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Sherlock in Health

How artificial intelligence may improve quality and efficiency, whilst reducing healthcare costs in Europe

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Summary

Various megatrends are impacting healthcare systems in Europe, creating a scenario where artificial intelligence based technologies could be deployed for the benefit of all stakeholders. Converging of these trends, such as, aging of the population in the region, the resulting high cost of healthcare, coupled with patients becoming more demanding and value-focused, is creating a situation where technology can help in improving healthcare access, quality and affordability. It is not hard to imagine a future with intelligent technologies helping us diagnose diseases faster, and assisting doctors in treatment decisions, armed with evidence based analysis of likely outcomes.

AI is increasingly becoming a part of the healthcare ecosystem. Some of the applications developed, though in early stages, are having an impact across care pathways, starting at prevention, to diagnosis, treatment and recovery. At this stage, it is very important to analyse the demand and potential benefits from AI applications in healthcare in Europe. This will not only help us distinguish between realistic hopes and unrealistic hypes, but will also help in focusing our efforts in the right areas.

Analysing demand and potential benefits throughout healthcare is very complex and many factors come into play. We looked into three care pathways as a representation of both the benefits that might accrue from AI use in healthcare and the medical dilemma's it will create. We estimate that large-scale AI use could yield benefits of the following magnitude.

- **For childhood obesity**: AI use could yield cost saving of up to EUR 90 billion over the next ten years. This saving estimate includes benefits from lower medical costs, and reduced losses from lower productivity and sick days. AI could also help in increasing the efficiency of self-monitoring for preventing obesity.
- **For diagnosis of dementia**: AI use could help save up to EUR 8 billion in diagnosis cost over the next ten years, largely driven by increased rate of diagnosis at primary care level. AI can help diagnose with up to 90 percent accuracy, bringing it to a large proportion of dementia patients who never receive a formal diagnosis.
- **For diagnosis and treatment of breast cancer**: AI use for diagnosis and treatment of breast cancer could be very helpful in early detection, also helping in treatment decision making and reducing doctors' direct engagement in potentially repetitive tasks. It could help save up to EUR 74 billon over the next ten years, if used on a large scale.

However, achieving these benefits will not be easy. Various challenges exist, such as lack of sufficient data, enabling data standards and regulations. According to various experts we interviewed, technical, legal and financial feasibility of adopting AI will be critical. Equally important, will be to assess the psychological feasibility – is the public actually ready and receptive to AI adoption in health? Based on our analysis of constraints and interviews with industry experts, we make three recommendations to help improve technology-driven healthcare services in Europe.

- Introducing a **balanced scorecard** in policy making will ensure that the focus is not restricted to any one policy area, such as: improving the quality of healthcare; containing the cost of care; or managing overall population health.
- Moving **quickly and consistently on regulations** will ensure that the vision on AI within the healthcare industry is matched and supported by timely regulations.
- **Redefining reimbursements** to support outcome based care will alleviate any payer related concerns for providers and patients, providing the much needed development boost to AI tools.

Introduction

Access to quality and affordable healthcare is a challenge that is growing every day. Increasing demand and increasing scarcity of health care personnel has put pressure on healthcare delivery, which is in constant need of optimisation. According to data collected from several EU nations, medical errors and healthcare related adverse events occur in eight to twelve percent of hospitalisations. Preventing such mistakes could help to prevent more than 3.2 million days of hospitalisation each year within the EU[1].

Technological breakthroughs in artificial intelligence and the availability of big data present the promise of reducing such errors, whilst making healthcare more accessible and affordable. Artificial intelligence will not completely replace physicians and care workers, but it can play a key role in reducing the pressure on healthcare systems and be a decision supporting tool for physicians.

In this paper we assess the healthcare landscape[2] in Europe[3] and its readiness for artificial intelligence (AI) applications. We also estimate the probable benefits of using AI applications in healthcare, based on three different but interrelated dimensions: potential cost savings to patients; rise in efficiencies in healthcare services; and the increase in accessibility of healthcare services. Furthermore we analyse three conditions and associated care pathways:

- Prevention of childhood obesity;
- Diagnosis of dementia; and
- Diagnosis and treatment of breast cancer

Based on the analysis, we identify some major challenges and the following steps needed, in order to begin moving to large-scale AI adoption and advanced healthcare.

[1] http://www.euro.who.int/en/health-topics/Health-systems/patient-safety/data-and-statistics

[2] AI will have an impact on all health related fields including healthcare services, pharmaceuticals, and life sciences. For this study, we are only looking at the potential impact on healthcare

[3] The geographical scope of the study covers Europe. Interviews have been conducted in Austria, Germany and the Netherlands

Megatrends impacting healthcare

European healthcare systems are amongst the most expensive in the world as measured by the share of healthcare spending in GDP. Apart from rising costs, there are various trends that impact healthcare in Europe, rendering it apt for the deployment of intelligent technologies.

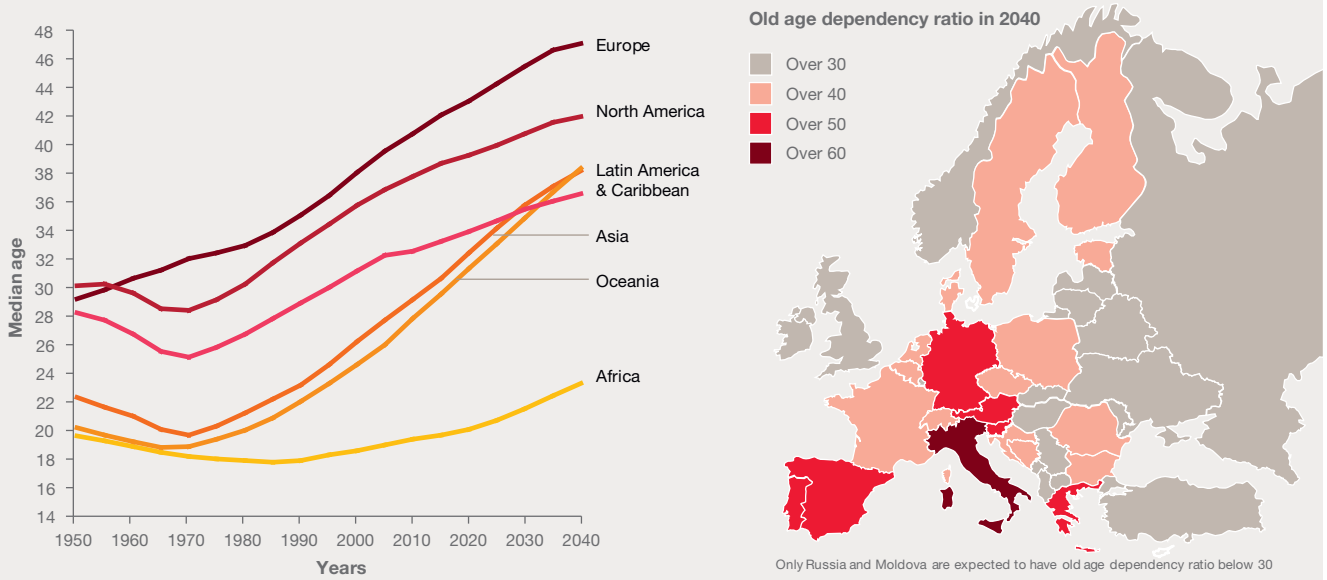
1a. Increasing number of elderly citizens

Citizens within Europe are rapidly ageing. In 2015 almost 18 percent of the European population was aged 65 or older. In 2040, this figure will have increased to 26 percent, adding 56 million people to this age bracket. Due to demographic pressures, health workforce shortages will remain a major concern within Europe.

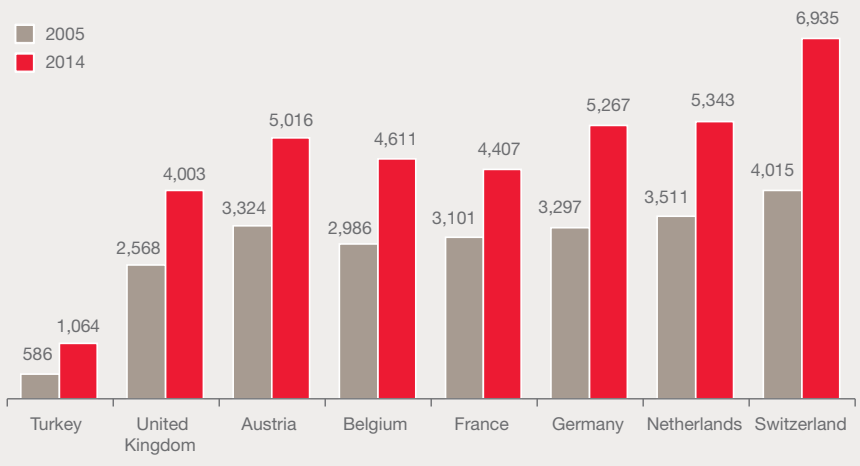
1b. Mounting healthcare expenditure

Healthcare expenditure within EU countries is amongst the highest in the world. The level of healthcare expenditure in Germany was at EUR 321 billion in 2014, the highest among all EU countries, equivalent to 11.0 percent of GDP[4]. It might continue to rise, as healthcare expenditure is one of the fastest growing expenditure categories of modern economies.

