scenario. The intervention scenario was defined as a programme aimed at reducing progression for individuals at risk of type II diabetes through detection and early lifestyle intervention. The possible results of this scenario are modelled using parameters from Randomised Control Trials:[37] that is to say, the results showing success of lifestyle intervention in the treated group of the RCT are used to assume the same level of success for the aggregate scenario that targets the whole population between 55 and 74. Costs of intervention and direct medical costs under the two scenarios are calculated using robust national-level sources. The first results of the simulation under the treatment scenario are a substantial reduction in the prevalence of type II diabetes and a sizeable reduction of direct medical costs, which already make the intervention worthwhile (reduced medical costs offset the cost of the intervention). Yet, the Australian researchers did not stop there and went two steps further: a) they input the reduced prevalence results into a traditional model of household labour supply to estimate the impact on the supply of labour from having more individuals not affected by pre-diabetes and diabetes conditions; b) the results from this intermediate step are then inserted into a CGE model of the Australian economy to estimate the aggregate macro impact of the increased labour supply made possible by the reduced prevalence of diabetes. At this point, the value of aggregate impact is much larger than the cost of the intervention, which reinforces the case if compared to the initial results coming only from the micro level simulation. Naturally, the process of linking three simulation models at micro, meso, and macro level is technically complex and can be criticised from

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[36]   http://www.cdc.gov/nchs/nhanes.htm
[37]   In the case of the Australian study, they used evidence from the Finnish Diabetes Prevention Study [151-153].

a methodological and epistemological perspective. Yet, it tries to take advantage of the strengths of both micro and macro-simulations, while minimising their weaknesses.

System Dynamics modelling for chronic diseases. The SD approach, first developed in the early 1970s[154], models dynamically and recursively the cause and effect relationship between variables. As in the case of dynamic microsimulation, it is not agent-based.[38] SD models function with a set of simultaneous differential equations, each of which "*calculates the value of a variable at the next time step given the values of other causal variables at the current time step*"[22] [p. 20].

Recently, SD has often been used in the US to simulate the impact of interventions on chronic diseases and in particular several contributions can be found in the *American Journal of Public Health*[39] and in other relevant journals, such as *Preventing Chronic Disease.* In two ground breaking articles, it is argued that systemic thinking and systemic modelling are not only an opportunity but also a necessity as they could improve public health policies and avoid past policy failures[156, 157].

Of these SD-based simulations, we will now describe in more detail one applied to diabetes to look at the interesting results produced and one on cardiovascular disease, simply to provide an idea of how such approaches can reflect system complexity.

The first is a study sponsored by the US Federal CDC[40][158] cited earlier. As in earlier cases, its starting baseline is provided by sources of rich country-level evidence, such as:

- US Census Bureau (population growth and death rates, and health insurance coverage);
- National Health Interview Survey (diabetes prevalence and diabetes detection);
- The earlier-cited NHANES Survey (pre-diabetes prevalence, obesity prevalence);
- Behavioural Risk Factor Surveillance System (glucose self-monitoring, eye and foot examinations, use of medications).

In addition, the country-level research literature provided information on effects of diabetes management and prevention intervention and on diabetes costs. This information was used to calibrate model parameters. The basic causal structure of the model reflects population flows and stocks (in and out of the pre-diabetes and diabetes prevalence status). After simple projections of the baseline conditions in the future, the model tested, using hundreds of differential equations and 20 parameters, the following three intervention scenarios: a) improved clinical management of diabetes; b) increased management of pre-diabetes; c) reduction of obesity through preventive lifestyle interventions. The results obtained, summarised in Figure 7, are very telling.

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[38] For a good illustration of this feature of SD compared to the characteristics of Agent-based Models, see for instance [155].

[39] See for instance the full set of articles and the need for systemic thinking and simulation for healthcare policies contained in Volume 96, No 3of March 2006 (http://ajph.aphapublications.org/content/vol96/issue3/index.dtl)

[40] More precisely, jointly by the divisions of Diabetes Translation and of Adult and Community Health of CDC.

Figure 7: Diabetes type II prevalence and deaths: treatment scenarios
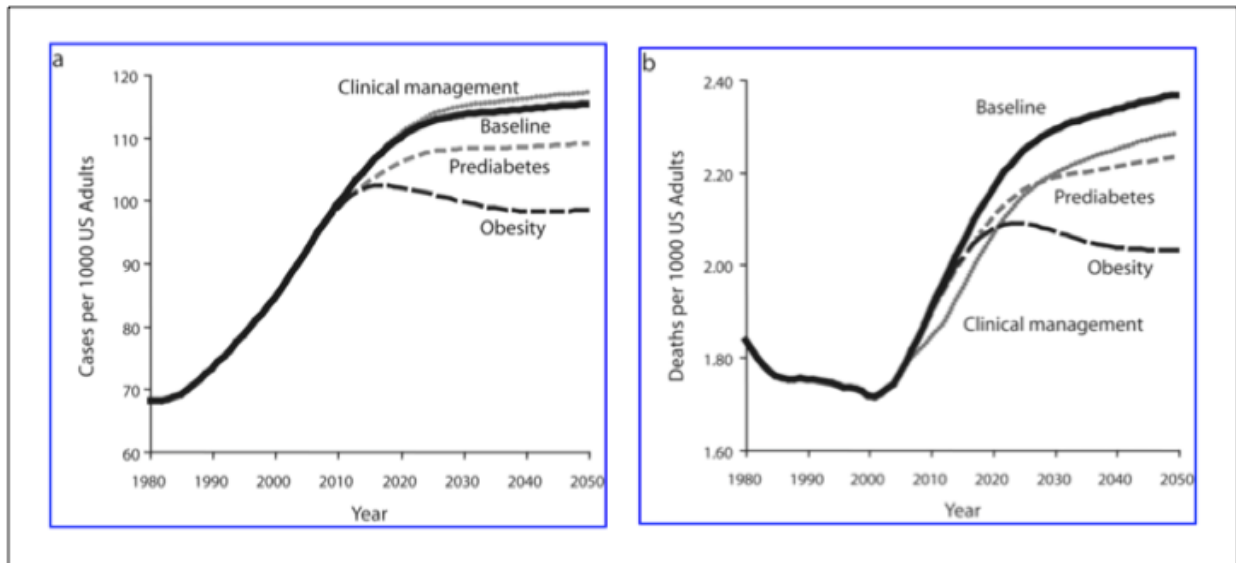
Source: [158] p. 492

The left hand side reports the results for prevalence and shows that: a) improving clinical management increases total prevalence compared to the no action trend (baseline); b) better management of pre-diabetes conditions reduces prevalence compared to both baseline and clinical management but does not reverse the growing trend; c) only interventions to prevent or reduce obesity effectively close the faucet of prevalence and reverse the trend. The right-hand side of Figure 7 looks at the impacts on the deaths: a) better clinical management clearly reduces deaths compared to the baseline scenario (this being the other side of the coin of increasing prevalence: people live longer with diabetes) but does not reverse the trend; b) the same can be said for pre-diabetes management; c) intervention that prevents or reduces obesity entirely reverses the trend and substantially reduces deaths. The implications of this modelling exercise are straightforward:

- Only prevention can reduce deaths and contain costs at the same time (because it also reduces prevalence);
- Hence, only prevention can lead to increases in Health Adjusted Life Expectancy (HALE): more people will live longer lives without diabetes type II.

