Socio-economic impact of mHealth
An assessment report for the European Union

pwc

Executive summary

mHealth could save 99 billion EUR in healthcare costs in the European Union (EU) and add 93 billion EUR to the EU GDP in 2017 if its adoption is encouraged.

99 bn
Total healthcare
cost savings in 2017

23 bn
Private
savings
(23%)

76 bn
Public
savings
(77%)

93 bn
Total GDP addition
in 2017
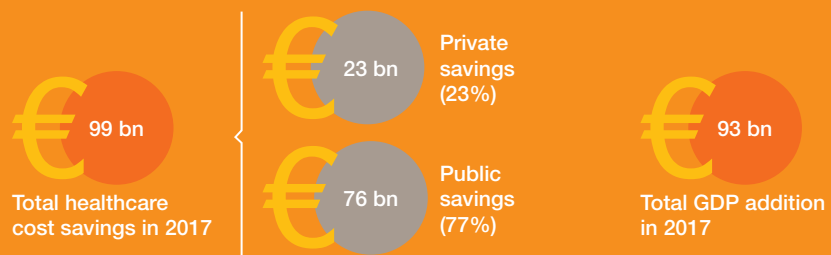
Source: PwC analysis

EU healthcare systems face significant challenges that are creating concerns about the sustainability of healthcare delivery. The combination of increased prevalence of chronic disease and an ageing population that continues to grow is exacerbating the burden on healthcare delivery and costs across multiple EU member states. Furthermore, well publicised budgetary constraints and a shortage of healthcare resources have created a scenario that inhibits these EU member states from meeting this increased healthcare demand. At the same time, the EU recognises the acute importance of investing in healthcare to tackle these challenges. Various stakeholders in the EU are looking at ways to make healthcare systems more sustainable and improve their citizens' health. This will improve wellbeing, increase employability and reduce health inequality.
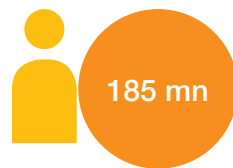
Potential of mHealth

To address these challenges, EU healthcare systems are moving care for chronic conditions and ageing population from hospitals to community homes. There is an increasing focus on making care more patient-centric so that patients can be empowered to manage their care. With mobile technologies becoming pervasive across the continent, mobile solutions are beginning to support these new healthcare delivery solutions. These mHealth solutions can influence patient behaviour to improve lifestyles, enable remote treatment of chronic conditions and equip healthcare providers to make better clinical decisions. As a result, patients can stay healthier and resources can be better utilised, whilst also limiting the demand for healthcare and lowering the costs of care.

By using mHealth solutions to their potential, healthcare systems in the EU can achieve the following:
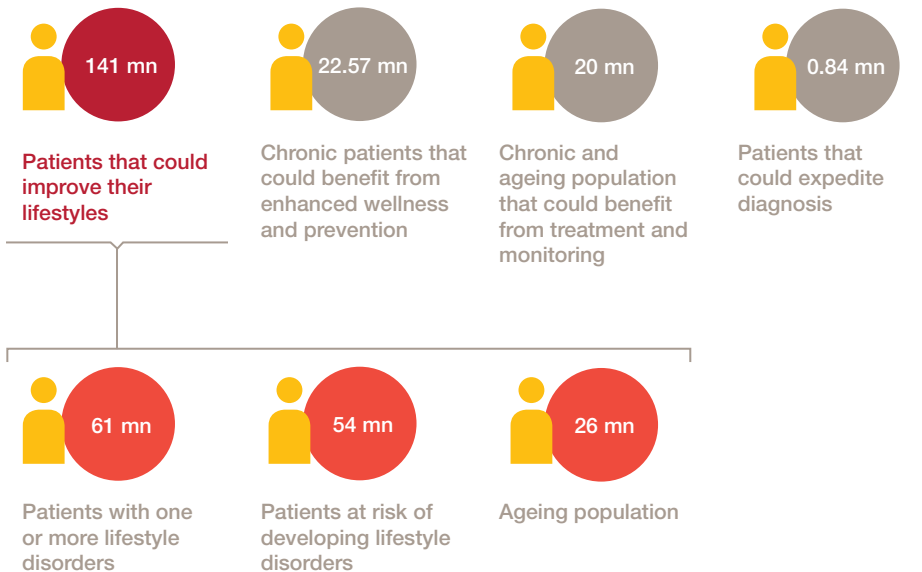
- Save 99 billion EUR in total annual healthcare spend in 2017 after the cost of extra workforce to support mHealth.

- These savings will translate to 76 billion EUR of public expenditure and 23 billion EUR of private expenditure.

- This equates to treatment of an additional 24.5 million patients against a constant number of doctors and facilities.

- Help 185 million patients lead healthier lives and gain 158,000 years of life.

- Of the total 185 million patients who can potentially benefit from mHealth, 141 million patients could improve their lifestyle to some extent through improving how they manage their medical conditions.

- Of these 141 million patients, 61 million could successfully address one or more lifestyle disorders. Another 54 million could avoid the risk of developing them and a further 26 million patients, who are ageing, could become more involved in managing their care and lifestyles.

€ 99 bn

Total healthcare cost savings

€ 69 bn	€ 3.7 bn	€ 32 bn	€ 0.17 bn	€ - 6.2 bn
Wellness and prevention	Diagnosis	Treatment and monitoring	Cost savings in ADE	Workforce to support mHealth

185 mn

Total mHealth users that could benefit

141 mn	22.57 mn	20 mn	0.84 mn
Patients that could improve their lifestyles	Chronic patients that could benefit from enhanced wellness and prevention	Chronic and ageing population that could benefit from treatment and monitoring	Patients that could expedite diagnosis

61 mn	54 mn	26 mn
Patients with one or more lifestyle disorders	Patients at risk of developing lifestyle disorders	Ageing population

Source: PwC analysis

By the virtue of its benefits, mHealth could enable 11.2 million chronic patients and 6.9 million patients at risk of developing chronic diseases to extend their professional lives and improve their productivity . This would add 93 billion EUR to the EU GDP in 2017.

Barriers to adoption and their impact

Socio–economic impact of mHealth in 2017	100% adoption (full potential)	10% adoption (if no action taken)
Total healthcare cost saved (bn EUR)	99	6.6
Public care cost saved (bn EUR)	76	5.1
Private care cost saved (bn EUR)	23	1.5
GDP added (bn EUR)	93	6.5

Source: PwC analysis

Although initial estimates of mHealth benefits provided by ongoing mHealth pilots and expert opinion have been promising, there is a strong possibility that these potential benefits will be limited, if the adoption of mHealth is not encouraged. Multiple barriers, such as regulatory, economic, structural and technological, are limiting the adoption of mHealth. The need of harmonisation between health and mobile regulatory frameworks, the lack of incentives to healthcare providers towards mHealth solutions and the absence of clearly defined business models aggravate the slow adoption of mHealth solutions. These barriers could limit the adoption of mHealth solutions to only 10% of its 2017 potential, realising only about 5% of the potential benefits by 2017.

Overcoming the barriers

Since the mHealth ecosystem has a broad set of stakeholders and most mHealth benefits are systemic, the onus lies on the regulators and payers to maximise the potential of mHealth by quickly intervening with regulations, incentives and initiatives that encourage its adoption and use.

The following key actions and initiatives could help drive the adoption of mHealth:

- Integration of mHealth with the nationwide healthcare strategy of various EU member states to align the development of these solutions with their most relevant healthcare priorities.

- Creation of policies and frameworks that encourage the development of innovative mHealth solutions and harmonise the regulation between the delivery of healthcare and mobile health services.

- Creation of incentives that encourage, both, patients and healthcare providers to adopt mHealth solutions, and mandate greater cohesion of healthcare providers across levels and regions.

- Spreading of awareness and provision of education on mHealth for healthcare professionals, patients and consumers.