Oldest region in the world



Rising healthcare expenditure[5]



[4] http://ec.europa.eu/eurostat/statistics-explained/index.php/Healthcare_expenditure_statistics
[5] http://stats.oecd.org/index.aspx?DataSetCode=HEALTH_STAT#

Although the ageing population in Europe is increasing, this does not necessarily imply healthier living. Research from the UK showed that for the average British person, the amount of healthcare resources they consume begins rising significantly from around the age of 50 and rises particularly sharply beyond age 70[6]. In the Netherlands, more than EUR 10,000 is spent on healthcare per inhabitant aged 75 or older, and the spending increases to more than EUR 50,000 for people aged 95 and older[7]. As the size of older cohorts expands, the fraction of people who spend this EUR 50,000 gets bigger, causing the rise of healthcare spend as a fraction of GDP.

1c. Changing patient attitudes and behaviours

Over the past two decades patient assertiveness has increased, partly because of the rising incidence of chronic diseases. With major and chronic diseases together accounting for 87 percent of the deaths in the EU[8], they are the biggest cause of death and disability, requiring continuing care. Many diseases that were previously terminal are now managed over long periods. As a result, patients are progressively inclining towards taking more control over their health and have become much more demanding in their interactions with health professionals. Increased access to consumer health technologies has also contributed to this trend. Patients are more likely to actively manage their own health and to seek information and consultations when required, shifting care from hospitals into communities and homes.

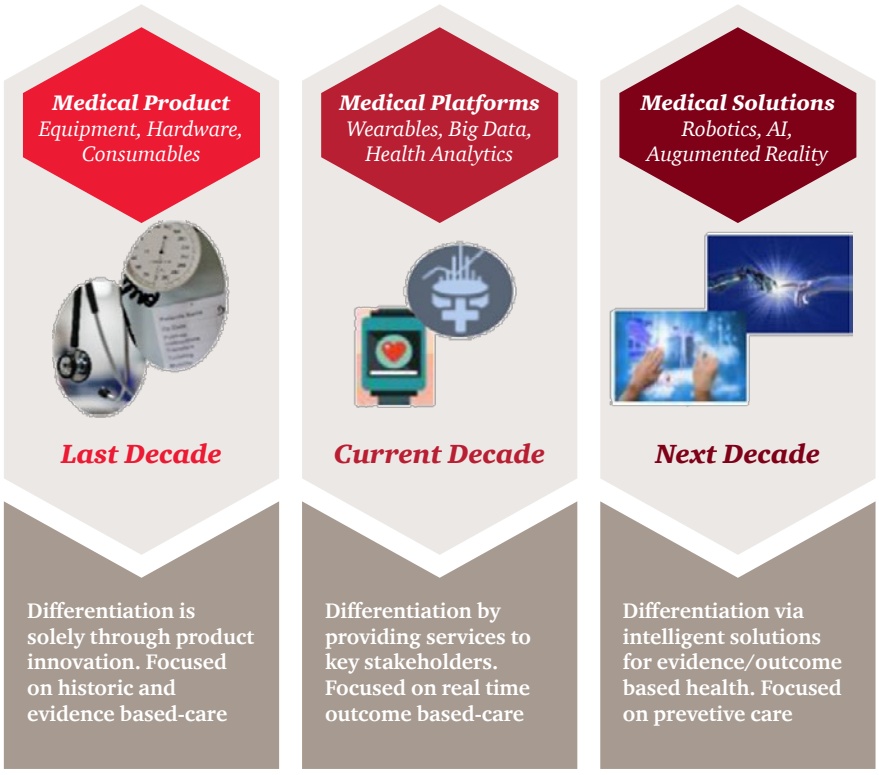
1d. Shift from volume to value

The changing attitudes of consumers is impacting how healthcare services are monetised. The fee-for-service models of the past might not be sufficient to cater to the changing demands of patients, as they move from passive healthcare recipients to active value-seeking customers. The current model incentivises provision (or over-provision) of services, but does not do enough to incentivise improving the value that the healthcare service brings to the patient. As the trend moves from volume to value in healthcare services, the need to have reliable, consistent, and technology based solutions will rise.

1e. Evolution of medicine

As the study of medicine is evolving, we are gaining a better understanding of disease. New technologies are making a data driven medicine revolution possible, where scientists are able to analyse large amounts of relevant medical (e.g. diagnostic data, EHRs etc.) and non-medical data (e.g. internet search history, social media profiles etc.) in a short time frame, to personalise medicine and reduce errors and costs. It is already possible to personalise treatments based on the genetic features of a patient, as done by companies like Foundation Medicine, OncoDNA and Caris Molecular Intelligence. Much of what we do in health care is not yet evidence based. The data revolution will allow us for a better understanding of what treatments are truly effective.

Evolving focus area in healthcare



[6] http://www.if.org.uk/archives/7133/new-data-confirms-relationship-between-age-and-health-spending
[7] http://eengezondernederland.nl/Heden_en_verleden/Zorg/Zorguitgaven_naar_leeftijd_en_ziektegroepen
[8] https://ec.europa.eu/health/major_chronic_diseases/diseases_en

1f. The data wave

The healthcare industry generates a huge amount of data. According to IDC estimates, the volume of healthcare data will grow to 2,314 exabytes by 2020, growing at the rate of 48 percent annually. According to IBM, healthcare data doubles every 24 months[9]. Beyond that it is not just healthcare systems that generate a large amount of potentially usable data. Sensors in smart watches and fitness trackers register heart rates, blood pressure and sleep patterns automatically and continuously, adding them to the cloud of health data. Even social media adds to the amount of healthcare data that is already available. Research shows that psychologists can detect depression early[10], based on one's Facebook or Instagram account.

Both the healthcare and technologies industries have been looking for tools and methods to integrate and analyse this unstructured data, to be able to use it for diagnostics, treatments and evaluation of new medicines. Incumbents and start-ups are looking into big data, data analytics, predictive analytics and AI to discover patterns in healthcare data that were formerly unknown.

Each of these trends signal towards an environment that is ready for the deployment of AI driven technologies in healthcare. At the same time there are various concerns and uncertainties around the effectiveness of such technologies, data privacy and market readiness, which makes it difficult to imagine how the healthcare system in Europe will look like in ten years' time. Some of the key questions remain, including: could the use of cognitive technologies result in better health care at lower costs for everyone?

[9] http://www-07.ibm.com/hk/watson/health/

[10] http://www.nytimes.com/2012/02/24/us/facebook-posts-can-offer-clues-of-depression.html

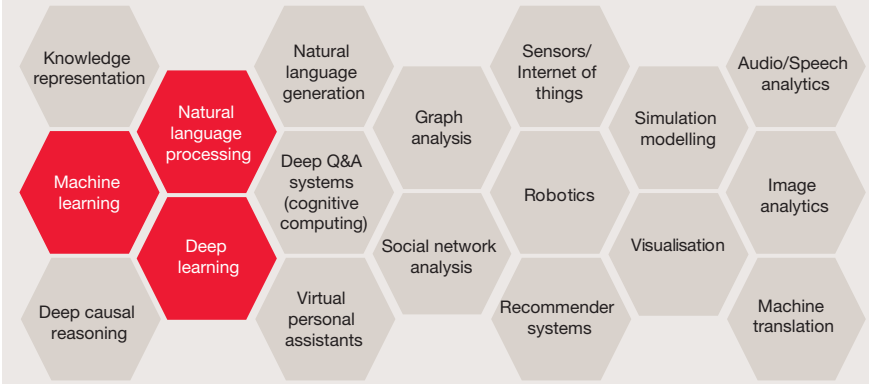
AI in healthcare

AI will undoubtedly have a profound influence on the healthcare industry. It has the ability to process information much faster than any human can, thus proving to be a great tool to increase efficiencies, as well as solving the problem of misdiagnosis and medical errors to a large extent. AI is already being implemented across different hospitals worldwide, to improve diagnosis and to enable faster, more accurate treatment. It is not only hospitals and doctors that are impacted; areas like consumer health is also being revolutionised, with sensors that can detect symptoms at early stages and predict a potential health incident, ahead of time, to prevent it.

AI is a very broad category with various subfields. For this study, we look at varied applications of AI, from sensors and IoT devices, to more complex systems that apply natural language processing and machine learning, to reveal insights from large amounts of unstructured data.