With respect the first bullet point, we can add that, according to the latest (November 2010) simulated estimation of possible savings in treating diabetes, prevention yields a combined total of $ 237 billions worth of potential gains, whereas improved medication adherence produces $ 34 billion gains[147].

From the second study on intervention to reduce the prevalence of cardiovascular disease, we simply provide Figure 8 with brief comments.

Figure 8: Simulation model for cardiovascular disease (CVD) outcomes

Blue solid arrows: causal linkages affecting risk factors and cardiovascular events and deaths.

Brown dashed arrows: influences on costs.

Purple italics: factors amenable to direct intervention.

Black italics (population aging, cardiovascular event fatality): other specified trends.

Black non italics: all other variables, affected by italicized variables and by each other

Source: [159], p. 1.

Figure 8 shows the capability of SD to map all possible causal relations, identifying the factors amenable to policy intervention (those in purple italics in the figure). It is worth noting that a map of causal relations such as the one in the figure, as well as simulating the effects of a policy intervention, would also be of great value to identify where ICT-supported services could be used to affect the factors in purple italics in the figure. This suggests that micro-simulations and SD may not be alternative choices but may be used for different purposes and then integrated. It also important to stress that this modelling exercise could rely on the earlier-mentioned national level NHANES survey and on the US Medical Care Consumer Price Index (CPI) provided by the Bureau of Labour Statistics for robust quantification of medical costs.

Agent-based Modelling as a potentially integrative tool. Finally, we explain how Agent-based Modelling (ABM) could help refine the previous examples, by outlining two limitations shared by dynamic microsimulation and SD approaches, both related to the definition and inclusion in the model of intervention scenarios.

When the previous modelling examples test intervention scenarios, two important assumptions are not made completely explicit: a) defining a prevention intervention decided at a higher level and testing it also implies that the higher-level policy decision will be applied by all lower-level players (regional and/or local health authorities, hospitals, primary care units, etc); b) when they use parameters from RCT studies to factor in the modelling the rate of success of a prevention intervention, they assume that the results from such trials can be extrapolated to all the population groups targeted by the intervention. Both are very strong assumptions, which could be themselves the object of a modelling exercise. It is well known that compliance by lower levels with policy changes is far from complete. We have also mentioned earlier the limits of RCT

with respect to real life complexity and it is possible that a prevention intervention will have on the population at large not exactly the same effect it had on the treated group of a RCT. Both these two challenges are amenable to being treated through an ABM simulation that could integrate either microsimulation or SD approaches. We first very briefly illustrate what ABMs are and how they can be used and then we come back to this point.[41]

ABMs are a computational method to create, analyse and simulate models including individual agents interacting within an environment. So, they are agent-based rather than variable-based (such the one discussed earlier). Agents are separate computer programmes or part of computer programmes that represent social actors, embedding several behavioural characteristics and capabilities (e.g. sending and receiving messages, enacting strategic behaviours, reacting to environmental input, etc). Whereas traditional models deal with aggregate individual units or with stylised agents (i.e. the typical firm or the rational consumer), ABMs enable us to take into account difference in preferences among actors belonging to the same group. For instance, we can build a model where a few healthcare professionals act as champions and innovators, others as followers, and still other as resisting innovation and change. All agents in ABMs are programmed as having: a) autonomy; b) social ability; c) reactivity; and d) proactivity. Moreover, the programmes enable them to have perceptions, to perform actions, to have a memory and store messages (i.e. incentives), and their own policy (a set of rules). ABMs have been typically applied to understanding the process of innovation diffusion and adoption within a specific industrial sector with a much more sophisticated and socially-informed approach than is possible in the conventional S-Shaped descriptions. ABMs can simulate the natural processes by which order emerges within a system, in this case the diffusion of innovation, and also how this can change as a result of policy treatment of the structure of incentives (agents perceive the change, memorise it and eventually change their sets of rules to adapt to the changed incentives).

So, it should be clear by now that ABM could be used to simulate different adoption scenarios on the side of healthcare institutions and professionals of the intervention scenarios defined in the previous microsimulation and SD examples. Data from traditional survey describing the structure and flows of a network shaping of a given population of agents can be inserted into an ABM application to test to what extent adoption of an innovation or a policy is resisted or alternatively may result in positive cascade network effects. By using ABM in such way one could further break down the three treatment scenarios of the US diabetes study (management of diabetes, management of pre-diabetes, prevention) into six, by including for each two sub-scenarios of high or low adoption of, or compliance with, the policy intervention decided at an higher level, thus obtaining a more realistic picture.

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[41] The literature on ABMs is large and growing. At this stage, however, we offer only one key reference to an introductory book[22] . Further review of the relevant literature will be conducted as part of the work proposed for this exploratory research.

3. Evaluation of eHealth and IPHS: *ex ante* modelling a necessity

3.1. The productivity paradox and the economics of ICT: a primer[42]

The most recent, comprehensive and systematic review of studies on the impact of broadly-defined eHealth reveals that healthcare is currently characterised by the IT productivity paradox[161]. For this reason and also to give a brief overview of general macroeconomic and microeconomic approaches to the study of ICT, we start with the following digression.

Robert Solow's famous quip that "You can see the computer age everywhere but in the productivity statistics"[43] was systematised into the Productivity Paradox [162, 163], the 'paradox' being the remarkable advances in computer power and in IT investments by firms and the relatively slow growth of productivity at the level of the whole economy (at least in the period 1970-1990). This has given rise to a real research industry on the IT paradox with hundreds of article, of which the following 27 references are only a small selection [164-190]. The initial explanations for this paradox were mainly two: a) measurement errors (imperfect indicators used and unobserved variables); and b) time lag (it takes a while after the introduction of ICT before productivity gains start to emerge).

Although the IT paradox cannot be relegated once and for all to history, later macroeconomic studies using the growth accounting approach have shown that the productivity resurgence witnessed in the US from the second half of the 1990s could be attributed to a large extent to the impact of ICT.[44] Moreover, other studies showed that the productivity gap between the EU countries and the US could be attributed to lower and less effective adoption of ICT by European firms.[45] Microeconomic studies have challenged the findings of growth accounting or better specified them, showing that ICT produce productivity gains only when matched by investment in broadly defined organisational capital such as re-organisation, change management, and training of personnel.[46]

Regardless of the findings of these two alternative approaches, it is interesting to briefly illustrate the kind data used for each and some of the inherent problems, which in the case of healthcare are even more complex:

- Growth accounting models use an aggregate of all system (or industry level) data on ICT capital investments, non-ICT capital investments, labour input, and variations in aggregate output (output growth). Leaving aside other variables and considering that these sorts of approaches have been applied since the 1990s, it is telling that they still face measurement problems related to ICT.[47] If we translate this into the healthcare sector, where measurement of output in volume

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[42] This brief introduction contains a summary of a more in depth analysis of this topic (and of the relevant literature) we produced elsewhere[160].

[43] R. Solow, We'd better watch out. New York Times, July 12, p. 36.

[44] See for instance [191, 192]. Further analysed references can be found in [160].

[45] According to Inklaar et al [193], the contribution made by ICT capital deepening (capital per unit of labour input) to labour productivity growth in Europe is about half the contribution it makes in the US. Further analysed references can be found in [160].

[46] See for instance [194-196] . Further analysed references can be found in [160].