The effective implementation of these recommendations needs collaboration amongst stakeholders. Since regulators and payers can facilitate this collaboration, urgency on their part to act is essential. It will help ensure that the potential benefits of mHealth are not pushed out too far to be inadequate in addressing the current and future healthcare challenges in the EU.
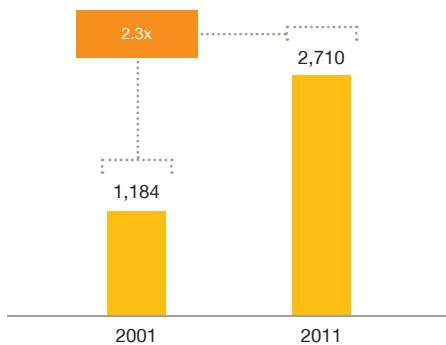
Socio-economic impact of mHealth

2.1 Current healthcare challenges in the EU

Sustaining healthcare systems

> *Rising healthcare costs in the EU need to be lowered in order to limit the burden on the population and payers.*
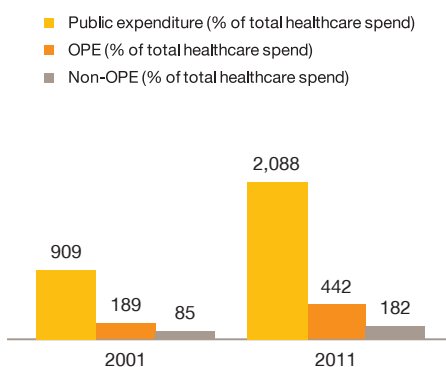
Although health advancements made across the EU are reflected in the increased life expectancy and adoption of the latest technologies, the challenge that health poses to governments is still greater than ever. Steadily rising healthcare costs amidst a stressful economic environment in the EU are constraining the healthcare systems of its member states.

[1]On an average, EU member states spend 9% of their GDP on health. These healthcare expenses have been rising faster than national incomes in most member states, making it harder for the social contributions to cover them.

[1]According to a report by the EU Economic Policy Committee, healthcare costs could increase by 4 to 8% of the EU GDP in a few decades, widening the gap between national incomes and healthcare spend.

To address the current gap, healthcare budgets are being cut across many countries including Germany, Italy and Spain. The out-of-pocket contribution of people to health expenses is growing and considerable concerns around the sustainability of universal healthcare systems are emerging.

EU healthcare spend per capita (EUR)

2.3x

2,710

1,184

2001   2011

Source: The World Bank, PwC analysis

Public expenditure, OPE and non-OPE (EUR per capita)

- Public expenditure (% of total healthcare spend)
- OPE (% of total healthcare spend)
- Non-OPE (% of total healthcare spend)

2,088

909

189   85

442   182

2001   2011

Source: The World Bank, PwC analysis

The growing healthcare burden of chronic patients and ageing population

Chronic diseases such as Type 2 Diabetes Mellitus (T2DM), chronic obstructive pulmonary disorder (COPD) and cardiovascular diseases (CVD) create a significant burden on EU's already strained healthcare systems. [2]According to the Organisation for Economic Co-operation and Development (OECD), there were around 30 million people living with diabetes (Type 1 and Type 2) in the EU in 2011 and [3]about 10% of the total annual healthcare expenses in the EU are spent on diabetes (Type 1 and Type 2). Poorly managed diabetes and the complications it induces result in significantly high hospital admissions, increasing the cost of care and consumption of healthcare resources.

The prevalence of such chronic diseases is high and increasing. Prevention and better management of chronic diseases should therefore be a priority for the EU and its member states.

> *Chronic diseases could lead to 718 billion EUR in lost wages in 2017.*

Besides the significant healthcare burden, chronic diseases also pose a severe risk to the quality of life and productivity of patients. High

1   Source: EU Economic Policy Committee study on budgetary challenges posed by ageing populations (http://europa.eu/epc/working_groups/ageing_en.htm)
2   Source: OECD Health at a glance: Europe 2012
3   Source: IDF, LSE, GOLD report on COPD (http://www.goldcopd.org/uploads/users/files/GOLDReport_April112011.pdf)

EU population with chronic conditions

■ 2012
■ 2017

Bar chart values:
- T2DM: 28, 30
- COPD: 12.9, 15.2
- CVD: 23, 26
- Ageing population (>65 years): 94, 95
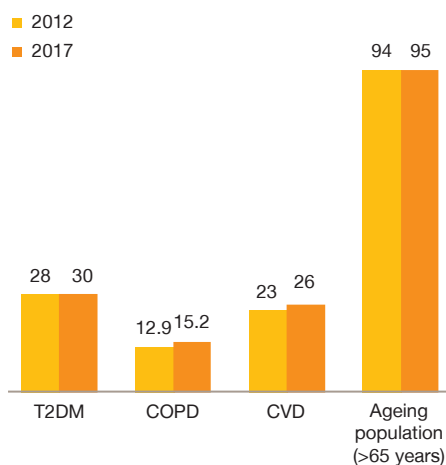
Source: OECD Health at a glance- 2012, PwC analysis

DALY (Disability Adjusted Life Years) losses from these diseases make early retirements and higher-than-normal unpaid absenteeism common for chronic patients. [4] The resultant loss of work life and wages is significant.

According to PwC estimates, by 2017, around 70 million chronic patients could lose up to 718 billion EUR in wages due to around 60 billion work hours lost in absenteeism and early retirement.

Socio–economic impact of chronic diseases in 2017	T2DM	COPD	CVD
[5] Absenteeism (days per year) per patient	42	19	47
[6] Early retirement per patient (years)	1.2	6.7	3
Labour hours lost (bn)	15	34	11
Wages lost (bn EUR)	194	403	121

Source: PwC analysis

This potential loss of wages would aggravate the financial strain on the healthcare systems by limiting the social security contributions that fund the healthcare budgets, limiting the financial sustainability of healthcare delivery.

The ageing EU population, aged 65 years or above, also contributes significantly to the healthcare burden since they require medical attention more often and many of them, such as chronic patients, need continuous care due to the multiple health conditions they suffer from at the same time.

- [7] According to the EU Economic Policy Committee, 30% to 40% of EU's healthcare expenses are spent on people aged 65 years or above.

- The share of this group in the overall population is expected to rise from 17% in 2010 to 30% in 2060. Additionally, the care costs for ageing population could rise by 30% to 55% by 2025 from 2010 levels.

- [8] By 2050, there will be only two people working for every person above 65 years of age in the EU from the four in 2004, which may make it harder for the working population to support these rising healthcare costs.

[9] With only 3% of healthcare expenses in the EU being allocated to prevention, there is clearly scope to invest more in the prevention of chronic diseases and avoid the significant costs these diseases generate. In addition, both, chronic patients and the elderly patients have a significant role in ensuring that their wellbeing is maintained and complications can be avoided. By using secondary preventive methods, chronic and elderly patients can manage their diseases better and reduce their severity, thereby limiting the associated healthcare costs.

4   Source: LSE Health, London School of Economics, Investing in Health (http://ec.europa.eu/health/strategy/policy/index_en.htm)
5   Source: LSE Health, London School of Economics, Netherlands Expert Centre for Work-related Respiratory Disorders , http://www.bmj.sk/2010/11110-02.pdf,
6   Source: LSE Health, London School of Economics, Department of Health UK, www.efanet.org/wp-content/documents/FletcherEUEdinburgh.pptx
7   Source: EU Economic Policy Committee study on budgetary challenges posed by ageing populations http://europa.eu/epc/working_groups/ageing_en.htm
8   Source: EU Economic Policy Committee study on budgetary challenges posed by ageing populations http://europa.eu/epc/working_groups/ageing_en.htm
9   Source: EU Health 2020 vision

Growing prevalence of unhealthy lifestyles

Unhealthy lifestyles such as poor dietary and physical regimes and smoking lead to disorders such as obesity and hypertension. These disorders in turn are leading causes of chronic diseases such as T2DM, COPD and CVD.