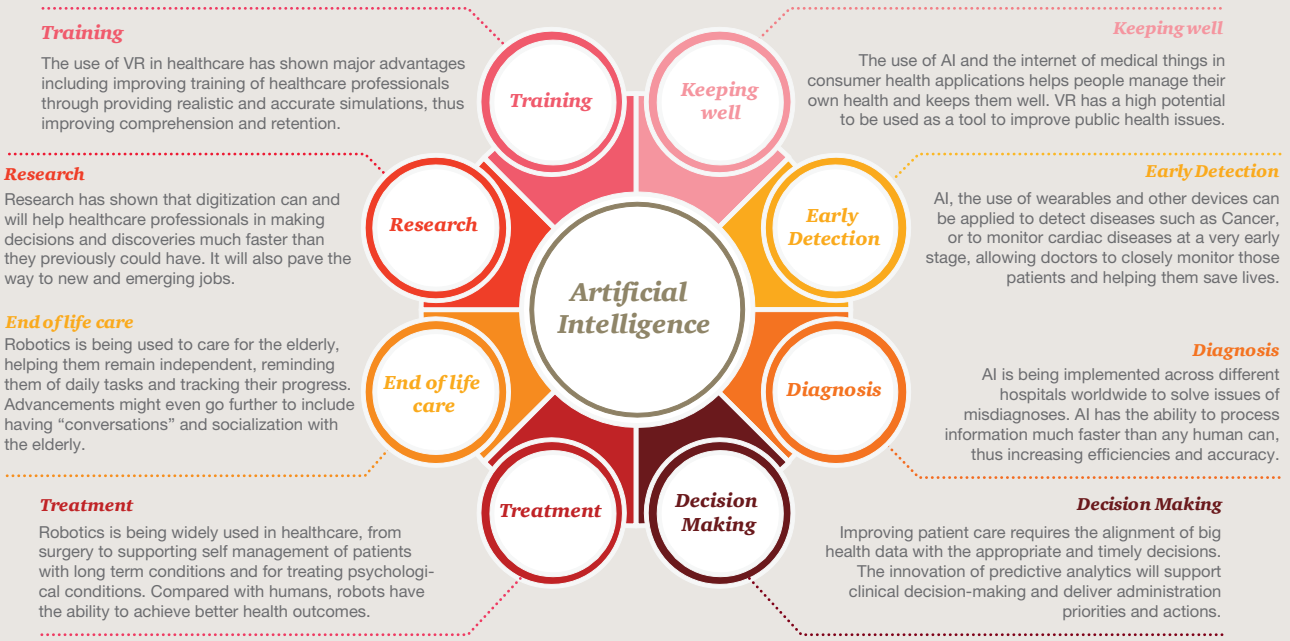
While the industry might not be ready to exploit the full range of AI possibilities, such as autonomous intelligence[11] because of various challenges, it is already on the path to use assisted intelligence[12] and augmented intelligence[13] to some extent. The sub-fields of machine learning and natural language processing are fast becoming transformative for the healthcare value chain.

AI subfields



Not exhaustive

AI applications in healthcare



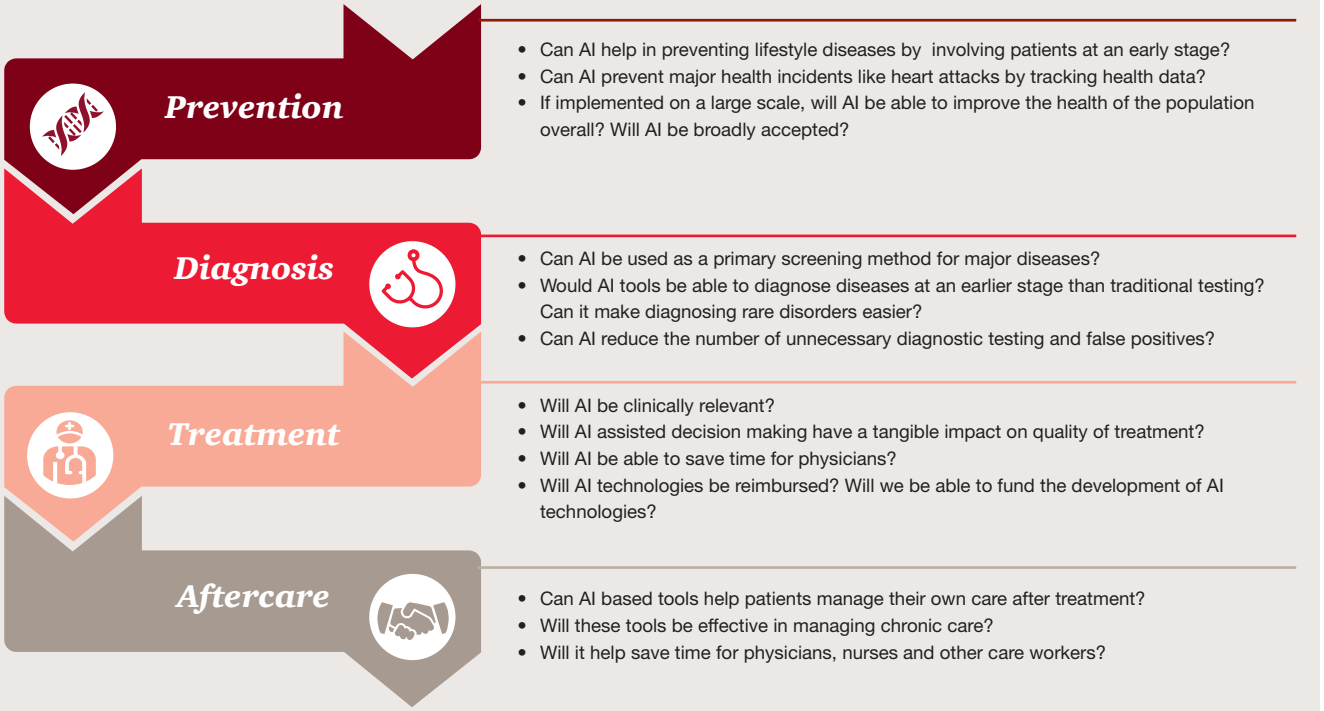
[11] Refers to AI that is autonomous in decision making and acts with limited human intervention
[12] Refers to AI that assists in decision making
[13] Refers to AI that augments human capacity, for example helps in making diagnosis faster and more accurate
[14] https://ec.europa.eu/digital-single-market/en/blog/future-robotics-and-artificial-intelligence-europe

Some of the applications developed using AI are having an impact across the care pathways, starting at prevention, to diagnosis, treatment and recovery. For instance, Pathway Genomics is developing an application that will provide customised health advice, based on a user's specific genetic makeup. Cyrcadia's iTBraTM is a wearable vest, for the detection of breast cancer at early stages. CardioDiagnostics has developed a device that is able to remotely monitor its wearer for heart irregularities, and is used to improve cardiac monitoring and rhythm management. ViterosHealth has a developed a predictive analytics platform that identifies people whose health is most likely to deteriorate, and implements change protocols to prevent catastrophic health events. IBM Watson for Oncology, on the other hand, generates a list of potential treatment options, ranked by applicability to a specific case.

While many developments in AI health applications are happening outside of Europe, the region has made progress in this field as well. Half of all professional service robots are produced in Europe, and many recent breakthroughs in AI were developed by European laboratories such as DeepMind's AI software[14]. In addition to the inroads made by research laboratories, it is also important to analyse the demand and potential benefits from AI applications in Europe. Only then will we be able to understand and differentiate between the "hope" and the "hype" of AI in health.

The adoption of intelligent technologies on a large scale, is largely dependent on the answers to the above questions. It makes sense to only consider large scale AI adoption after the potential benefits are established beyond doubt. We should be looking at the potential benefits to the health of citizens, cost savings in the long term and the impact on existing healthcare structures. So, what will the impact of large-scale adoption of AI in healthcare in Europe look like? Are we looking at a significantly lower cost to the patient? What about the risk of overdiagnosis? Will it result in better access to care services? Since the questions are very complex and as many factors come into play, we will look into three care pathways as a representation of both the benefits that might accrue from AI use in healthcare and the medical dilemma's it will create.

Hope or hype?



Methodology

In this paper, we evaluated care pathways for three conditions – prevention of childhood obesity; diagnosis of dementia; and treatment and aftercare of breast cancer. For each of these pathways we assessed the potential impact that AI applications can have if implemented on a large scale. The aim was to investigate whether these tools can fulfil their claims of: improving the quality and accessibility of healthcare, and reducing the cost of healthcare to patients and to society.

Potential cost saving to patients

Assessing potential cost savings from AI applications involved looking at various aspects. The first step was to conduct a literature scan to develop a cost estimation framework. Apart from looking at the prevalence and incidence of the conditions in Europe, the literature scan also focused on the cost of the three care pathways – including medical costs, non-medical costs, indirect costs such as productivity losses and absenteeism, and societal costs.

At the next stage, we studied the current applications of AI in each pathway and the expected improvements in the near future. Likely improvements included the accuracy with which AI could help diagnose or the time that the tools were likely to save. All the assumptions formed using a literature scan were verified and modified based on interviews with experts*.