[47] For instance, technical progress produces continuous changes and reductions in the prices of ICT, which make it difficult to measure ICT capital investments across time. There are different approaches across countries to deal with this problem and this exacerbates measurement problems.

is only just beginning and data on ICT investments is very scattered , it is easy to understand why the application of growth accounting to study ICT in healthcare has been ruled out for now and for some years to come[197].[48]

- Firm-level microeconomics of ICT use very rich datasets (especially for companies listed on the stock market that must make public a large amount of their data) including ICT investments together with several variables used as proxy measures of investments in organisational capital. This approach can also be ruled out for healthcare given the current lack of data on ICT investments by hospitals, not to mention information about organisational capital.

3.2. The promises of eHealth and IPHS

We have reviewed in depth the possible contribution of eHealth applications which fall under the heading of IPHS elsewhere [198] and the promises of broadly defined eHealth have also been widely discussed, for instance in [161, 199]. We provide below a brief account of these promises and relate them to the available evidence on the contribution that health status could make to increasing economic growth and reducing social costs.

Effective use of ICT in healthcare can support better and timelier sharing of information between patients and professionals, among professionals, among healthcare tiers (primary, secondary, tertiary) and between health and social care - in short, across all the involved players. Sharing information is a way of transforming this information into actionable knowledge. Better healthcare knowledge engines can in turn increase patient safety and clinical outcomes, improve productivity and optimise the use of resources, reduce administrative burden, and curb the opportunistic behaviours that cause unnecessary costs. All of this may also reduce errors and avoidable adverse events with the consequent reduction of the associated costs.

In particular, IPHS can produce better diagnosis and treatment, support prevention activities by helping people to avoid the onset of diseases altogether or by delaying the moment when they affect patients' Activities of Daily Living (ADL) and increase patients' utilisation of health and social care resources. IPHS can help both patients and professionals make better decisions and manage diseases more effectively and efficiently. Certain specific applications can also enable patients to play a more active and informed role in making decisions on health and lifestyle management. Other applications can help the elderly to remain independent, allowing them to stay in their own homes, thus reducing the costs of institutionalised care. So, from the user perspective, IPHS can improve quality of life, prolong dignified independent living, and in some cases prolong working lives. In addition, preventive and lifestyle management applications can help younger active groups to stay healthy and preserve their productivity. From an internal perspective, IPHS, like other eHealth applications, can help health and social care organisations to increase their output efficiency - that is to say, to "**do more with the same**". IPHS, though part of disruptive innovations entailing substantial re-organisation and institutional change, can bring about cost-effective ways of dealing with very large segments of the potential patient population while their needs are still less demanding and acute. At the same time, in this way they could reduce the workload for general practitioners as regards face-to-face consultation, the use of ambulatory services, and hospitalisation. This could also improve healthcare

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[48] Although later in this section we show that a mere growth accounting exploration in healthcare could at least be attempted.

professionals' job satisfaction as they would be able to dedicate more quality time to more complex activities and better face-to-face interaction with patients/citizens with specific needs if they were relieved of more routine tasks. IPHS could therefore have two important impacts: firstly they could be the source of important efficiency gains and cost savings and secondly, they could result in increased job satisfaction. They could help reduce fragmentation and foster integration and exchanges across healthcare system tiers and across health and social care. Finally, the take up of IPHS can lead to the emergence of new markets for innovative industries with the consequent creation of new jobs.

So, if all these promises materialise, IPHS can help improve health status and at the same time increase the productivity and efficiency of the healthcare sector, creating new markets and jobs for innovative industries. To sum up, they can contribute to positive spill-over effects, as shown in Figure 9.

Figure 9: The potential spill-over effects of IPHS
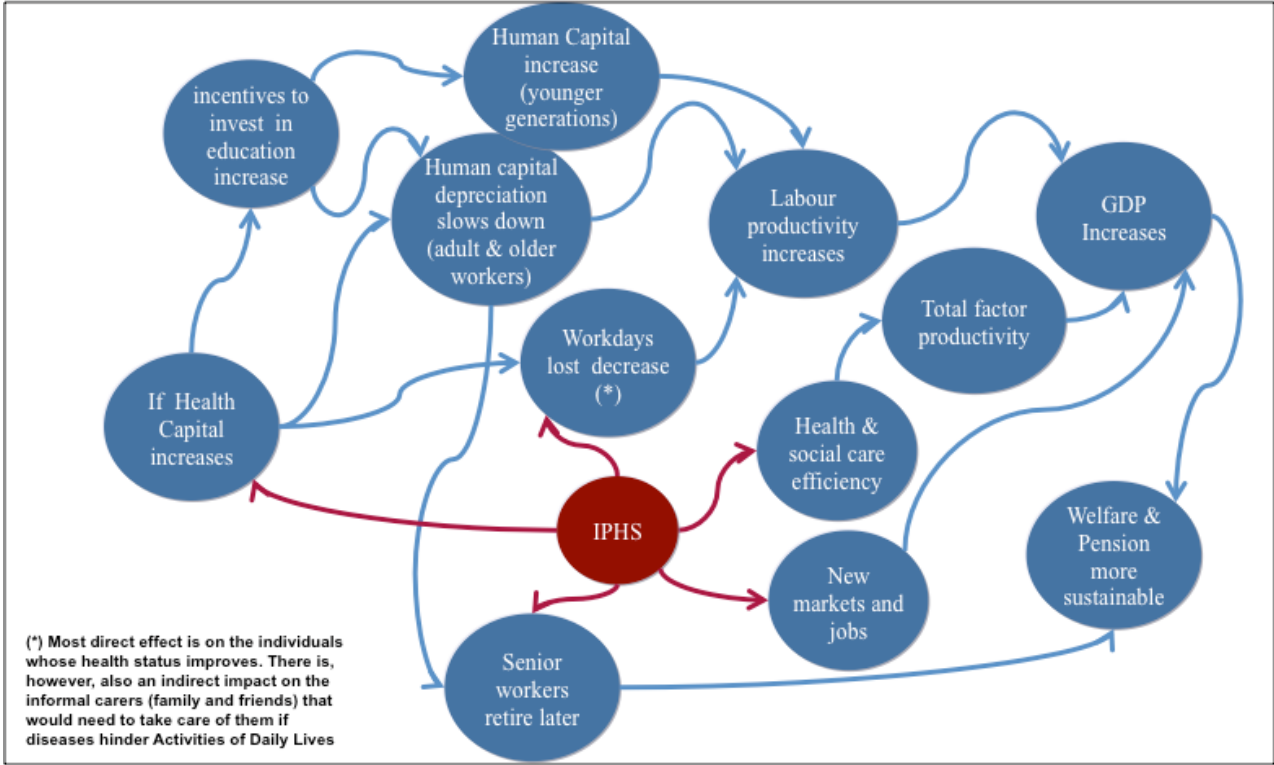
Source: Authors elaboration

The potential health outcomes of IPHS, especially for the relatively younger age groups and for older workers, would increase health capital and, as seen earlier, and increase labour productivity and GDP directly and indirectly. The broadly defined efficiency gains IPHS could bring could feed into Total Factor Productivity and thus also affect GDP positively. Intervention directly targeted at older workers, besides bringing the already-seen productivity gains, could delay retirement and ease the demographic pressure on the financial sustainability of welfare and pension systems. Finally, by creating new market opportunities, IPHS could also lead to an increase in the output of innovative ICT industries, which are known to have a direct impact on GDP growth.