[10]*Around 52% of the EU population is overweight, 17% of which is obese.*

With more than 300 million people who are smokers, obese or hypertensive, there is a significant portion of the population that is at the risk of developing chronic diseases. To limit the future healthcare burden, it will be as important to prevent and manage the lifestyle disorders as the chronic diseases.

The shortage of healthcare professional resources and its impact on access to care

Many EU member states are concerned about current or future shortages of doctors and nurses. [11]Switzerland could see 75% of their general practitioners retire by 2025 while Germany may have to replace more than 50,000 doctors, including around 23,000 GPs, by only 2020. This lack of resources creates a risk of reduction in access to primary care and an inefficient utilisation of the limited healthcare budgets.

Need to enhance effectiveness and efficiency of healthcare delivery

To limit the healthcare burden of chronic diseases and elderly care, many healthcare systems in the EU are focusing on empowering patients to manage their conditions better and more independently. They are moving chronic care outside of hospitals to community care settings. However, the shortage of doctors and nurses is also contributing to a growing focus on increasing patient-centricity, which encourages patients to proactively manage their health and collaborate more with the healthcare provider even when outside the hospital.
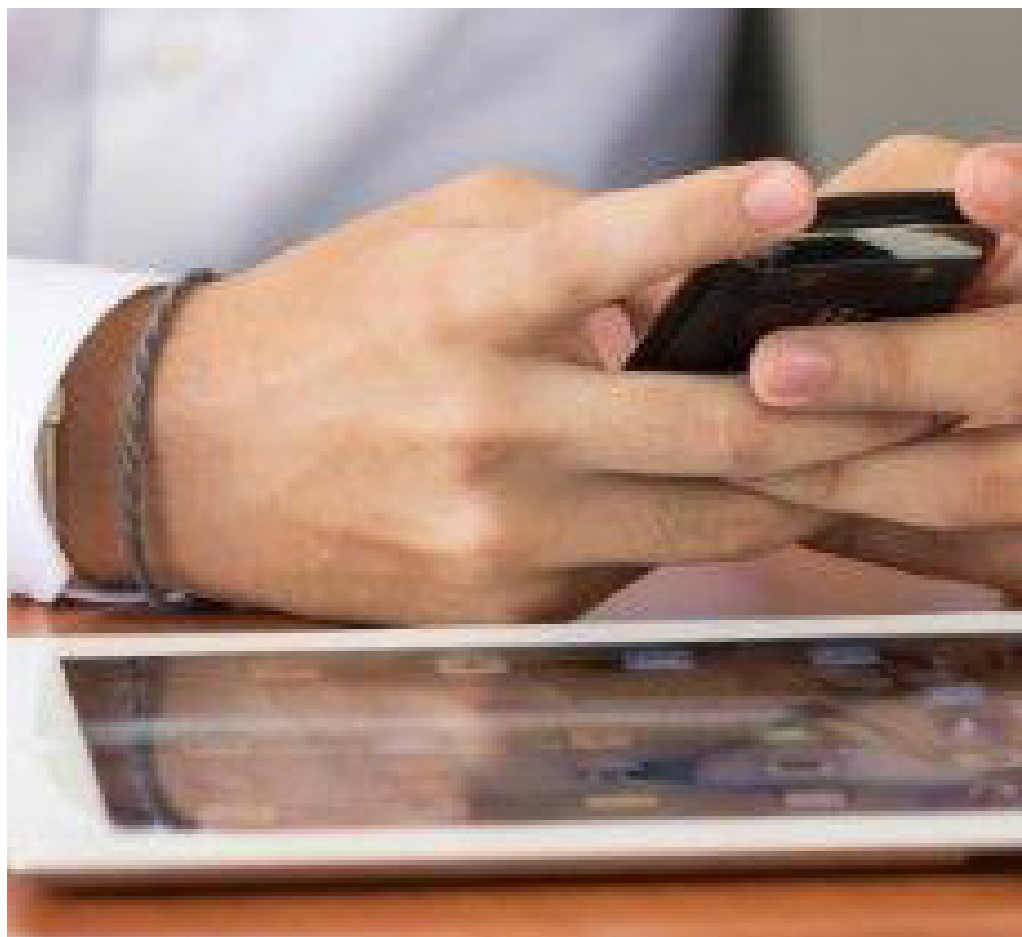
Increasing the patient-centricity of care could move delivery of care outside hospitals and make patients more responsible for their health, limiting the healthcare burden and freeing up healthcare resources.

To attain these objectives together, the healthcare systems in the EU would need to leverage technologies or solutions that help patients adopt behaviours to prevent diseases, optimise the quality of care, lower its costs and keep patients and doctors remotely connected to each other.

2.2 Addressing the challenges through mHealth solutions

mHealth solutions help prevent diseases and promote health, while lowering the cost of care and freeing up resources for additional patients that may not have adequate access to healthcare.

With mobile technologies becoming more widespread, mHealth solutions can increase the effectiveness of healthcare delivery across all patient solution pathways from wellness to monitoring by positively influencing patient behaviour, making care more patient-centric and improving clinical outcomes. Healthcare delivery can also be made more efficient by lowering the cost of treatment due to the need for fewer hospitalisations and through enabling current resources to treat many more patients in parallel.

As aforesaid, enabling remote treatment and monitoring, mHealth solutions can help shift care for chronic and ageing patients from hospitals and community care settings to their homes, thereby providing patients with greater access to healthcare resources remotely. Furthermore, remote interactions and reminders to take medication can increase dietary and treatment compliance levels. Complications can, therefore, be avoided and treatment costs reduced. The reduction in need for hospitalisation can free up physical and human healthcare resources to treat additional patients.

10 Source: OECD Health at a glance: Europe 2012
11 Source: Remedy presented to cure doctor shortage(www.swissinfo.ch), German Medical Association (BÄK) - National Association of Statutory Health Insurance Physicians (KBV) study (http://www.thelocal.de/society/20100903-29587.html#.UY-ylLXDA9Y)

> *"Mobile health has the potential to deliver larger benefits than tele-health as it is more accessible than tele-health."*
>
> **Horst Merkle, Roche Diagnostics**

In addition to this, mHealth solutions can empower citizens with information and motivation to improve lifestyles and reduce the threat of chronic diseases. Effectively, due to the various benefits mHealth provides, it may be highly useful in galvanising healthcare systems to attain their objectives and empowering patients cost-effectively.

Assessing the socio-economic impact of mHealth

mHealth can create a socio-economic impact across four dimensions by improving the effectiveness and efficiency of care.

Covering a wider population, mHealth can help people receive a higher quality of care at lower costs. By improving the delivery of healthcare across the four dimensions listed below, mHealth solutions can reduce hospitalisations, enable healthier lives and create a more productive employee base, facilitating a significant socio-economic impact:

- *Wellness and prevention:* Supporting citizens in making lives healthier by improving lifestyles and reducing the incidence of disease through education, awareness and behavioral changes.

- *Diagnosis:* Expediting the diagnosis of chronic diseases in order to limit their severity and associated treatment costs.

- **Treatment and monitoring:** Administering care remotely through mobile-based communication technologies that support patient mobility and reduce the need to visit hospitals.

- **Stronger healthcare systems:** Enhancing clinical decision-making and improving the utilisation of physical and human healthcare resources by providing the system and staff more information and analysis.

In this report, we have quantified the health benefits that mHealth solutions can provide across the four dimensions discussed above by using initial outputs from relevant studies and their validation by healthcare experts in relevant geographies. While we have referenced these inputs throughout the report, the methodology and assumptions for quantifying the impact have been detailed in the appendices.

2.2.1 Enhancing wellness and prevention

The significance of healthier lifestyles

The lack of education and information on the importance of wellness and prevention can keep 39.9 million people exposed to the risk of developing chronic diseases due to unhealthy lifestyles.