Using the information collated from primary and secondary sources, a cost estimation framework was developed, that compared the cost of each traditional care pathway, with the cost estimation in the scenario where AI is implemented on a large scale. The framework takes into account the potential cost of implementation**, its efficiency in preventing, diagnosing or treating the conditions, and costs that will need to be incurred despite the use of AI.

Increase in accessibility and efficiency of healthcare

Improvements in accessibility and efficiency of healthcare were evaluated, mostly on the basis of a literature scan as well as recent developments in the field of AI in healthcare. We looked at various aspects to judge accessibility improvements, including, but not limited to: extent to which AI enables patients or primary care practitioners to prevent or diagnose diseases; and potential gains from reducing a physician's time involvement in a particular pathway, thereby freeing up advanced care capacity.

Assessing efficiency benefits included looking at factors such as: improvements in the accuracy of AI tools, as compared to humans; and overall decreased error in medical services, for example reduced false positive results, in the case of diagnostic testing.

* Interviews were conducted with hospitals and clinics, payers and technology companies active in the AI space

** Since there are various applications, with varying cost of implementation and reported efficiency, the cost saving estimation is done on the basis of information availability

Prevention of childhood obesity

Obesity is one of the biggest public health challenges of recent times. Recent estimates suggest that in 46 out of 53 countries within Europe, more than 50 percent of adults are overweight or obese, and in several of those countries the rate is close to 70 percent of the adult population[15]. This trend is also of major concern in children and adolescents. According to estimates from the WHO's Childhood Obesity Surveillance Initiative (COSI), around 1 in 3 children in the EU aged 6-9 years old were overweight or obese in 2010. The estimate was 1 in 4 in 2008[16].

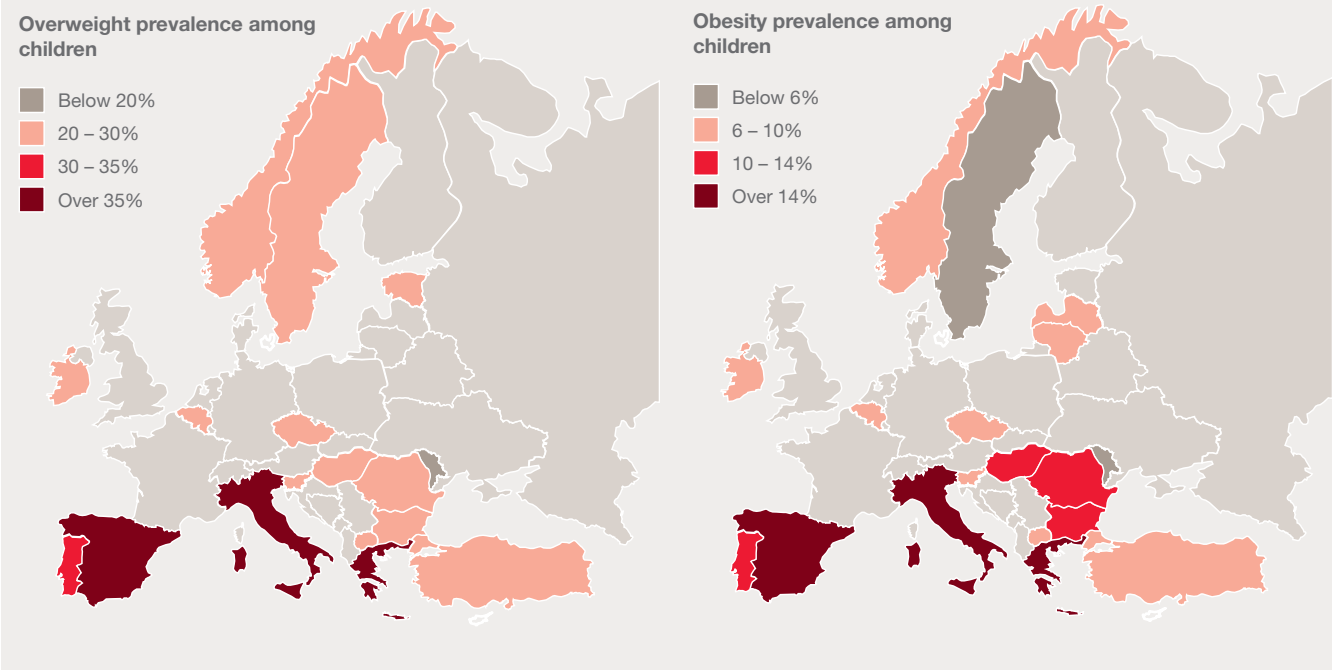
Economic burden

Being overweight and obesity also imposes a significant burden on the health systems of EU countries. It is estimated that every year around seven percent of national health budgets across EU countries is spent on conditions linked to obesity. Indirect costs such as loss of productivity, work absences due to health issues and premature death, also add to the financial burden at the country level. In the EU, around 2.8 million deaths per year result from causes associated with being overweight and obesity.

The per capita cost associated with childhood obesity do not become evident until later in life. However, data suggests that 60 percent of the children who are overweight before puberty are likely to be overweight into early adulthood as well[18]. Childhood obesity is strongly associated with risk factors for cardiovascular disease, type 2 diabetes, orthopaedic problems, and mental disorders, and consequently higher healthcare costs in adulthood. Its seems to be a near universal fact that overweight and obese individuals incur higher healthcare costs, as compared to people within the normal weight range. According to research conducted in the USA, adult obesity raised annual medical care costs by USD 3,508 per obese individual, as compared to individuals of normal weight[19]. Another study in Europe estimated the costs for overweight and obese individuals were, respectively, 9.9 percent and 42.7 percent higher, when compared to normal weight adults[20].

The cost implications of obesity is not limited to higher medical costs. Obesity also causes higher indirect costs such as drop in productivity and loss of work

Childhood obesity is becoming widespread[17]



Comparable data not available for other countries

[15] WHO European Region, http://www.euro.who.int/__data/assets/pdf_file/0009/325782/9th-COSI-meeting-report-en.pdf?ua=1
[16] http://ec.europa.eu/health//sites/health/files/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf
[17] http://www.euro.who.int/__data/assets/pdf_file/0009/325782/9th-COSI-meeting-report-en.pdf?ua=1
[18] http://www.euro.who.int/en/health-topics/noncommunicable-diseases/obesity
[19] https://www.ncbi.nlm.nih.gov/pubmed/25381647
[20] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5034461/
[21] https://www.ncbi.nlm.nih.gov/pubmed/18188080
[22] http://ec.europa.eu/health//sites/health/files/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf
[23] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4586339/

days. Research confirms that moderately or extremely obese workers (BMI ≥ 35) experience higher health-related work limitations. According to one study obese individuals experienced a 4.2 percent health-related loss in productivity, 1.18 percent points more than all other employees[21].

Intervention in childhood and role of AI

While various efforts are made to contain obesity among adults, it is increasingly becoming evident that preventive interventions targeting children could be more effective. According to research, interventions implemented early in life could yield a return on investment of 6–10 percent[22].

Studies are assessing the effectiveness of using machine learning techniques to prevent obesity, by analysing clinical data in children as young as two years of age. If clinical data could be modelled to effectively predict future obesity in children, physicians could target those at risk more easily[23]. At the moment, most interventions are aimed at older children who already begin showing signs of higher than normal weight. With AI tools we might be able to intervene at a much earlier stage. Additionally, AI can help study the impact of an intervention among different populations, thereby helping in expanding or modifying an approach.

AI is also helping to improve our understanding of obesity and its risk factors. It is enabling researchers to study the association between obesity and a range of factors related to genetics, metabolism, environmental, and lifestyle and dietary habits, so we are no longer restricted to the traditional understanding of the condition. Taking a multifactor approach could reveal why certain obese people develop associated conditions like diabetes, while others do not. AI could help in modelling complex relationships and recommending intervention approaches that are targeted to individuals and their genetic makeup.

*Cost**

The current population of obese and overweight children in Europe is estimated to be nearly 33 million.

If this population continues to be obese or overweight into adulthood, it could cost over EUR 3000 per capita in direct medical costs per year. The cumulative costs over the next decade could accrue to in excess of EUR 290 billion.

Large-scale AI application for prevention of obesity among children in Europe, could save up to EUR 90 billion over the next ten years.

The cost saving estimate includes benefits from lower medical costs, and reduced losses from lower productivity and sick days.

Accessibility

According to US research data, as much as 48 percent of all patient visits might not be screened for obesity at all, 66 percent might not be diagnosed and 54 percent might not be counseled. Additionally, 70 percent of visits by patients with clinical obesity were not diagnosed**.

Though this is an old assessment and a similar estimate is not available for Europe, there could still be large accessibility gaps for obese and overweight patients, that can be bridged using AI applications.

Efficiency

Various studies indicate that children and adolescents can achieve significant reductions in BMI when they self-monitor, using methods such as smartphone-assisted behavioural weight control interventions*** - indicating the effectiveness of technology solutions in preventing obesity, compared with traditional interventions.