The following question naturally arises: is there any evidence that eHealth in general and IPHS in particular are delivering their promises? The answer is, as we show next, we still do not know.

3.3. State of the art in eHealth and IPHS evaluation

General overview. In recent years, we have witnessed unprecedented efforts all over the world to improve healthcare and affect health outcomes by leveraging Information and Communication Technology (ICT). Between 2003 and 2011, according to WITSA data, the US healthcare sector will have spent approximately $ 500 billion in ICT, Western Europe[49] $ 531 billion, Eastern Europe[50] $ 25 billion, and Japan $ 128 billion [200]. Another source[51] indicates that healthcare investments in ICT have grown substantially and in most countries account for between 2% and 6% of total healthcare spending. Certainly, healthcare spending in ICT is a larger aggregate than eHealth (where underlying basic ICT such as personal computers, work stations and ordinary communication expenditure are not included).[52] Regardless of the reliability of these figures, eHealth investments have undoubtedly increased in the last decade. This can be indirectly gathered from a 2010 survey of eHealth deployment in European hospitals which shows that 85% of them already have electronic medical records and very large percentages also have at their disposal several other applications such as ePrescription, eBooking, etc [201]. After at least ten years of sustained investment and effort, the available evidence on cost-effectiveness is inconclusive, as shown in several reviews and meta-reviews [160, 161, 197, 199, 202-205], despite the fact that the number of studies evaluating HIT impacts is growing exponentially. In 2002, 652 such studies only focussing on telemedicine were identified for the period 1980-2000 [205]; in 2006, 252 evaluation studies of more broadly defined HIT were found for the period 1994-2005 [202]; and the latest available review report identified an additional 1,300 studies published between 2005 until 2009 [161].[53] As noted [199], in the growing body of literature, one can find both those who herald the potential of ICT and those who bemoan the backwardness and unmet expectations of healthcare. The same applies to impact. The 2006 review found studies that demonstrate both positive impacts and no impacts or even negative consequences. Tellingly, the latest 2010 review found positive impacts, but also that 'there is some evidence suggesting that the implementation of HIT may, on the contrary, foster medical errors and even lead to higher patient mortality rates' [161]. To give an example, an analysis of EHR concludes that they may lead to medical errors and even increase costs by justifying a greater intensity of services with higher provider billings but no increased productivity [232]. Naturally, there are also several studies showing outstanding results. Yet, the evidence on the whole can be considered inconclusive at best. This means, it must be stressed, that we cannot conclude that eHealth has, or has not had a positive impact.

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[49] Includes Norway, Switzerland and Turkey, but does not include Malta, Cyprus, Luxembourg, and Iceland.
[50] Including also Russia and Ukraine.
[51] Market research company IDC [161].
[52] For instance, this is the approach followed in Capgemini/Rand study delivered for the European Commission where total eHealth expenditure for the EU27 in 2009 was estimated at € 14 billion. Yet, having clarified this distinction, the gap between the Capgemini/Rand estimate and the WITSA data seems sizeable: € 14 billion versus € 60 billion. The € 46 billion gap surely cannot be attributed only to the underlying ICT which were removed from the estimation of eHealth expenditure provided by Capgemini/Rand. While it is beyond the scope of this report to dig further into this difference, we thought it worth pointing out.
[53] An illustrative selection of such reviewed studies have been retrieved and consulted during the preparation of this report [82, 206-236].

Possible explanation of inconclusive evidence. Several possible explanations have been advanced for the delay in obtaining conclusive evaluation evidence. According to Lapointe et al, healthcare is experiencing the same productivity paradox seen earlier and lack of conclusive evidence can be attributed to measurement errors and time lag [161]. Adang and Wensing argue that variable returns to scale in healthcare in combination with inflexible factors of production are responsible for an efficiency discrepancy (investment in ICT not showing in increased output) due to the different economies of scale, scope and learning[237]. Measurement is indeed problematic in healthcare, not only for technical reasons and lack of data gathering activities, but also because of institutional characteristics[203]. There is no measure of performance analogous to profits from private sector firms, and healthcare organisations tend to pursue multiple objectives that are either difficult to measure or lead to different measurement goals which produce data with little comparability. ICT implementation may have effects that are multidimensional and often uncertain in their reach and scope, and difficult to control. In addition, the realisation of benefits from ICT implementation strongly depends on contextual conditions[197], which further compound the problem of comparability.

The specific case of IPHS. The lack of conclusive evidence on IPHS is less surprising for their adoption lags behind other eHealth applications [201]. On the other hand, remote-monitoring and treatment can be seen as belonging to the wider family of Telemedicine, which has been practiced now for three decades or more. Despite this, there is still no conclusive evidence that it is cost effective [205]. During Phase 1 of SIMPHS, a large body of RCT and Cohort studies analysing the impact of remote-monitoring and treatment of the three main groups of chronic diseases (diabetes, Chronic Heart Failure CHF, and Chronic Obstructive Pulmonary Diseases COPD) was gathered and analysed,[54] a selection of which was mentioned earlier[82-89, 92-94]. The evidence is mostly positive, including reduced mortality rates and better utilisation of hospital resources. Yet, it is still not conclusive as regards all-cause hospitalisation. A systematic meta-review of RCT on remote monitoring of CHF, for instance, concludes that evidence on cost-effectiveness is not conclusive due to the fact there is no proof that all-cause hospitalisation is reduced (remote monitoring of a CHF patient reduces the use of the hospital for this disease, but the patient may end up being hospitalised for another disease)[84]. In our opinion, this conclusion results from a measurement error. RCT rarely quantify and value in monetary terms the QALY produced by reduced mortality and improved quality of life, not to mention the possibility of going back to work for the relatively younger patients. If these two measures were included in this disease-specific form of evaluation in methodologically sound ways, it is likely that there would be conclusive evidence of positive cost-effectiveness. To our knowledge there is no single contribution that systematically evaluates the impact that IPHS usage has on the internal efficiency of the healthcare units adopting them. Neither are there any specific studies on the more social care-oriented application of IPHS on users or on the institutions providing social care, if we leave to one side the much-cited individual cases of best practice (i.e. the Scottish West Lothian Council experience with tele-assistance at the homes of impaired elderly people).

The data challenges for EU27 evaluation efforts. The US and the EU27 are entities of comparable size and importance. However, the former is one country and the latter

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[54] See Abadie, F., Codagnone, C., et al. (2010), *Strategic Intelligence Monitor on Personal Health Systems (SIMPHS), op. cit.*, pp. 45-55, and Chapter 9.

consists of 27 countries with more or less pronounced differences in healthcare institutional models, age structure of the population, level of health status as measured by standard OECD health outcomes indicators, and in how diseases are classified and treated (resulting in important differences in prevalence and medical costs statistics). This obvious observation has important implications for past and future activities within the SIMPHS research framework, as well as for the modelling pilot proposed in next section.

At country level, it is possible to find granular and reliable baseline data such as those used in the modelling exercises we reviewed earlier for the US and Australia (i.e. National Examination surveys producing data on disease prevalence and other relevant variables, or data on the direct medical costs of diseases). However, this kind of data has not been gathered at EU27 level.