[12]According to expert opinion, an improvement in wellbeing effected through a healthy diet and regular exercise can reduce the risk of developing a chronic disease by 50% to 73% depending on the type of disease. With 39.9 million people expected to be at severe risk of developing T2DM, COPD and CVD in 2017, enhanced wellness can ensure disease free lives for some of these patients.

Regular exercise and a healthy diet can reduce the chance of T2DM patients developing complications by [13]around 30% while half of the CVD patients may be able to avoid complications and hospitalisations. By 2017, improvement in lifestyles across the 70 million plus chronic patients in the EU can significantly reduce the healthcare burden and costs.

"Finding a doctor or finding information is not so much a challenge. The major challenges are self-motivation and adherence. I think this is one of the major opportunities for mobile health where we can work with patients or users."

Bastian Hauck, Founder, Team Blood Glucose

Inducing healthier lifestyles using mHealth solutions

mHealth can enable such lifestyle improvements by equipping patients with relevant information on their mobile devices, thereby helping them make improved and informed lifestyle choices. mHealth solutions that focus on wellness and prevention can help them make better decisions about simple aspects of their lifestyle such as the food to eat, ways to counter the urge to smoke, and the number of steps to walk. A key reason for the reluctance to manage one's lifestyle better is lack of self-motivation and adherence. Interactive, self-directed mHealth solutions can motivate patients to improve their lifestyle by developing a game-like mindset in attaining everyday fitness goals.
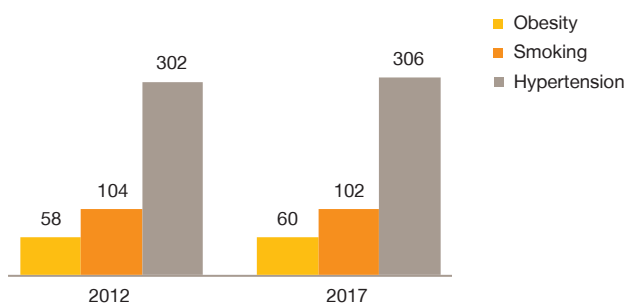
Healthcare providers can help ageing patients manage their care better by encouraging them to use mHealth solutions that involve them in maintaining wellness. These mHealth solutions enable patients to store their test results, readings of health parameters and the curative measures they take. Doctors can use the patient's health history built over time to make the treatment more patient-centric and effective.
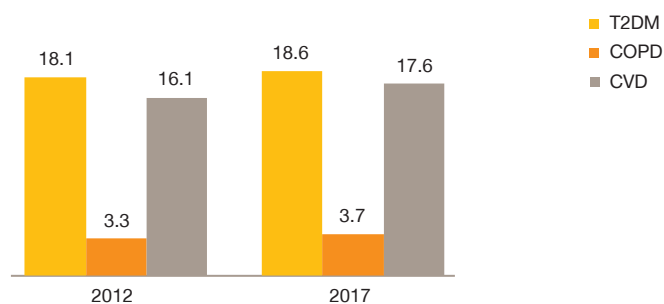
Lifestyle disorder prevalence in EU (in mn)

Legend: Obesity, Smoking, Hypertension

	2012	2017
Obesity	58	60
Smoking	104	102
Hypertension	302	306

Population at risk of developing chronic conditions in the EU (in mn)

Legend: T2DM, COPD, CVD

	2012	2017
T2DM	18.1	18.6
COPD	3.3	3.7
CVD	16.1	17.6

34% of obese people benefit from self-directed weight loss program and counselling

8% of smokers quit smoking successfully if constantly motivated and reminded

32% of hypertensive population can benefit from regular tracking of their blood pressure

60% of potential diabetics can avoid T2DM through healthy diet and exercise

73% of people at risk of COPD can avoid it through improved diet and fitness

50% of people at risk of CVD can avoid it through improved wellbeing

Source: JAMA Internal Medicine, Cochrane Tobacco Addiction Group, Turner White, OECD Health at a Glance- 2012, Silverchain.org, PwC analysis

13 Source: http://ndep.nih.gov/media/gp_toolkit.pdf

Improving lifestyles using mHealth

SAPO Fit, an application to control obesity (Portugal)
Developer: SAPO, Portugal Telecom
This mobile application helps users to monitor in real time the calories eaten, by detailing the food intake, and the calories burned when physical activity is undertaken. SAPO Fit may be personalized to keep a daily Personal Health Record (PHR) of an individual's food intake and daily exercise, and to share this with contacts and communities on a social network to encourage optimisation of one's wellness regime and motivating one to stay fit by encouraging a collective endeavour.

Source: European Directory of Health Apps 2012-13
(http://www.patient-view.com/-bull-directories.html),
Pub Med (http://www.ncbi.nlm.nih.gov/pubmed/22657250)

Traffic Light Food Tracker, a tool that helps people eat healthy food (Various EU member states)
Developer: Cancer Council Victoria, Obesity Policy Coalition
Language support: German, English, French, Dutch
This mobile application helps people eat more healthy food by using traffic light colours to rate the nutrition details of a food item listed on its packaging The user types in the content details such as total fat, saturated fat, sugar and sodium content per 100 grams, and the app calculates a traffic light evaluation of unhealthiness of the food item — green for low, amber for medium, and red for high. It can help people take better control of their food and dietary choices to avoid many lifestyle diseases such as obesity and hypertension.

Chronic disease prevalence in EU (in mn)

- T2DM
- COPD
- CVD

2012: 28.5, 12.9, 23.7
2017: 29.3, 15.2, 25.9
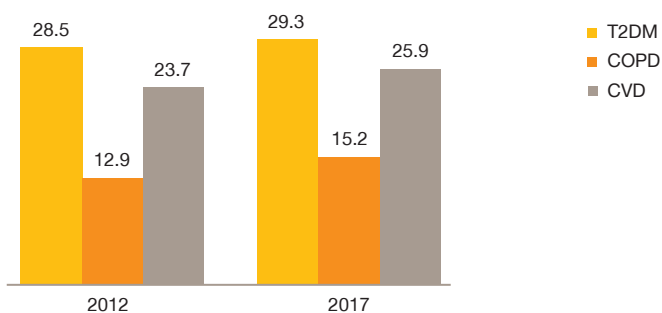
31% of Type 2 diabetics can benefit from healthy diet and exercise

73% of COPD patients can improve their conditions by focusing on wellbeing

50% of CVD patients can help improve effectiveness of care through improved wellbeing

Source: National Institutes of Health's Diabetes Prevention Programme, Silverchain.org, Eurekalert.org, PwC analysis

8 Source: http://ndep.nih.gov/media/gp_toolkit.pdf

mHealth could help 6.9 million citizens better manage the risk of chronic diseases by improving their lifestyle.

By using the type of mHealth solutions discussed earlier, healthcare providers and patients can successfully control the incidence of lifestyle disorders and maintain wellbeing by the following ways:

- According to PwC estimates, potentially, 29.1 million obese people in the EU may use mHealth solutions regularly in 2017 and 9.9 million of these may be able to reduce weight enough to avoid needing treatment for obesity.

- Out of the 102 million smokers, 48.8 million can potentially use mHealth solutions regularly and 3.9 million smokers could quit smoking successfully.

The resulting improvement in lifestyles and preventive measures enabled by mHealth can significantly lower the risk of chronic diseases by the following ways:

- By 2017, out of the 39.9 million people at risk of developing chronic diseases in the EU, 24.1 million could use mHealth solutions regularly to manage their lifestyles and take measures such as monitoring their blood pressure and diet to maintain wellbeing.

- The regular use of these solutions can help 11.37 million patients of the 24.1 million to improve their respective lifestyle disorders enough to reduce the risk of disease.

- Accounting for the reduced probability of developing chronic diseases amongst these 11.37 million patients, 6.9 million patients can significantly limit the risk of developing chronic diseases at all.