* Future costs from childhood obesity has been estimated using the current prevalence rate of childhood obesity (keeping constant), along with direct and indirect costs of obesity in adulthood. This includes cost of treatment of associated diseases (type 2 diabetes, orthopedic issues etc.) and cost from loss of working hours. The costs have been forecast to grow at the rate of 6.5 percent. Cost benefits have been estimated using reported accuracy and efficiency of AI driven tools in eliminating childhood obesity.

** https://www.ncbi.nlm.nih.gov/pubmed/19197264

*** http://mhealth.jmir.org/2016/3/e102/?trendmd-shared=0

Potential benefits from large-scale AI application

While the potential benefits from AI use in obesity prevention is huge, it is not easily achievable. The prediction of obesity risks before it actually occurs, triggers important questions from a medical and cost perspective. Our ability to know that a child is at risk of something, does not necessarily mean we can effectively help the child. Is it beneficial to start treatments early, or to wait until the child is actually obese? Is it better to screen and apply early interventions for a large group of children at risk of developing obesity? The potential is undoubtedly there, but a critical policy approach will remain necessary.

One of the biggest challenges to reducing obesity and associated costs, is to be able to use AI tools successfully in altering human behaviours. While such tools are very effective in predicting obesity and detecting warning signs early, it is not proven to be effective in changing habits associated with the condition, like overeating or a sedentary lifestyle. Detecting genetic predispositions to obesity will not lead to effective actions, until a remedy is proven successful.

Diagnosis of dementia

Dementia is one of the most common causes of disability and mortality among the elderly, affecting more than 10.5 million people in Europe. Western Europe has a disproportionately high share of the European dementia population, at 7.5 million people (over 70 percent). Prevalence varies between countries. Italy and Germany have more than 20 people with dementia per thousand, while Slovakia has less than 10 people per thousand. Some of the variation between countries is explained by their different age demographics. As dementia prevalence is known to increase with age, a rapidly aging population indicates a rise in dementia cases. By 2035, the total number of people living with dementia in EU countries is expected to reach 15 million[24].

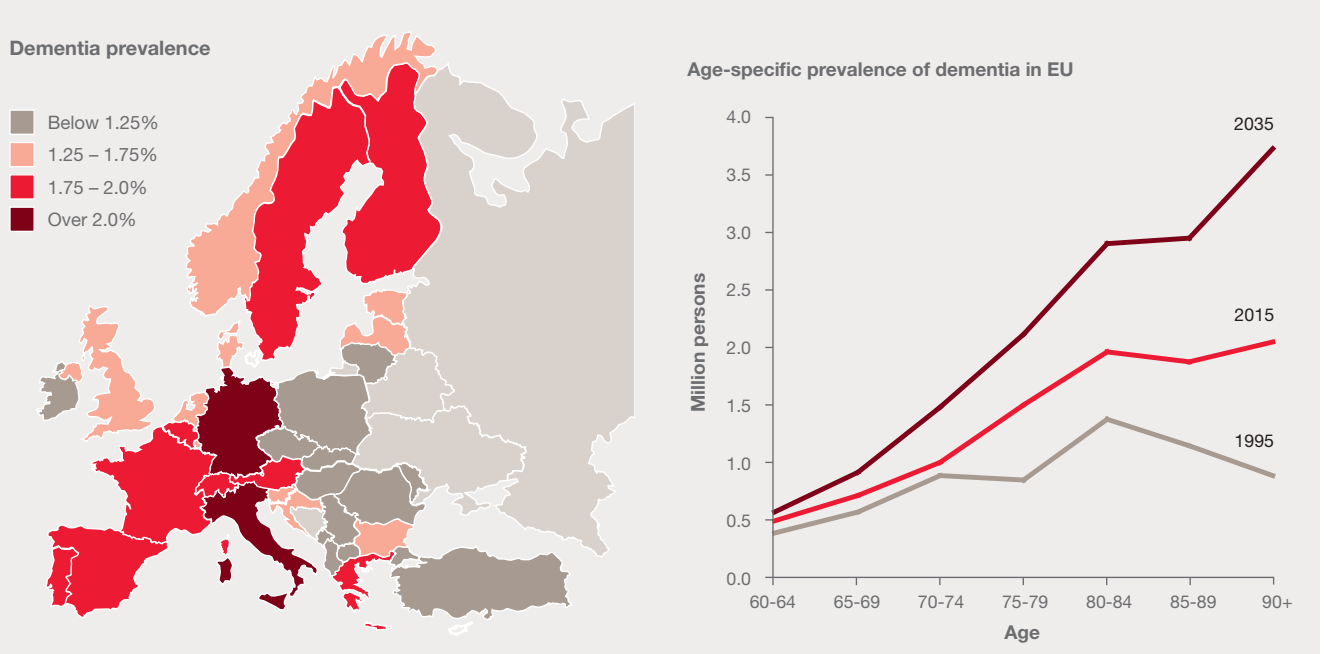
However, dementia prevalence could actually be significantly higher than estimates, as many people with dementia never receive a formal diagnosis. According to some estimates, only 20-50 percent of dementia cases are recognised and documented in primary care in high income countries[25].

Economic burden

The associated economic costs are huge – the total cost from dementia globally was estimated at USD 818 billion in 2015 (equivalent to 1.09 percent of global GDP), of which Europe accounted for over one-third at USD 301 billion. The per capita cost of dementia in Western Europe was as high as USD 35,000 in the same year[27]. Various other estimates are also available, all emphasising the high costs of dementia care. A UK study estimated that the health and social care costs for dementia were almost the same as the combined costs attributable to cancer, heart disease and stroke.

It is important to note that almost 80 percent of the dementia cost burden comes from indirect and social care costs, with the remaining 20 percent attributed to direct medical care. This emphasises the importance of early diagnosis, as it can help with early symptomatic treatment, advanced care planning and in delaying the need for care homes, bringing down the indirect cost burden.

Prevalence of dementia in Europe[26]



Comparable data not available for other countries

[24] https://www.alz.co.uk/research/statistics, http://www.oecd.org/els/health-systems/Item-4c-HCQI-dementia-OECD.pdf
[25] https://www.alz.co.uk/research/statistics
[26] http://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-europe-2016/estimated-number-of-people-with-dementia-in-eu-countries-by-age-1995-2015-and-2035_health_glance_eur-2016-graph65-en
[27] https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf
[28] Prince et al. (2011b: 12)
[29] Targeted screening refers to the screening of specific sets of people who may be at risk, for example people over the age of 85
[30] Systematic screening refers to systematically screening high risk people at regular intervals
[31] https://www.meddeviceonline.com/doc/artificial-intelligence-could-aid-earlier-diagnosis-of-alzheimer-s-0001

Intervention in primary care and role of AI

With traditional methods the earliest a patient gets diagnosed is, usually, when they experience early cognitive changes and subjective impairment, and in many cases, after the clear onset of cognitive decline and disability. With AI based methods, it can be possible to diagnose a patient at an earlier stage, where there are almost no clinical signs[28]. This could be realised by using a targeted[29] or systematic screening[30] approach at the primary care level. AI can also be used for screening the population for individuals at risk of developing dementia, by testing their cognitive abilities using digital near-patient tests, such as tests that can be administered using mobile phones or tablets.

Studies are also being conducted to combine AI and machine learning with MRI techniques that measure blood perfusion in the brain to diagnose early forms of dementia. One such study in the Netherlands reported that this approach could predict the onset of Alzheimer's disease with 82 – 90 percent accuracy[31]. As research in the field matures and more efficient AI tools are developed, it might be possible to diagnose dementia at very early stages, or even before it starts impacting a patient.

*Cost**

There are an estimated 3 million new cases of dementia in Europe every year, and is expected to rise to 3.5 million new cases a year by 2025.
The diagnosis of this population could cost nearly EUR 5 billion in a year, if all cases are diagnosed, rising up to EUR 10 billion in ten years.
Large-scale AI application for diagnosis of dementia in primary care in Europe, could save up to EUR 8 billion over the next ten years.
The cost savings will be achieved due to increased rate of diagnosis, and by moving a greater proportion of diagnosis to the primary care level.

Accessibility

AI use would improve access to precise diagnostic evaluation at the primary care level, which, according to estimates, is unavailable to 50 – 80 percent of patients with dementia in high income countries**.
This would reduce the time burden on specialist facilities to diagnose cases that can be handled at the primary care level.

Efficiency

Some developing approaches that use AI techniques, have the potential to diagnose and classify the form of dementia that patients are suffering from, with up to 90 percent accuracy***.
Such high levels of accuracy will be able to significantly improve the efficiency of dementia diagnosis using traditional methods.