There are no internationally compiled and comparative statistics reporting even disease prevalence and average medical costs by disease for the EU27. The situation in terms of prevalence data and medical costs statistics in Europe is, to say the least, fragmented, as shown in detail by our review elsewhere.[55]

For instance, for any given year we do not have EU27-comparable data on incidence (flow) and prevalence (stock) for CHF, or COPD, or Diabetes, let alone broken down into age groups. For diabetes, the situation is slightly better as the International Diabetes Federation (IDF)[238-240] provides EU27 data for diabetes prevalence in its annual report. Yet, IDF data do not include incidence and statistics broken down by age groups. For CHF [241-247] and for COPD [248-254], we only have data from separate epidemiological studies and surveys that compare only a few European countries and provide very contrasting pictures. Lack of comparable data is attributed to different diagnostic practice for cardiovascular diseases in general[255], and also for the other diseases. Given the lack at EU27 level of such basic starting data, it is pleonastic to add that we do not have access to the kind of data which has allowed the Australian study to simulate treatment scenarios over more than 3,400 different population cells. The situation for medical costs is even more difficult. The most well-known and used dataset is the OECD Health Data (currently its 2010 edition) and it does not contain medical cost data by disease. The only monetary variables contained in the OECD Health Data are aggregate data on healthcare expenditure (broken down by source of funding or by functions); all other variables are expressed in volume metrics. For instance, OECD data reports an interesting utilization statistic that could be easily translated into cost per disease: average length of stay in hospital for CHF, COPD, and Diabetes. To translate this figure into cost, in fact, we would need to know how much a day in hospital costs for each of the three different disease categories for every country, at least on average. However, this cost translation is not included in the OECD statistics. The reason is that even Member State-level statistics on this either do not exist, or they are not reliable, or simply are not comparable.[56] In the absence of homogenised statistics on costs, the only sources available are one off and contradictory data reported in international studies for a handful of European countries. For instance, the total costs of CHF have been estimated to range between 1% and 2% of total health expenditure depending on the country, or between € 11-23 billion (using, as a baseline, the value of total healthcare expenditure in 2007), which is clearly too wide for any reasonable extrapolation. There

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[55] *Ibidem*.

[56] Personal communication with OECD officials.

are no statistics whatsoever as to ICT capital investments and running costs for IPHS solutions. During SIMPHS Phase 1, we managed to gather through field work some data about these costs but only for a few regions in a few countries, and for a couple of ICT industry players. At the time of writing, this work is ongoing as part of SIMPHS Phase 2. We will probably be able to reinforce the evidence but not to the point of having standardised and comparable data for all of EU27.

Whereas the above discussion focuses on the disease-specific level of analysis, current SIMPHS 2 work allows us to also consider the sub-sectoral level of analysis (i.e. hospitals and primary care units). For reasons of logistical feasibility (IPTS being based in Seville), SIMPHS researchers during the first few months of 2011 worked closely with hospitals and primary care units in three Spanish administrative regions (Andalucía, Cataluña, and Basque Countries) to gather data for the evaluation of IPHS and, more generally, of integrated care enabled by ICT. The good news from this field work is that a great deal of data exists, if one is able to go into hospitals and primary care units and dig it out from their information systems. On the other hand, we found that, even within the same administrative region, data are recoded in different ways in different hospitals or primary care units. These differences are manageable and can be recomposed into comparable sets of data as we are working closely with the professionals administering the information systems. We can understand the logic of codification and identify the comparable items across different producing units. It goes without saying that, if this level of variability exists in all EU27 countries, the construction of comparable datasets from hospitals of all these countries will be a formidable task. As in Spain, the relevant data also exist in most other countries. Gathering this data and making them comparable is certainly not impossible, but evidently this task requires a lot of time and financial resources to be accomplished.

We will come back to the more general implications of these data challenges in **Section 4.** Here, we limit ourselves to anticipating that, in view of these challenges, the modelling pilot presented in Section 4 will start from only one country. It would be impossible, in the limited time and budget initially available, to gather the relevant data for more than one country.

Evidently, we cannot undertake modelling with this kind of data. For this, we would need (as in the case of prevalence) to gather information on medical costs country by country and make it comparable.

Finally, we do not have EU27-comparable information to quantify the cost of potential IPHS intervention, and filling this gap would also require country-by-country data gathering.

Many of the EU27 countries probably have the equivalent of the US NHANES or of the Australian AusDiab, but they would have to be retrieved country by country, translated, analysed, and pre-processed to make them comparable.

As a result of these data challenges combined with the limited resources and time allocated to the exploratory modelling research project, we will start with one disease and one country.

3.4. Towards modelling of IPHS impact

3.4.1. Summing up

To sum up the discussion in this section and the previous one, we can use the following synthetic narrative.

1) Healthcare and ageing today constitute a great societal challenge for Europe and, at the same time, an opportunity for inclusive growth;
2) The financial sustainability of healthcare systems are under strain, given public budget problems;
3) Health status has been compellingly shown to be an important component of human capital, which impacts on productivity and economic growth;
4) eHealth in general and IPHS in particular can contribute to improving health status, increasing healthcare system efficiency, and creating new market opportunities in innovative ICT industries;
5) Currently in Europe, both at EU and country levels, important policy and investment decisions are being made in the domain of eHealth and other fields in response to the new goals set in the EU 2020 strategy and in the Digital Agenda for Europe. Policy makers urgently need evidence to support these decisions;
6) Unfortunately, however, evaluations of eHealth in general and of IPHS in particular based on *ex post* approaches (empirical/ experimental or analytical with testing of hypothesis through empirical evidence) have produced inconclusive and fragmented evidence on cost-effectiveness. Several future research directions (see **Section 4**) can improve the situation but it will take five to ten years before more robust and conclusive *ex post* evidence is produced;
7) On the other hand, in the domain of public health *ex ante* evaluations (not considering the ICT dimension) are being increasingly conducted using a variety of modelling techniques (dynamic micro-simulations, SD, micro-macro modelling linkages, etc). These include modelling the impact of policy intervention addressing the management and prevention of chronic disease, the two key objectives on which IPHS also focus.

Therefore, our conclusion is that, to fill the existing evidence gap from the perspective of policy makers in a relatively short time, modelling the impact of IPHS is the only possibility - in a certain sense, this is a necessity rather than an opportunity.

In the next two sub-sections, we present the research logic and design of the modelling exploration that IPTS will carry out during the period April 2011 to April 2012 and the research agenda for the longer term.

3.4.2. IPHS Pilot Modelling: research objectives, rationale, and design

As stated, modelling of IPHS impact is a policy necessity that can be feasibly addressed by applying the approaches and insights derived from the modelling exercised reviewed earlier to the specific case of ICT-based intervention.

Yet, to date, there is no single micro or macro economic modelling that deals specifically with the potential impacts of IPHS in the US, other non-EU countries, or the EU. Our general more ambitious and long-term objective is, thus, to "*leverage the insights of these emerging approaches and lay down the foundations and roadmap for IPTS to become the first research institute in Europe to elaborate a comprehensive micro-macro modelling tool that would enable us to simulate the potential impacts of ICT-supported health and*

social care services (IPHS)". More concretely, there are five objectives that are clearly within reach of the one-year exploratory research project we propose:

(a) To investigate at a general methodological and theoretical level the possibility of linking micro and macro modelling to simulate the potential impacts of IPHS;

(b) To use Agent-based Modelling (ABM) to model the structure of incentives and strategies of the relevant stakeholders in particular healthcare ecosystems and simulate the conditions that may lead to institutional innovation and high take up of IPHS. This will support the take up scenarios to be used in the micro/macro-simulations;

(c) To make contact with the different and diverse communities of both health experts and modellers whose experience and expertise may be relevant for the micro and macro modelling of IPHS impacts;

(d) To pilot, using appropriate software and data, the ABM-supported micro/macro modelling to simulate the potential impact of IPHS in one European country for one disease;

(e) To lay down the roadmap for the future work that IPTS may want to undertake, such as: a) scaling up the pilot to more countries; b) completing a ready-to-use tool for future impact assessments.