The reduction of risk spreads across the key chronic diseases we have assessed – T2DM, COPD and CVD:
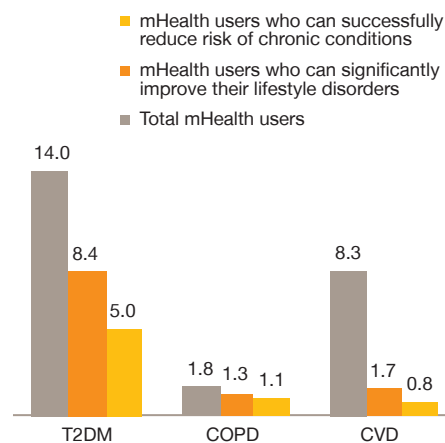
- Around 14 million of the 18.1 million people at risk of developing T2DM could better manage their obesity or hypertension by using mHealth solutions regularly. Of these 14 million patients, about 5

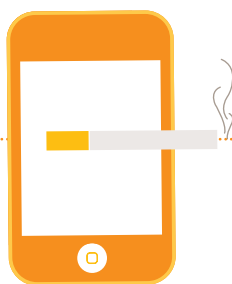## mHealth could enable 61 mn users to improve their lifestyles (in mn)

- Users who can benefit from mHealth
- Total mHealth users

Hypertension: 147, 47.0
Smoking: 49, 3.9
Obesity: 29, 9.9
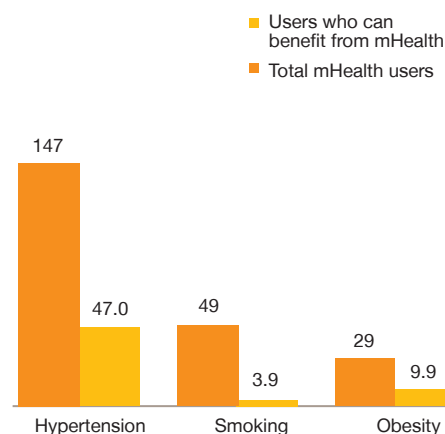
Source: PwC analysis

mHealth could reduce risk of chronic conditions for 6.9 mn users by 2017

- mHealth users who can successfully reduce risk of chronic conditions
- mHealth users who can significantly improve their lifestyle disorders
- Total mHealth users

T2DM: 14.0, 8.4, 5.0
COPD: 1.8, 1.3, 1.1
CVD: 8.3, 1.7, 0.8

Source: PwC analysis

Burden of smoking

- Tobacco is the single largest avoidable health risk in EU.
- About 94% of the smokers in EU start smoking before they turn 25.
- Around 50% of smokers die prematurely (on an average 14 years earlier).
- It accounts for nearly 700,000 premature deaths across EU.

Growing focus on anti-smoking

- The European Commission has launched campaigns like Ex-smokers are Unstoppable, in order to encourage young adults in the age group of 25 years to 34 years smoking.
- iCoach is an online digital health coaching platform that helps individuals quit smoking. It provides tailored feedbacks, sends users daily e-mail tips as reminders for motivation.
- Researchers have estimated that mobile phone programmes could nearly double the chance of quitting for at least six months, from 4 to 5% in control groups to 6 to 10% in intervention groups.

Impact of mHealth on smoking

- By 2017, mHealth has the potential to save 2.6 billion EUR by helping people quit smoking.
- Such avoidance of smoking will result in 2 billion EUR tax loss for the government.

million could successfully reduce the risk of developing T2DM.

- About 1.8 million people from among the 3.7 million at risk of developing COPD may improve their lifestyle conditions enough through regular use of mHealth solutions that support smoking cessation and improved wellbeing. Of these 1.8 million, 1 million can successfully reduce the risk of COPD.

- Similarly, of the 17.6 million people at risk of developing CVDs, about 8.3 million people could successfully use mHealth to make lifestyle and dietary improvements. Of these, about 833,000 could successfully reduce the risk of developing CVD.

Limiting burden of chronic diseases	Risk reduction	Incidences prevented till 2017
T2DM	5.0 mn	161,000
COPD	1.1 mn	363,000
CVD	0.8 mn	65,000

Source: PwC analysis

The reduced risk can avoid 589,000 incidences of chronic disease by 2017, helping healthcare providers across the EU dedicate their resources to sustain the treatment of other patients.

Helping patients suffering from chronic diseases manage their condition better

Improved lifestyles can help 11.2 million patients suffering from chronic diseases manage their condition better and increase the effectiveness of cares.
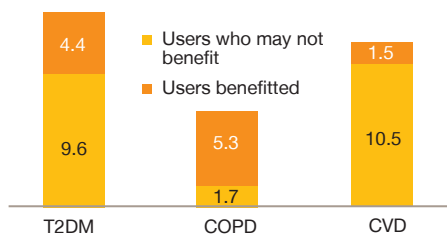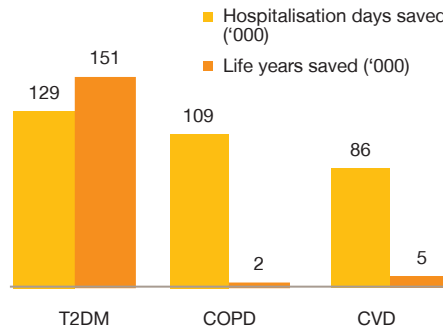

Source: PwC analysis

Empowering patients to self manage diseases and prevent complications

iBP Blood Pressure, a tool to track blood pressure (UK)
Developer: Leading Edge Apps
This smartphone application helps patients track blood pressure values and determine whether these are normal, high, or at hypertension. Using interactive graphs, it shows periodic trends of the user's user blood pressure and indicates statistics such as lows, highs and averages over periods of monitoring. The application helps a hypertensive patient get more involved in managing one's condition better.

OnTrackDiabetes, for self management of diabetes (UK)
Developer: Gexperts Inc
This mobile application helps diabetics self-manage their condition by tracking various relevant parameters such as blood glucose, blood pressure (BP), exercise, food, medication, pulse and weight. It produces a variety of graphs and reports, and creates a log book which can be shared with the doctor for analysis. Through active lifestyle management, the tool can help diabetics to take more control over their disease and delay diabetes induced complications.

Source: PwC analysis

Source: European Directory of Health Apps 2012-13

By supporting chronic patients in improving their lifestyles through mHealth solutions, healthcare providers can encourage these patients to monitor their diet, physical activity and medications. The solutions can help healthcare providers and patients track the impact of these changes on relevant health parameters, allowing doctors to customise and improve care. By doing so, 11.2 million chronic patients in the EU could manage their conditions better by 2017.

Optimising use of healthcare resources
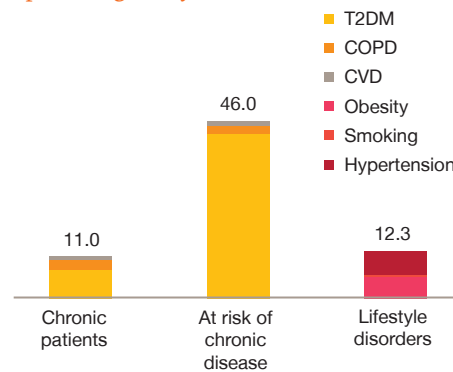
Source: NYY-Tunstall-NHS study, PwC analysis

The impact of mHealth enabled wellness-oriented measures could help healthcare systems address the key needs of enhancing quality of care and making delivery more efficient. The reduced incidence and severity of chronic diseases could lower the burden on healthcare facilities by avoiding 324,000 days of hospitalisation. Patients at risk of developing chronic diseases and those suffering from it could collectively live 158,000 years longer.

By reducing the severity and incidence of chronic diseases, mHealth solutions could save a total of 69 billion EUR in treatment costs, allowing healthcare delivery systems to better cope with reducing budgets. The increased availability of healthcare resources and budgets could also allow healthcare systems to ensure better access to care by treating additional patients.