* The ten year cost of dementia diagnosis has been estimated using the current rate of incidence of the disease globally, assuming it to remain constant over ten years. The incidence translated to Europe, is used along with the cost of diagnosing dementia in primary care and specialist care (from literature scan), with an assumption of a 6.5 percent year on year growth. Cost benefits from using AI in dementia diagnosis is based on assumptions from expert interviews.
** https://www.alz.co.uk/research/statistics
*** https://www.meddeviceonline.com/doc/artificial-intelligence-could-aid-earlier-diagnosis-of-alzheimer-s-0001

Potential benefits from large-scale AI application

The use of AI tools to detect dementia could help immensely in early detection, however the challenge in this care pathway is the lack of treatment options. We may be able to diagnose patients earlier, but it triggers a dilemma. Does early detection really help patients? For some, knowing what is going on may be a relief, for others the diagnosis of incurable dementia might be horrifying.

Early detection might allow us to take actions to delay the onset of the disease, which may or may not be effective. It is likely that using AI to detect dementia at very early stages, would only make patients aware of the inevitable onset of the disease, leaving them with little or no treatment options.

Diagnosis and treatment of breast cancer

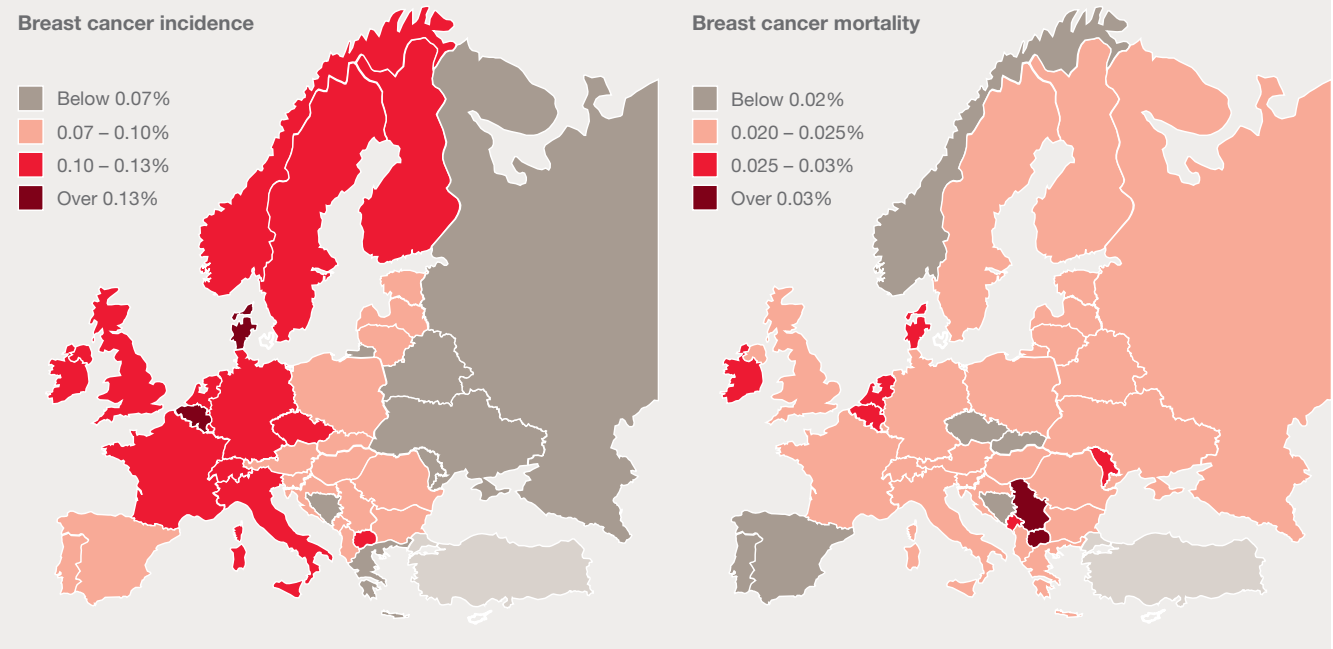
Globally, breast cancer is the most common cancer in women, and accounts for a high percentage of all cancer deaths in women. The incidence of breast cancer in Europe is high, accounting for 28 percent of all cancers in women[32]. There is variance between countries in the region: Belgium has the highest rate of incidence of breast cancer in Europe (147.5); followed by Denmark (142.8); and the Netherlands (131.3). The countries with the highest mortality rate include: Macedonia (36.3), Serbia (31.5) and Belgium (29.5)[33].

Economic burden

Cancer in general causes significant economic burden on economies, from high cost of treatment and care, to loss of productivity and early mortality. Though studies conducted in 2012 showed that lung cancer accounted for the highest economic burden, breast cancer was estimated to cause the highest healthcare costs, at EUR 6 billion each year. This accounted for 13 percent of the total cancer healthcare costs in the EU[35].

One of the biggest challenges of containing breast cancer cost, is to ensure detection and treatment at early stages. Mammography-based screening for early diagnosis is considered somewhat controversial and imperfect in some respects[36]. If breast cancer is not detected in the early stages, then treatment costs escalate rapidly as the disease progresses to the more advanced stages. According to a US study conducted in 2016, the average (insurance allowed) cost per patient differed widely by cancer stage at diagnosis – rising from USD 60,637 at stage 0 to USD 234,682 at stage IV (0-12 months post diagnosis)[37]. Another cost study conducted in Belgium (2011) found total average costs of breast cancer amounted to EUR107,456 per patient over 6 years. The total costs consisted of productivity loss costs (89 percent of costs) and healthcare costs (11 percent of costs)[38].

Incidence of breast cancer in Europe and associated mortality[34]



Comparable data not available for other countries

[32]http://www.euro.who.int/en/health-topics/noncommunicable-diseases/cancer/news/news/2012/2/early-detection-of-common-cancers/breast-cancer
[33]Age standardised rates per 100,000, http://eco.iarc.fr/eucan/CancerOne.aspx?Cancer=46&Gender=2
[34]http://eco.iarc.fr/eucan/CancerOne.aspx?Cancer=46&Gender=2
[35]https://www.sciencedaily.com/releases/2012/09/120928085356.htm
[36]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4589101/
[37] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4822976/
[38] https://www.ncbi.nlm.nih.gov/pubmed/20306109
[39] http://www.sciencealert.com/ai-analyses-mammograms-30-times-faster-and-20-more-accurately-than-doctors
[40] http://mediarelations.uwo.ca/2015/09/18/researchers-at-western-university-hope-to-use-artificial-intelligence-to-improve-breast-cancer-patient-outcomes/

Intervention and role of AI

Various AI applications are being developed to assist in early detection and accurate diagnosis of breast cancer. Many of these tools are proving effective in test phases (in one study AI was able to analyse mammogram results thirty times faster than doctors, and with 99 percent accuracy[39]), and to potentially open the door for better treatment during the early stages of the disease. Screening programs are generally understood to save lives, but they also create an issue by finding cancers that would never progress enough to cause significant problems to the patient, or death. AI could assist us in analysing mammogram findings, not only checking for the presence of cancer but also on its aggressiveness.

Apart from applications in diagnosis, other AI developments are allowing doctors to decide on a treatment plan that is most likely to be successful, by evaluating many different alternatives. In a pilot study AI was able to predict a patient's response to two common chemotherapy medications used to treat breast cancer, with over 70 percent accuracy[40]. Using such AI applications doctors would be able to make an informed decision about treatment direction. As research in the field progresses, AI could potentially be very successful in such applications because of its superior computation ability, allowing it to analyse various relevant data points, including genetic data, DNA / RNA sequencing data, -omics profiles, and electronic health records, as well as certain lifestyle data.

AI could also play a greater role in the aftercare of breast cancer patients. Robots are already assisting in breast reconstructive surgeries, and could also play a role in testing for and analysing the likelihood of cancer recurrence.

Cost

Large-scale AI application for treatment and aftercare of breast cancer in Europe, could save up to EUR 74 billion over the next ten years.
The cost savings include the likely reduction in treatment cost to patients, due to decline in doctor's direct engagement in repetitive tasks.
It also accounts for time saved by using AI assistance in determining best course of treatment.

Accessibility

Oncology departments throughout Europe are on the verge of staff shortages, especially nurses, due to the increasing patient loads and longer survival times.
It is estimated that there will be a 16 percent increase in the number of radiation treatment courses needed, from 2012 to 2025, increasing pressure on available resources**.
Use of AI tools could help to reduce the time needed for treating each patient and could allow patients to manage their own care between visits, effectively increasing the available capacity of doctors and nurses.

Efficiency

AI methods could improve the efficiency of treatments, by predicting which treatments would yield better outcomes.
AI could also help in reducing false positive tests from mammograms that are frequently referred for biopsies – according to one study the rate of false positive tests among all examinations conducted in the Netherlands was nearly 10 percent***.

* The cost from breast cancer treatment for the next ten years has been calculated using the incidence and mortality rates from the condition in Europe (keeping constant), and cost of care per patient per year. The cost of care is taken as an average of cost of the disease in different stages; and is assumed to increase at 6.5 percent per year. Cost benefits from using AI in treatment of breast cancer is based on assumptions from expert interviews.