As regards scope, we decided on one country and one disease as detailed below:

- Type 2 Diabetes was chosen as the most appropriate disease for three reasons:

  i) among the various diseases analysed in the course of SIMPHS Phase 1, Type 2 Diabetes was the one for which the availability of prevalence statistics and survey data was highest;

  ii) Type 2 Diabetes provides grounds, not only for better managing the conditions of the very elderly, but also for preventing pre-diabetes and mild morbidity (for the 55-64 age group) and risk factors (for 45-55 age group) from developing into full-blown conditions which hinder patients' Activity of Daily Life (ADL). Using ICT in this field can produce real productivity gains by helping individuals to stay at work;

  iii) the preliminary review of the literature shows that microsimulation models for Type 2 Diabetes have already been developed and need only to be adapted to include the ICT factor.

- Spain was considered to be the ideal country for the pilot study, not only for obvious reasons of logistical feasibility, but also because SIMPHS Phase 1 research had shown this country to have one of the highest rates of diabetes prevalence in Europe (Spain also registered almost a 230% increase in obesity prevalence between 1987 and 2008). At the same time, Spain has higher than average adoption of eHealth and national and regional policy makers are strongly committed to this topic.

Figure 10: Research rationale
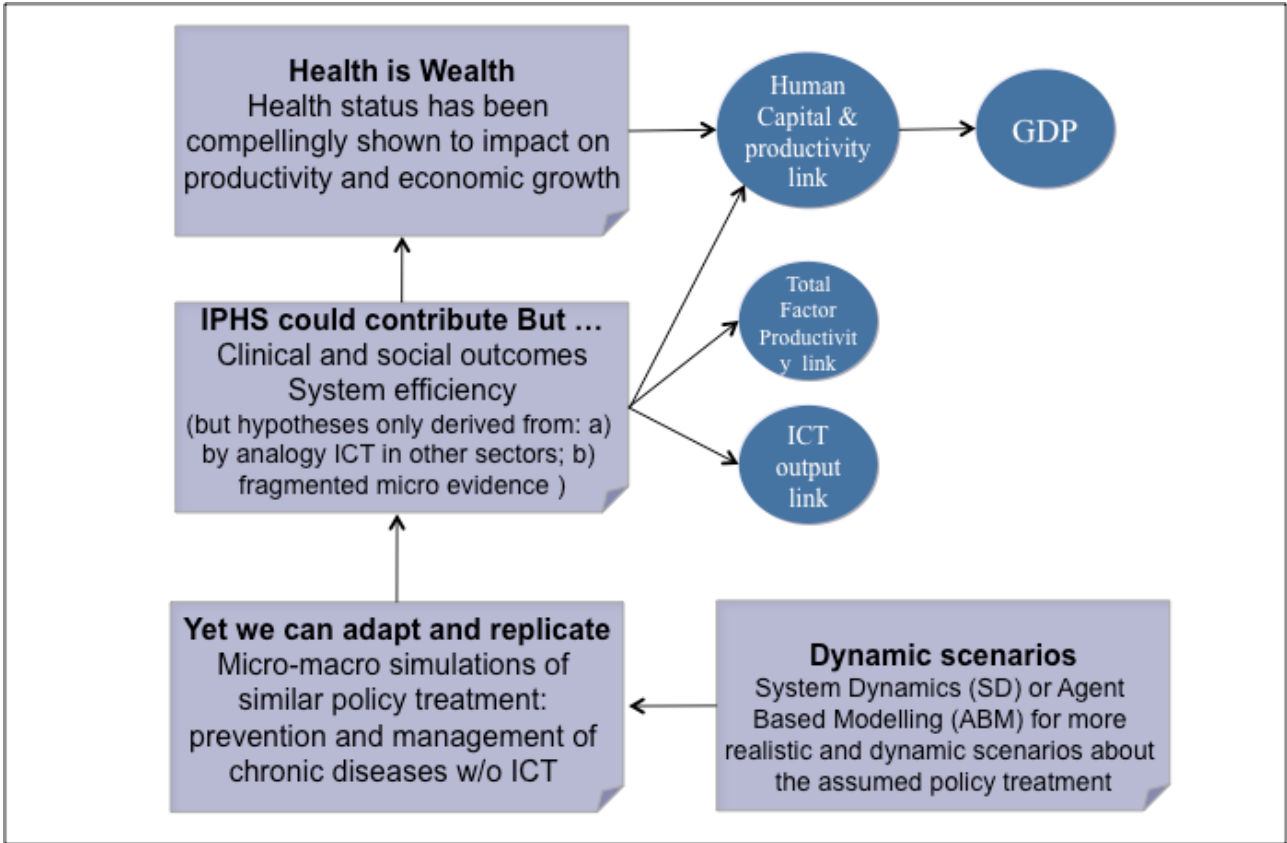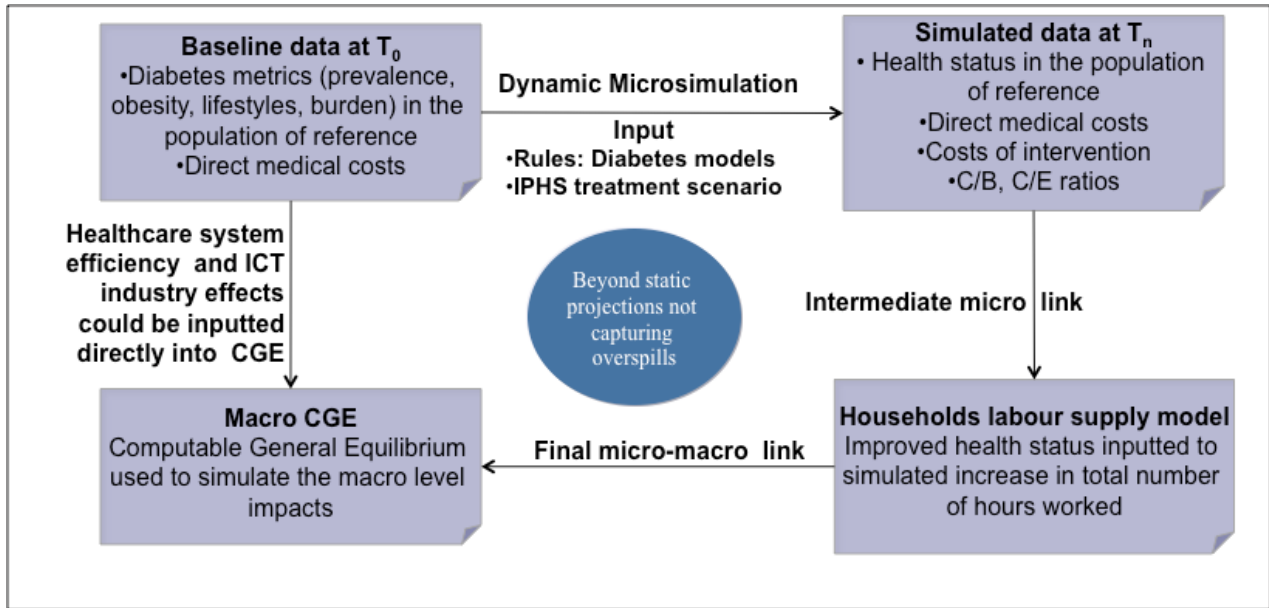
Figure 10 better structures the narrative presented earlier and requires no further comments as it is self-explanatory.