Impact for diabetes

- *By 2017, mHealth can save 5 mn people from being at risk of developing diabetes.*

- *About 161,000 cases of diabetes can be prevented.*

- *Lives of 5,200 diabetics can be saved.*

- *About 151,000 life years can be saved for people at risk of developing diabetes.*

- *Around 13 bn EUR in earnings can be added by avoiding absenteeism and 5.3 bn EUR by avoiding early retirement.*
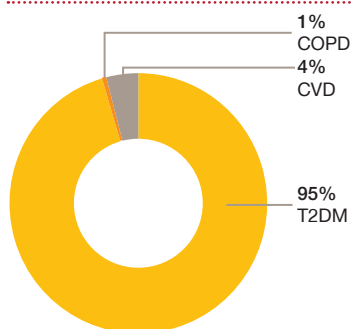
2.2.2 Expediting diagnosis

The importance of early diagnosis

Delay in diagnosis of chronic diseases increases complications and treatment costs

9.4 mn people at risk of chronic disease can use mHealth-enabled diagnosis regularly

- 0.2% COPD
- 0.9% CVD
- 98.9% T2DM
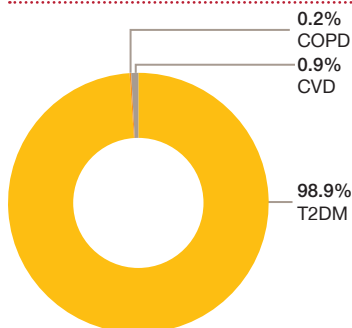
815,000 people can diagnose chronic diseases early

- 1% COPD
- 4% CVD
- 95% T2DM

Source: PwC analysis

Enabling remote diagnosis

AirStrip CARDIOLOGY, remote diagnosis and treatment decision making tool for heart patients

This smartphone application enables physicians to view electrocardiograms on their mobile devices. It allows clinicians anytime and anywhere access to live and historical ECG data of patients on their iPad and iPhone, along with enhanced analytics. It helps clinicians to make faster, more informed diagnosis and treatment decisions. When treating cardiac patients, these extra minutes can help patients recover quickly by expediting medical intervention and prevent heart damage.

Source: http://www.businesswire.com/news/home/20111220005893/en/App-Store-Names-AirStrip-CAR-DIOLOGY-iPhone-Medica

The latent nature of chronic diseases leads to delays in diagnosis. [14] On average, 40% of T2DM patients are not aware of their condition until seven to eight years after the disease has developed. Around 50% of people are usually not aware of the causes of disease and their symptoms. In addition due to the lack of access to diagnostic facilities, these factors contribute to patients not undergoing preventive health check-ups and thereby delaying the diagnosis of disease.

"The National Diabetes Inpatient Audit tells us that at any one time around 15% of hospital beds are taken up by people with Diabetes. Of these, only 9% of patients have a primary diagnosis of diabetes, the rest are there for other complications. There is a real need for hospitals to capture patients early and understand the condition because treating a complication condition is more costly per day."
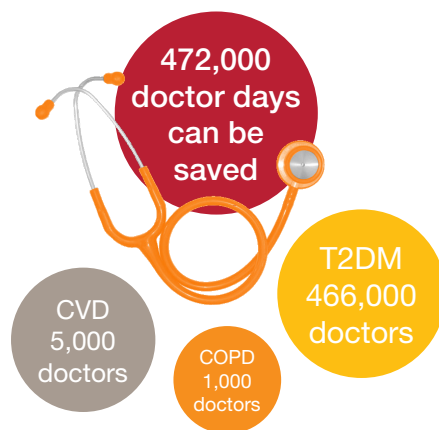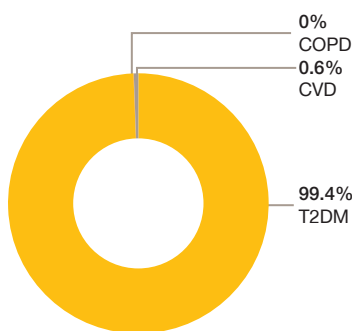
John Grumitt
Vice President, Diabetes UK

"About 80% of limb amputations due to diabetes are completely avoidable if proper diagnosis is done periodically. If a limb is lost than the chance of life for 5 more years is 30% and the chance of living for 3 years is 50%. The social and economic cost is simply enormous and largely avoidable."

John Grumitt, Vice President, Diabetes UK

Due to these reasons, most chronic diseases get diagnosed when complications appear. Hence, the severity of the chronic disease increases, resulting in increased hospitalisation and higher treatment costs.

14 Source: IDF Atlas, 2012,PwC analysis

3.7 bn EUR costs saved due to improved outcomes

0%
COPD
0.6%
CVD

99.4%
T2DM

472,000 doctor days can be saved

CVD
5,000 doctors

COPD
1,000 doctors

T2DM
466,000 doctors

Source: e-health initiative report by California Healthcare, PwC analysis

Expediting diagnosis using mHealth solutions

A total of 0.84 million patients could benefit from mHealth through the expedited diagnosis of chronic diseases and timely medical interventions, saving 3.7 billion EUR in treatment costs.

mHealth solutions that enable remote diagnosis and self-assessment of symptoms enable healthcare providers to detect diseases earlier and facilitate timely medical interventions. These solutions educate patients on symptoms of disease, helping them understand if and when they need to undergo diagnostic tests. Some mHealth solutions also allow patients to store the results of diagnostic tests on their mobile devices and share these with the healthcare provider, eliminating the need of hospital visits. By doing so, mHealth solutions reduce the burden on, both, diagnostic facilities and care facilities. Hence, access to care increases and diagnosis becomes more affordable.

Increasing effectiveness and efficiency of care

Through educational and algorithmic solutions that allow patients to self-assess symptoms, mHealth can help 9.4 million regular users at risk of developing chronic diseases to expedite diagnosis. Accounting for the prevalence of various chronic diseases in the EU, PwC estimates that 815,000 patients can successfully detect chronic diseases early. These patients could avoid complications and seek medical attention earlier, reducing the need for hospitalization and saving 3.7 billion EUR in treatment costs. Doctors and paramedic staff could save 472,000 doctor days by having to treat fewer complications.

2.2.3 Delivering continuous care remotely

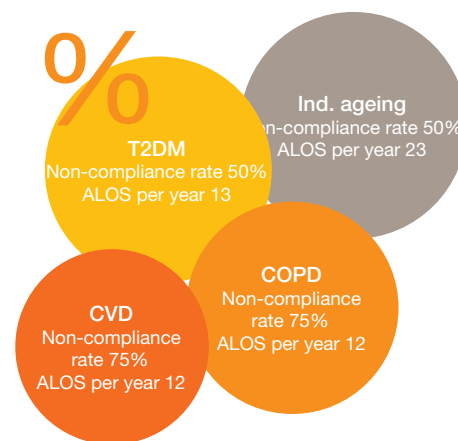*Monitoring patients that require continuous care*

Continuous care and the lack of treatment adherence in chronic conditions raises care costs and creates a need for monitoring.

Chronic diseases and elderly care require constant, real-time management. The patients need to be disciplined with their treatment and diet schedules. The high levels of adherence required from patients can be tiring and patients often miss their medication, resulting in non-compliance to treatment. Additionally, patients often mistake temporary relief for significant improvement and discontinue treatment or lower medication levels. The sub-optimal clinical outcomes resulting from these reasons lead to hospital re-admissions.

To limit this non-compliance and avoid hospital re-admissions, patients need to be continuously monitored in hospital for longer periods, which increases treatment costs and further burdens healthcare systems.
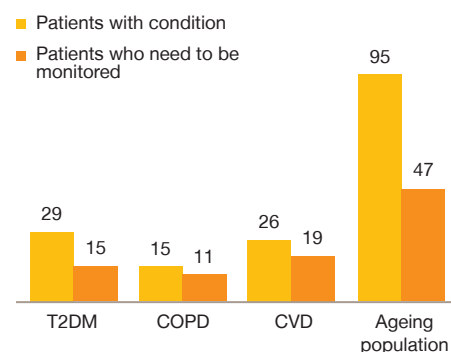
PwC estimates that 45 million chronic patients and 47 million ageing people in the EU could need monitoring by 2017.