** http://cancerworld.net/featured/no-time-how-staff-shortages-are-hitting-patient-care/

*** http://www.nature.com/bjc/journal/v109/n1/fig_tab/bjc2013253f1.html#figure-title

Potential benefits from large scale AI application

Use of AI in choosing treatment options for breast cancer may have high potential benefits if it helps in distinguishing between cancers destined to progress to terminal stages and those that are not. However, the challenge in this care pathway stems from complexity of the disease and the large number of variables at play. In many cases, even with AI tools supporting decisions, there might be very little time saved for the doctors. The benefits would largely accrue from increasing accuracy, but the direct benefits to patients in the form of lower costs might be harder to come by.

Challenges ahead

Despite the potential benefits, achieving large-scale AI applications in healthcare will not be straight forward. Not only is there a substantial research and investment requirement, but there are various other caveats and concerns that will need to be addressed, before AI has the promised impact on patients and the care they receive.

Availability of data

Most AI based tools use patient medical data (medical records, diagnostic images or data from wearable sensors etc.), and help in interpreting them. The tools analyse patient data against scientific evidence to come up with possible diagnosis, treatment options, or help prevent a health incidence or disease. Using AI tools on a large scale will also need large-scale availability of patient health information to power the algorithms and tools.
Healthcare and demographic data in any country is usually a mix of public and private collection systems, which may not speak to each other. For the tools to be most effective, mass data needs to be available in a structured and consistent way. This brings us to some important questions: is this patient medical and demographic data on which the tools are based, sufficient, reliable, readily accessible and up to date? Is sufficient scientific evidence available to make the tools accurate? Will these new data points be accepted when compared to traditional data sets, from e.g. randomised clinical trials?

Inadequate clinical data slows the development of AI technologies. It will continue to be difficult to get AI to assist in the diagnosis of rare diseases, if sufficient data on patients with rare diseases has not been captured. The merits of big data can only flourish when the data sets are very large, and because the biology is complex with a large number of variables, sample sizes are undeniably far too specific and small for generalisations to work.

"So far, datasets are too small and too young"

- John de Koning and Martijn Kleijwegt
Partners, Life Sciences Partners (The Netherlands)

"For the use of AI, the amount of data is usually decisive. The more the data, the higher is the level of intelligence. In addition to the data set, there is also the problem of linking to, for example, sociodemographic data. And in the field of treatments, there is often too little data"

-Rolf Kauke
Chairman, BKK Melitta Plus (Germany)

Reliable access to relevant personal eData is key

"With cancer for example, we haven't even reached the stage that the corner jigsaw pieces have been put in place. We don't even know the size of the puzzle yet, let alone the details. Data will help, but we will need an awful lot of them. A secret dream is to eventually also collect mental information, not just somatic"

- Hans van de Snellenberg
CEO, Hartwig Foundation

Data standards and privacy

At the same time, availability of data does not solve all problems. Healthcare being a highly regulated industry cannot use data recklessly. It is fundamentally sensitive information that can lead to disastrous consequences if mishandled. A number of AI-driven applications use sensors, allowing access to a live stream of data for analysis, and by extension to malicious access and manipulation. According to IDC's Health Insights group, one in three healthcare recipients was expected to be a victim of healthcare data breaches in 2016. Guidelines around data ownership, sharing, access, usage, and security is developing around the world, but regulation has so far been slower than the rapid technological developments. Regulations will need to reach a stable state before data and AI can be used freely and appropriately.

Cost of AI implementation

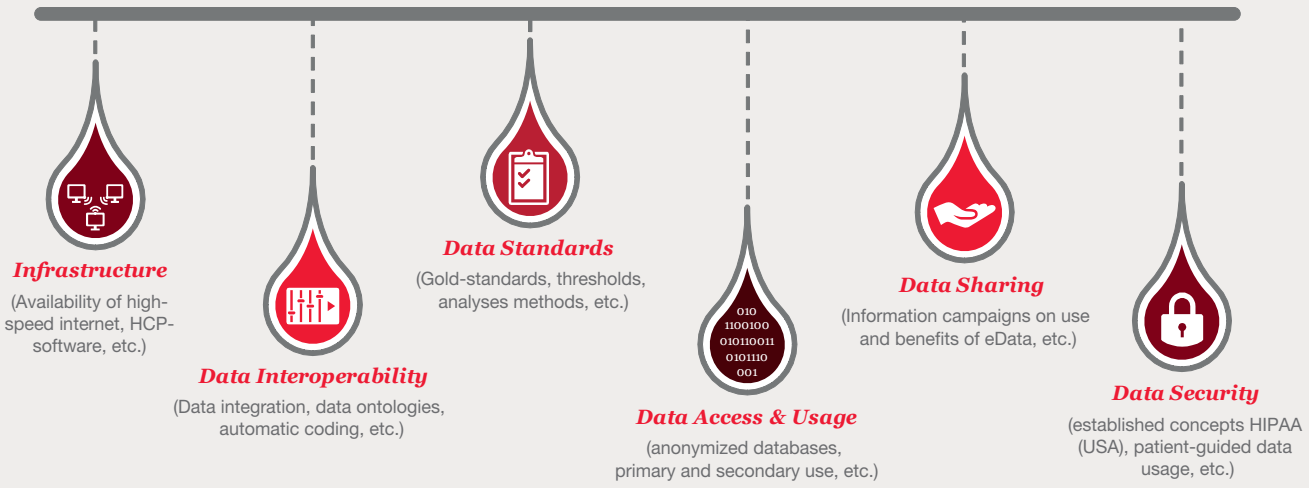
According to experts we interviewed, the cost of implementing AI for healthcare providers could stand at around five to ten percent of revenues over several years. This includes: cost of the technology; infrastructure; regulatory; and other recurring costs, and is pretty high for most burdened healthcare systems. As AI in healthcare gains scale, the associated costs could come down in the future. However, there is still a very long way for that, since most tools are still in the initial development and testing phases. Substantial investments in developing new technologies and tools will not be very effective, until we have the resources to implement them in hospitals and other care facilities.

While it is clear that the initial costs of implementation will have to be borne by healthcare providers, who will ultimately bear the cost burden is still unanswered. Will the costs get transferred to patients, or payers? What will be the impact be on the taxpayer? Could there be subsidies provided by government institutions? Most experts agree that the costs could be subsidised by governments in the future, but the effectiveness and potential benefits to patients will need to be proven first. An alternate viewpoint on the future, suggests that costs would continue to be carried by the technology companies developing the tools, to capture a future goldmine in the form of market share.

"In a regulated industry AI will need to be regulated as well. It will be challenge to regulate something that constantly learns and changes itself"

- Jeroen Tas
Chief Innovation and Strategy Officer, Philips (The Netherlands)

Data are the enabler but also the issue



HIPAA refers to the Health Insurance Portability and Accountability Act (US), which has created national standards to protect individuals' medical records and other personal health information

Patient willingness

For AI to be used on a large scale, patient readiness is key. The need to see a doctor in person and rely on him has been at the core of all healthcare services for a long time. AI challenges this idea to some extent, by attempting to move some of the patient reliance to AI tools, instead of a human doctor. Unless patients are ready to consult with AI-based tools and rely on them to give medical advice, technological developments would not yield any results. Additionally, the willingness to share personal health data is required for AI to develop and deliver results. According to a survey conducted by PwC, there is growing enthusiasm among consumers to engage in original ways with innovative technology, for their health and wellness needs; however, the market might not yet be completely ready.

Though this willingness is growing, it is contingent. The readiness to engage with AI and robots is high, only if it means better access to healthcare, as well as speed and accuracy of diagnosis and treatment. The level of acceptance also differs by the type and severity of the condition. People were most prepared to use AI and robotics for monitoring and providing advice, and least accepting for monitoring and delivering babies, as well as setting broken bones, where the stakes might be perceived to be higher.