Figure 11 shows the preliminary research design as it stands at the end of the work on this report. This design may change as the research progresses, in the light of further systematic analysis of the literature and of interaction with the community of modelling experts.

Figure 11: Research design

Baseline data at T_0
- Diabetes metrics (prevalence, obesity, lifestyles, burden) in the population of reference
- Direct medical costs

Dynamic Microsimulation

Input
- Rules: Diabetes models
- IPHS treatment scenario

Simulated data at T_n
- Health status in the population of reference
- Direct medical costs
- Costs of intervention
- C/B, C/E ratios

Healthcare system efficiency and ICT industry effects could be inputted directly into CGE

Beyond static projections not capturing overspills

Intermediate micro link

Macro CGE
Computable General Equilibrium used to simulate the macro level impacts

Final micro-macro link

Households labour supply model
Improved health status inputted to simulated increase in total number of hours worked

Source: Authors' elaboration

Although it may change, it is nonetheless worth illustrating briefly. First, we will gather for Spain the same kind of granular baseline data that we have seen used in the US and Australian modelling exercises. Next, we will select a diabetes microsimulation tool from those available and define several diabetes treatment scenarios using our knowledge of IPHS interventions and their outcomes. On this basis, we will run the microsimulation producing data on prevalence and costs under the baseline (no action) and the treatment scenarios. In Figure 11, we did not include a QALY dimension as the feasibility of this is dubious, but we will explore the possibility of including one in the microsimulation. From the results on diabetes prevalence obtained under the treatment scenarios, we will extract the amount of extra labour supply that improved conditions will produce with respect to the baseline scenarios. This will be input into a traditional meso-level household labour supply model to simulate the increase in productivity and employment. Finally, these results will be input into a CGE model for Spain, together with estimates of how increased adoption of IPHS will lead to higher ICT industry output, and produce macro-level simulation of positive spillovers

3.4.3. Current and future activities: synergy with SIMPHS work

Besides carrying out the scoping activity that produced this report, we have already contacted healthcare authorities in three Spanish regional communities (Andalucía, Cataluña, Basque Country) and will soon contact the Spanish Ministry of Health. We have also started reviewing alternative software tools for microsimulation, supply of labour, and CGE. Future activities for the first year pilot modelling will include:

- Literature review and analysis;
- Missions to interview experts
- Organisation of a Workshop with key international modelling experts;
- Data gathering and piloting of modelling design;
- Final report and drafting of articles for peer review publication.

Exploratory research can by definition fail - partially or totally. In our case, for instance, data limitations and/or the technical complexity of linking micro and macro modelling

may prevent us from completing the full cycle of the research design. Nonetheless, our ambition is to achieve success.

Provided the pilot is successful, an additional activity will consist of designing a research agenda for the 2012-2013 period, which will aim to define the steps needed to scale up from one pilot in one country: a) to more countries and diseases; b) to turn modelling into a mainstream tool of *ex ante* impact assessment not only of IPHS-specific intervention but more broadly of all possible eHealth policy interventions.

It is worth noting that, while remaining two separate work streams, the modelling exploration (possibly to be mainstreamed in the future) and the SIMPHS activities have developed, and will continue to develop, in close synergy.

First, it was as a result of the challenges encountered while trying to produce the first extrapolation of RMT impact at the end of SIMPHS Phase 1 in 2009 that the scoping work presented in this report was launched and then completed in 2010. Second, the preliminary input from this scoping work has contributed to shaping the research design of SIMPHS 2 in that it led us to focus more realistically only on a limited number of countries in order to gather more granular and reliable evidence. Third, the very in-depth field work currently being undertaken in Spain will feed into both the pilot modelling and SIMPHS 2 deliverables. Fourth, SIMPHS 2 work in the other countries selected besides Spain (Denmark, Estonia, France, Germany, Italy, the Netherlands, and the UK) will help us decide how the pilot modelling can be scaled up in the future.

Having said that, we must also add a disclaimer as to what can be expected by the end of 2011 in terms of extrapolation of impacts. The pilot modelling will focus only on Spain, which means that EU27 extrapolations for SIMPHS 2 will be produced using the same limited and static methodology used in SIMPHS 1, although these will be based on better and richer empirical evidence and better refined scenarios and time frames.

4. Conclusions

The last OECD study on ICT and healthcare efficiency commented that inconclusive evidence has spurred an international controversy about whether or not the much-touted benefits and savings ICT could bring to healthcare have been achieved or, indeed, even measured[203]. The need to document, in robust way, the impact and added value of eHealth is becoming critical [227], since lack of evidence is causing policy makers to doubt the usefulness of investing public money in this field[256]. In the final paragraph of these conclusions, we argue that - to partially fill this gap in the short term - an *ex ante* modelling exercise is needed, to make up for the lack of conclusive evidence from *ex post* observational evaluations.

In this concluding section, we draw further implications from our analysis at different levels. At a higher level we: a) identify the mid-term priorities to be pursued to advance the ex post evidence on the impact of eHealth in general and of IPHS in particular (§ 4.1); and b) single out DEA as one of the most promising short-term approaches and argue for switching the focus toward integrated ICT interventions (§ 4.2). At a lower and more practical level, we recall once again how this exploratory work helped shape the research design of SIMPHS 2 (§ 4.3).

4.1. Directions for future *ex post* observational evaluations

Going back to the classification of evaluation approaches by level of analysis presented earlier (see § 2.1), the directions for future work needed to advance the state of the art in *ex post* evaluation of ICT usage in healthcare are listed below.

1. International macro-level evaluation (using panel regression or DEA).
   It would be worth using WITSA data on aggregate ICT spending in healthcare by country to run a panel regression and/or DEA (treating countries as if they were producing units). ICT would enter as the independent variable (indirectly representing policy efforts), whereas the dependent variable could be healthcare output (i.e. as measured by OECD Health data on number of treatments and consultations), while controlling for non-ICT capital (proxied by data on number of beds, number of scanners), total spending, and health outcomes. The aim would be to assess whether output growth emerges as a function of ICT spending. One could also add the index of eHealth adoption in hospitals as a variable in the equation. This would *de facto* amount to a sort of growth accounting exercise, but we repeat of a totally exploratory nature. In our view, at least a decade will have to elapse before data that can enable a robust growth accounting exercise in healthcare is available.