To sustain these monitoring needs with limited hospital beds, healthcare systems are exploring ways to treat patients at their homes.

%

T2DM
Non-compliance rate 50%
ALOS per year 13

Ind. ageing
Non-compliance rate 50%
ALOS per year 23

CVD
Non-compliance rate 75%
ALOS per year 12

COPD
Non-compliance rate 75%
ALOS per year 12

Note: ALOS: Average Length of Stay
Source: Rosemontpharma, Ericsson mobile health study, PwC analysis

Need for monitoring amongst chronic patients (in mn)

- Patients with condition
- Patients who need to be monitored

T2DM: 29 / 15
COPD: 15 / 11
CVD: 26 / 19
Ageing population: 95 / 47

Source: Rosemontpharma, Ericsson mobile health study, PwC analysis

Medipal, doctor-patient communication application (Sweden)
Developer: Novatelligence AB, Sweden
This smart phone application improves doctor-patient communication by helping a patient answer questions that the healthcare provider wishes to ask. The healthcare provider creates a 'Medipal' account for the patient, enters into it questions about one's treatment and medical condition that the patient should answer. This interaction with the remotely located doctor not only increases the patient's involvement in one's own care but also helps doctors to stay engaged with their patient's treatment cycle even if the patient doesn't visit the hospital.

mHealth can benefit a high number of chronic patients (in mn)

- Patients who need to be monitored
- Patients monitored using mhealth
- Patients benefitted
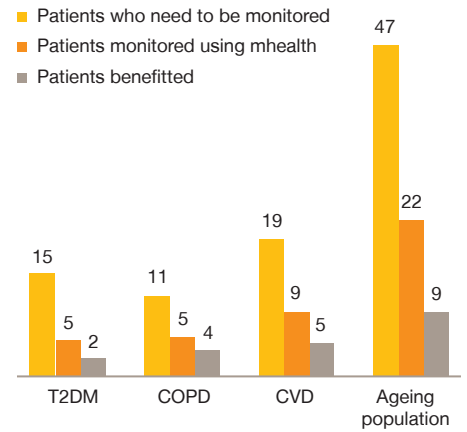
Enabling continuous care outside hospitals

> *mHealth enabled monitoring could help remotely deliver care to 22 million independently ageing citizens and 19 million chronic patients.*
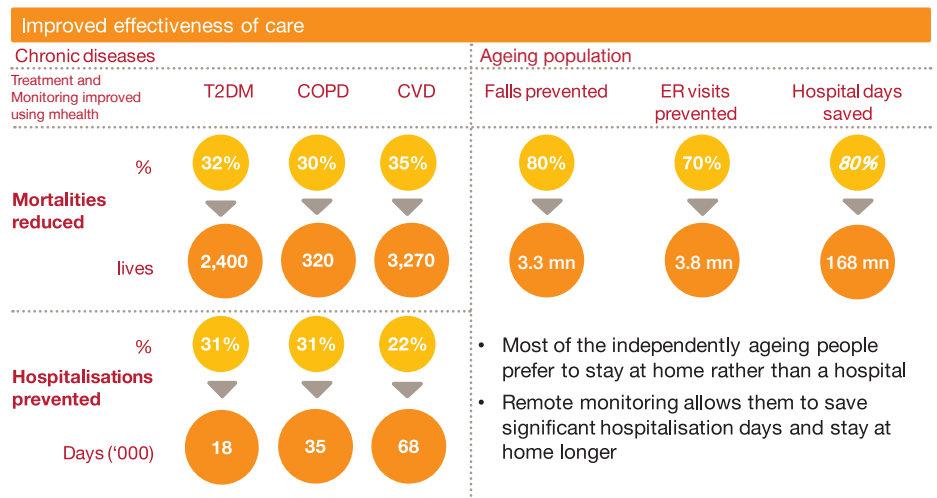
mHealth solutions help healthcare delivery systems to provide continuous care remotely by using mobile technologies. By keeping healthcare providers connected with patients while they are at home, these solutions can allow healthcare providers to monitor the health of patients and intervene when required. These solutions also motivate patients to improve their lifestyle and help increase their dietary and treatment compliance through SMS and call based reminders. Patients can transmit their pathological readings through connected mobile devices to their healthcare providers, who can then analyse the health patterns captured to optimise care and make it patient-centric. mHealth solutions can also help patients feel safer by helping healthcare providers track their movements remotely and raising emergency alerts earlier.

By empowering patients to self-manage care, healthcare providers can help 22 million ageing citizens and 19 million chronic patients regularly rely on mHealth for continuous care in 2017.

Enhancing effectiveness of care

> *Improved adherence and remote treatment enabled by mHealth can save 6,000 lives and reduce 168 million hospital days, increasing effectiveness of care.*

**mHealth can benefit a high number of chronic patients (in mn)**

- Most of the independently ageing people prefer to stay at home rather than a hospital
- Remote monitoring allows them to save significant hospitalisation days and stay at home longer

Source: Continua Health alliance, SeniorBridge, AXA Insurance, NYY-NHS Telehealth study, PwC analysis

Hospitalisation days saved (in mn)

Limiting burden of chronic diseases	Risk reduction	Incidences prevented till 2017
T2DM	13	31%
COPD	12	31%
CVD	12	22%
Ageing population	23	80%

Source: HOPE-European hospital and healthcare federation, PwC analysis

Hospitalisation days saved (in mn)
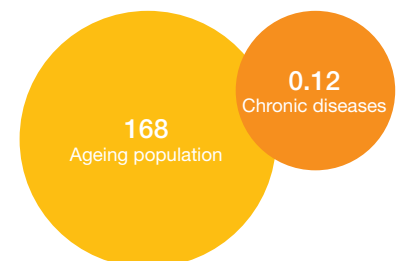
> *"Mobile health can help in reducing the readmission rates of the patient. It can help in taking the care away from the healthcare facility to home. It could also help in establishing an early warning system."*

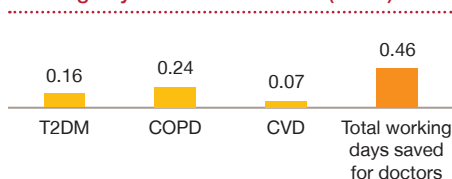**Alain Labrique, John Hopkins University**

Improved adherence and continuous remote treatment of chronic conditions using mHealth can help avoid severe complications and improve clinical outcomes. As a result, 11 million chronic patients can avoid 121,000 days of hospitalisation and 6,000 lives can be saved. In addition, elderly patients can avoid 3.3 million falls. Furthermore, improved emergency response and treatment compliance for 9 million elderly patients can save 168 million days of hospitalisation. There is also the additional benefit of having the comfort of staying at home thereby enhancing the quality of their life.

Healthcare cost savings (in bn EUR)

4.2	2.1	2.9	22.9	32.1
T2DM	COPD	CVD	Ageing population	Total savings
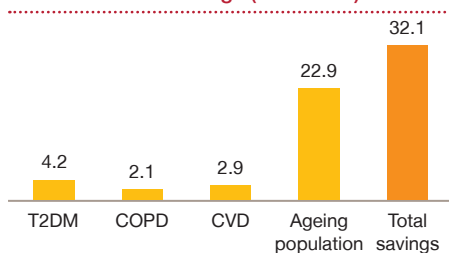
Source: PwC analysis

Working days saved for doctors (in mn)

0.16	0.24	0.07	0.46
T2DM	COPD	CVD	Total working days saved for doctors

Source: PwC analysis

Enhancing treatment compliance using mHealth

MoviPill, medication reminder application (Spain), Movistar (Telefónica)
The smartphone application encourages patients to take their medication at prescribed times by making the treatment adherence process more competitive. It uses a point based system to reward and reprimand the levels of drug adherence. Points are awarded or deducted based on how close to the prescribed time patients took their medication. Leaders are visible on a communal web based scoreboard and winners are awarded at the end of each week. Such participative applications motivate patients towards their care and improve treatment adherence.