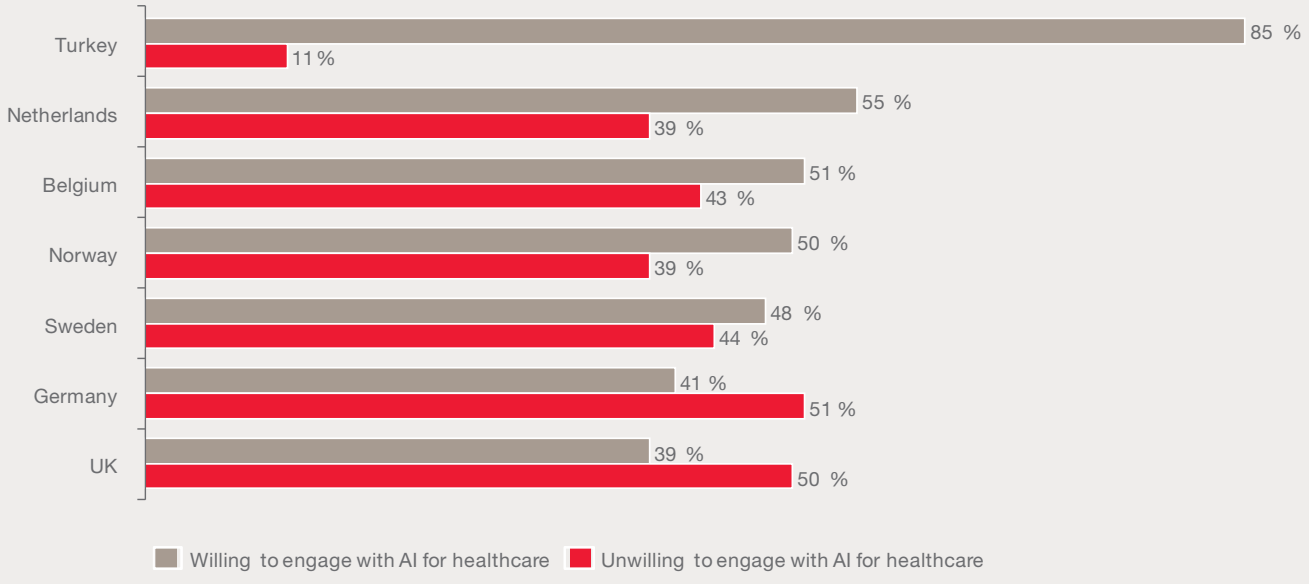
Overall, if the benefits of AI are proven to the future consumers, "consumer willingness" may not just support AI growth, but could act as a key demand driver that pushes healthcare providers to increase AI use.

"Companies that are making the ICU[41] completely digital, would continue to increase investments and come up with AI innovations. They will be rewarded in market share, while the innovations will save costs and improve quality for the patient in the future"

- Dietmar Pawlik
CFO, Städtische Kliniken München (Germany)

Market readiness is key

How willing or unwilling do you think you would be to talk to/engage with an advanced computer or robot with AI, that had the ability to answer your health questions, diagnose your condition and recommend treatment, if it was more accessible and could process your health information faster and more efficiently than a doctor or health professional?



[41] Intensive care unit

"The impact of the patient will increase. He will become the key demand force and models will be created to cater to the new demands"

- Thomas Lemke
CEO, Sana Kliniken AG (Germany)

Adoption by providers

Large-scale AI adoption by providers is another major hurdle, without which development of any AI tools cannot reach its potential. While there is a lot of optimism surrounding the use of AI among providers, this may not necessarily be mirrored by action. Some of the earliest and most widespread technology, sensor-based wearables have not been particularly successful in their use among providers. Most consumer wearables like Fitbit and Apple Watch have largely been used by consumers for personal applications, and almost negligibly to integrate into the clinical decision-making process by providers. There might be a lesson here for AI applications – creating a patient data stream in itself will not be sufficient to drive adoption among providers.
It will be important to have proven mechanisms to analyse the information and produce outcomes that are better, or as good as, outcomes achieved without AI intervention. For hospitals to adopt AI tools, a strong case needs to be made to warrant the heavy investments required in the face of financial constraints and time-tested processes.

AI adoption could also signal a change in providers' business models. Less complex care processes will move to the hands of patients and primary care, reducing the need for large hospitals for simpler care pathways. They will need to focus on the high-investment, complex care pathways to remain sustainable.

Impact on healthcare workers
As the use of AI in healthcare grows, its impact on healthcare workers will become apparent. While AI tools are not expected to replace doctors, it will impact all healthcare specialisations, with radiology for example more than others. Doctors and other healthcare workers will get a whole new range of patient-specific diagnostic and treatment tools. Business models will change for payers as well, all of whom will have to develop their skill sets to match these new ways of doing business.

Even with evolving skills, AI will make it possible to do more with less human resources. AI tools will focus on what it can do best, so that healthcare workers don't have to. While it might not be able to mimic the intuition and decision-making process of doctors and care givers, it has proven its ability to assist healthcare professionals in their decision making, saving time. This can have far reaching impact on the healthcare workforce. Will it cause a decline in the number of jobs available? Or will it help to bridge the gap in the availability of care workers?
In the end it will all boil down to the impact AI can have on patients and the benefits it can bring to the population. There are various concerns among practitioners, questioning the efficiency of AI applications, their ability to do what they claim to do, and the ability of regulators and policy makers to create an environment friendly for AI in healthcare. Each stakeholder must overcome its challenges to make AI a reality in healthcare.

"AI adoption will rise only if first, the quality of the delivered work by AI is verifiably superior compared to the doctors' results and second, if the question who will bear the responsibility in case of AI's mistakes in the medical treatment of patients is clarified"

- Mag. Helmut Kern (MA)
CEO, Hospital Barmherzige Brüder (Austria)

Recommendations

It is clear that AI has an important role to play in improving healthcare services. Despite it having glowing prospects, it is very likely to run into adoption and regulatory challenges in Europe. Based on the challenges assessed, we make three main recommendations which can set the tone for improving technology driven healthcare in Europe:

1. Balanced policy scorecard

Healthcare policy goals have seen a lot of instability over the years. Policy focus in different countries has varied, from focusing on improving quality to containing rising costs, at different periods of time. With one factor driving most of the policy decisions, it is easy to invest heavily in one factor, ignoring others. For instance, improving the quality of care has long been a focus area for healthcare, driving investments and improving life expectancy across nations. On the other hand, investments made in preventive healthcare is comparatively low - it is estimated that only of three percent of national health sector budgets in Europe is currently spent on public health and prevention[42].

This results in skewed development, where healthcare services perform better in one area, while other areas are overshadowed.

Different goals of better healthcare quality, lower costs and improved accessibility conflict with each other, and present a trade-off for policy makers. Achieving a policy environment that is balanced and caters to all needs is inherently challenging, but can be achieved by pushing technology adoption. AI driven tools can help achieve multiple healthcare goals in a balanced way, by reducing costs and improving quality and accessibility. Policy makers could set the ball rolling by setting up a "balanced policy scorecard", with the primary objective of establishing measurable strategic goals balancing all aspects of care. With a balanced scorecard in place, all aspects of healthcare would attract equal consideration, and would drive adoption of technology tools that have the ability to achieve multiple healthcare goals. AI tools can also help policy makers and other stakeholders such as providers and payers in balancing their healthcare goals.

2. Fast and consistent regulations

AI adoption cannot grow in line with the vision of the healthcare industry, unless it has regulatory support. Currently data use regulations around the world are in a state of flux. Predictably so, since the possibilities of data sharing and its applications are developing every day. However, if there is one prerequisite for the development of AI-driven health technologies, it is the availability of large amounts of health data.

Keeping privacy and security issues in mind, it will be essential to have clearly defined regulations on data capture, storage, sharing and use, to allow the advancement of AI technologies. Additionally, it will be important to have some level of consistency in the regulations, to allow technologies developed in other parts of the world to be used in Europe, and vice-versa.

3. Redefined reimbursements

As AI starts playing a greater role in treatment pathways, it will become important to redefine payer business models. Traditionally payer systems

Considerations for a balanced healthcare policy scorecard

Public health care

- Screenings and early detection of diseases
- Preventive healthcare interventions
- Increase in overall life expectancy
- Improved quality of life

Quality of care

- Improved understanding of diseases and treatments, better outcomes
- Personalised treatments of diseases
- Reduction of overdiagnosis and over treatment
- Effective health monitoring and timely care

Cost of care

- Low cost of curative and preventive care
- Affordable nursing and home care
- Low cost of care for elderly
- Containing cost of drugs
- Outcome based care

Accessibility of care

- Adequate hospitals and care centres
- Sufficient doctors and care workers
- Availability of self care tools
- Low waiting times

[42] http://www.euro.who.int/__data/assets/pdf_file/0009/278073/Case-Investing-Public-Health.pdf

have incentivised doctors to order more services, on volume, rather than on the value delivered to a patient. As AI makes inroads into more and more health services, doctors will have to spend less and less of their time on diagnosis or on evaluating treatment options, impacting reimbursements. How will reimbursements work when diagnosis is made by automated technology without a doctor's visit?

Driven by new technologies and patient demand, hospitals and healthcare facilities are expected to change their focus, moving away from volume-based metrics to outcome-based metrics, as a means to measure performance. Payers following suit will be a major boost to the adoption of AI tools by providers and patients. At the same time, it is not all without benefits for payers. Use of AI tools will allow payers to have a scientific basis to evaluate likely outcomes, leading to lower costs. Payers will be able to accurately assess if a more expensive treatment option is indeed expected to yield better outcomes for a particular patient, instead of solely relying on traditional processes and treatment protocols. The adoption of value-based model has started to gain traction in some countries.

The transformative power of AI technologies will continue to disrupt the healthcare industry, gradually pushing it towards proactive, efficient and economical care for everyone. As AI technologies develop, more success stories will come to light, pushing patients, providers and payers to accept and adopt. The challenges to large-scale AI adoption can only be overcome if various stakeholders work together and align on commonly accepted standards and methodologies, including regulators, legislators, payers, providers, pharmaceutical companies, medtech providers, technology experts, and academia.

The potential clearly exists, but the realisation might still be a few years away.

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