2. Sub-sectoral level DEA evaluation of ICT input /output and/or outcome efficiency
   The DEA approach is deemed to be one of the most promising ways of assessing the contribution of ICT to efficiency in healthcare [197]. For this reason, we treat it separately in the next sub-paragraphs:

3. Improved disease-specific evaluation through refined RCT and/or LCS.
   a. RCT (Randomised Control Trials) to evaluate the cost-effectiveness of IPHS should be improved in four ways. First, they should take into account co-morbidities and address the issue of reduction in all causes of hospitalisation. Second, they should be conducted in separate local settings but designed and executed in comparable ways in different countries. Third, they should always include a QALY component in

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monetary terms. Fourth, they should also follow up individuals in the treated groups to verify their employment situation and eventually factor in recovered productivity gains. These changes will take five to ten years to be delivered. Nonetheless RCT are useful in general, even under the present limitations, and also specifically as they provide increasingly robust and comparable parameters which can be calibrated into modelling exercises.

b. LCS (Longitudinal Cohort Studies), if well designed according to the principle and techniques of counter-factual causal evaluation models (i.e. difference in difference or regression discontinuity design),[57] can produce reliable and strategic evidence on the impact of ICT-based treatment. They would focus on cohort individuals receiving IPHS-based treatment in different locations (within a country and across different countries) and compare the before-and-after health outcomes in both treated groups and non-treated groups in other locations. Clearly, large-scale CIP pilots, like Renewing Health, are the best candidates for realising this kind of evaluation research design and IPTS is currently preparing a proposal to this end.

4.2. Using DEA to assess ICT efficiency impacts

We have explained what DEA does and how it does it, and provided examples of applications in § 2.2, so here we can briefly envisage how this technique can be used to evaluate the impact of using ICT in healthcare.

Comparable samples of producing units (i.e. primary care units or hospitals) can be analysed first at national level and then at international level. Given the technical requirements of DEA, the sample could be initially limited (25 units would be enough) and gathering the data needed would not be a daunting task. The evaluation could start with comparing aggregate monetary value of expenditure for ICT and for all other non-ICT fixed and variable costs to level of outputs (number of treatments for hospitals or of consultation for primary care units), while controlling for health outcomes. This sort of analysis would help us decide whether using ICT increases the input or output efficiency of hospitals or primary care units, assuming that current quality levels (measured by the health outcomes of the population of reference for each producing units) remain constant. One could also use DEA to perform an outcome efficiency analysis and correlate the usage of ICT directly with the population's health outcomes. This kind of approach will actually be tested by SIMPHS researchers using data that we have been gathering from primary care units in the three Spanish regions mentioned earlier. Though this approach is feasible in the short term at country level, scaling it up to EU27 level will need longer and more intense efforts. Surveys funded by the European Commission would help to speed up the building up of evidence. Nonetheless, robust and international EU27 DEA evaluation of ICT contributions to hospital efficiency will require at least another five years of data gathering, testing, and analysis.

From the strictly defined perspective of IPHS, application of DEA in this way seems unfeasible as long as the ICT variable is measured by all ICT expenditure and not by the expenditure strictly related to IPHS alone. As we argued, IPHS ICT costs are not currently available and it will take some time to have this kind of granular data on ICT

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[57] Counter-factual causal evaluation theory and related techniques are discussed in a separate IPTS report [160].

costs in a standardised and comparable way. Yet, this consideration allows us to argue strongly in favour of the need, in the short term, to abandon the focus on strictly defined IPHS costs for ICT in order to do some observational *ex post* evaluations.

In order to contribute in the short term to the construction of observational evidence on impacts, we argue that IPTS should abandon the focus on entities that are still too small to be measured robustly and look at ICT in a more integrated fashion. Considering that today RMT is about 1% of total eHealth activities in terms of market value, that no reliable statistics on its deployment by country exist, and that such data will not be available for 5 to 10 years, it makes no sense to run a DEA analysis that attempts to factor in only the IPHS-specific costs of ICT. It would be rather more fruitful to look at ICT in a more integrated fashion, not only because of the measurement problems but also in view of the argument below.

The new definition of IPHS provided earlier stresses the need for integration in two ways: first, for integration between the health and social care, and second and most important, for system integration. Briefly, truly integrated and personalised care services should: a) be produced as a result of cooperation between the different players (primary care, hospitals, local health units, social care departments and providers); and b) as a result of integration of front-end sensor monitoring systems with the back-office health information systems. These should not be stand alone operations if they are to become sustainable and mainstreamed into the common every day business of providing social and health (disease management) care. Chronic diseases are by definition complex and multi-dimensional, in that they are the result of many factors interacting during the course of people's lives and they also tend to manifest themselves in multidimensional ways. So, they need to be addressed with an integrated approach where ICT solutions of different types (and not only those delivering the final end facing IPHS component) must play a strategic role as both knowledge engines and service delivery platforms. ICT-based engines must provide access at the right time to the required data or insights on, among others, guidelines and safety, information about patient conditions, treatments and other pertinent characteristics, as well as reminders to providers at the point-of-care of important quality steps. In addition, ICT should provide special information based on tasks and processes, including facilitating population-based care, tracking measures of health over time, involving the care team, including the patient, and giving feedback about progress. It is evident that, within this context, RMT or ICT-based social care services (IPHS) represent only one component. In order to be effective for their specific purpose and at the same time contribute to the overall provision of integrated health and social care, IPHS should get data from other components of the system and provide their data to them. For instance, IPHS and EHRs should be integrated and inter-operable. IPHS should be able to access, process and store data onto EHRs. This is where ICT could support and trigger real integration and inter-institutional collaboration in the provision of care.

The corollary of this is that the integrated use of ICT should be reflected in the overall expenditure on relevant applications. Therefore, more aggregate ICT cost data can be used as proxies to test whether outputs and outcomes specifically related to chronic conditions increase/improve as a result of the size and intensity of the ICT input. In conclusion, DEA can be used to evaluate the ICT contribution to the management of chronic disease without having to gather and use scattered and unreliable IPHS-specific expenditure on ICT.

4.3. Implications for SIMPHS 2 research design

Finally, we will summarise briefly the implications of the findings of this exploratory research for the design of SIMPHS 2.

Since there are no ready-made internationally-compiled statistics on the kind of variables we need, and in order to develop the data in support of more robust projections, we need to go country by country and then sum up country-specific projections at EU27 level.

Country level statistics like these will not be sufficient and reliable data on clinical costs will need to be identified. Therefore, a well designed case study should be carried out to have at least some empirically-based insights into the costs of chronic diseases.

We would need to find out much more about the costs of tele-monitoring in Member States and take into account specifically the stage of the disease being targeted by the service.

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Abstract

This report contains the main findings of the scoping and exploratory research carried out in the course of 2010 by the SIMPHS research team (part of the TIESC Action within the Information Society Unit at IPTS) on the broadly defined issue of assessing the micro and macro impact of Integrated Personal Health and Social Care Services. SIMPHS, which stands for Strategic Intelligence Monitor of Personal Health Systems, is a three-year project collaboration between IPTS and Unit H1 (ICT for Health) of the European Commission's Directorate General Information Society. While this work is an integral part of ongoing research activities at IPTS, its strategic relevance has increased in the run up to the launch of the 2011 European Innovation Partnership on Active and Healthy Ageing, for which the SIMPHS project is expected to provide input during the impact assessment phase. While one of the key results we present is the need for a modelling approach for the *ex ante* assessment of the potential impact of IPHS, the focus of this work is more broadly that of considering what evidence is available on the impacts of IPHS in particular and eHealth in general. In this respect, the material presented in this technical report represents a one-off contribution in terms of an updated, exhaustive, and interdisciplinary critical review of the state of the art. It is worth stressing that this report brings together, in a coherent framework, different strands of literature. It goes beyond the more specific sub-field dealing with the evaluation of eHealth and spans health economics, clinical studies, general approaches in economics, and general modelling and health-specific studies.

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