Source: European Directory of Health Apps 2012-13

Increasing efficiency of care

> Increased effectiveness of care through remote monitoring can not only save 32.1 billion EUR in treatment costs but also reduce the shortfall of 1,840 doctors

By helping attain improved clinical outcomes and reduce the need of hospitalisation, mHealth enabled remote monitoring could save 32 billion EUR in healthcare costs across the EU. Healthcare providers can monitor multiple patients at once and prioritise patients to attend to, which reduces waiting times. According to PwC estimates, around 0.46 million working days saved for doctors can be saved as a result, which is the equivalent to 1,840 doctors being added to the system.

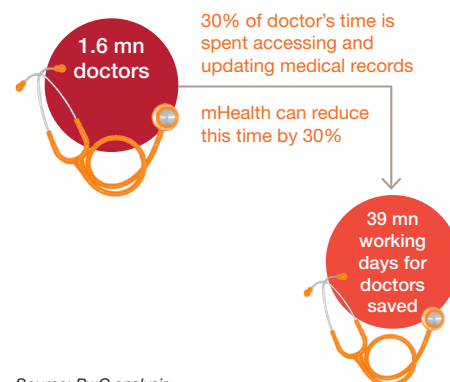## 2.2.4 Strengthening healthcare delivery systems

Inefficient utilisation of IT and electronic health records

Healthcare systems across the EU have varied capabilities to leverage information and communication technologies to support their practitioners. It is estimated that practitioners spend 25% to 30% of their time gathering and analysing medical and patient care data. The absence or inefficient use of electronic health records can limit the efficiency of a hospital. Lack of mobility support for doctors can keep them from accessing information on the move which limits the efficient utilization of their time.

Further, most doctors have to invest personal effort to seek information on the latest protocols, best practices and international updates. The lack of readily available relevant information can result in uninformed clinical decisions. Such decisions can lead to prescription and dosage errors, creating adverse drug events (ADEs) that cost EU healthcare systems 2.7 billion EUR per year in care costs and account for 1.1% of all hospitalisations in the EU.

Addressing the shortage of doctors through improved practitioner support

> mHealth could create 39 million working days for doctors by improving practitioner support, reducing the shortfall of doctors by 156,000.

1.6 mn doctors

30% of doctor's time is spent accessing and updating medical records

mHealth can reduce this time by 30%

39 mn working days for doctors saved

Source: PwC analysis

[16]Using tablet computers and other mobile devices can help doctors and paramedic staff to save 30% of their time spent on accessing and analysing information. Doctors and paramedics could update patient health records during consultations and plan their rounds better. By 2017, 1.6 million doctors across the EU could, save up to 39 million working days for doctors. This could not only create additional capacity equivalent to 156,000 doctors but also allow doctors to spend more time with patients that really need face to face attention, enhancing the quality of care.

Enhancing practitioner support

My Life Record, Electronic Medical Record system

Life Record EMR is a smartphone based application which provides patients better control of their electronic medical records. It allows patients to store their medical imaging, charts, medications and lab results. Patients can easily share such records with their doctors and nurses. It also includes features like e-prescription which saves doctor's time to write a prescription, allows patients to increase compliance and expedites medical interventions.

Source: http://www.myliferecord.com/index.html

> *"Next five years will see mobile explode in healthcare as there are possibilities that are emerging from the sort of facilities that mobile technologies are able to provide. The convergence between the mobile phones and traditional computers in form of tablets and smartphones will revolutionise the way healthcare is delivered."*

Lars Palmberg, Stockholm City Council

Helping healthcare providers stay informed can allow them to save 165 million EUR by preventing ADEs.

€ 2.7 bn

Cost of ADE (2017)

6%

- 35% of ADEs are preventable if adequate knowledge is available
- mHealth can help prevent 17% of preventable ADEs
- This results in overall ADE reduction of 6%

€ 165 mn

Cost reduction of ADE

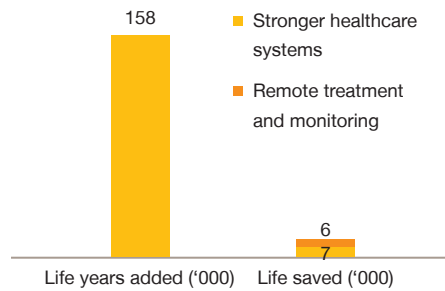*Source: Ispor.org , PwC analysis*

According to expert opinion, [17]35% of the ADEs can be avoided if practitioners have access to adequate information while writing prescriptions. mHealth solutions can help here by providing practitioners access to latest information, best practices and patients' medical records. Therefore, practitioners can check potential drug conflicts while writing prescriptions and make better clinical decisions, thereby improving the quality of care and patient safety. [3]In 2017, preventable ADEs could be lowered by 17% and 165 million EUR could be saved in treatment costs.
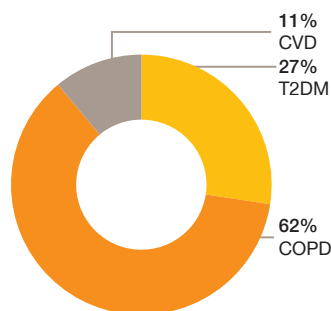
2.3 Creating value through mHealth

Enabling healthcare providers to empower patients

Adding up all the benefits of mHealth, enhanced healthcare delivery can empower 61 million people to improve their lifestyles, reduce the risk of developing chronic diseases amongst 6.9 million people and add a further 158,000 life years in 2017.

Creating healthier and longer lives

■ Stronger healthcare systems
■ Remote treatment and monitoring

158

6
7

Life years added ('000)   Life saved ('000)

Preventing 589,000 incidences of chronic diseases

11% CVD
27% T2DM
62% COPD

By 2017, mHealth could enhance effectiveness of care by the following ways:

- Helping 61 million patients improve their lifestyles.

- Helping 6.9 million people lower the risk of developing chronic diseases through lifestyle improvement and enhanced prevention.

- Helping prevent 589,000 incidences of chronic diseases.

- Helping 11 million chronic patients and nine million ageing patients reduce complications and avoid 169 million days of hospitalisation through remote treatment and monitoring.
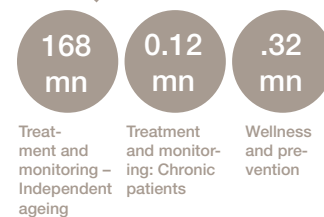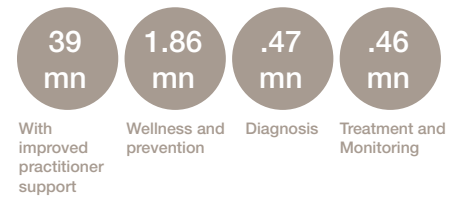
These benefits are significant because not only they can sustain healthcare systems longer but patients benefiting from mHealth can also stay healthier and prolong their lives.

Limiting the healthcare spend and improving its efficiency

By 2017, mHealth could save an aggregated 99 billion EUR in healthcare costs for the EU, with the EU governments saving 76 billion EUR and 537 EUR per regular mHealth user.

By using mHealth to enhance the effectiveness and efficiency of

Additional patients could be treated using the time saved for doctors and hospital beds freed up

42 mn Total doctor days saved > **126 mn** Additional patients that could be attended

39 mn With improved practitioner support

1.86 mn Wellness and prevention

.47 mn Diagnosis

.46 mn Treatment and Monitoring

169 mn Total hospital days saved > **24.5 mn** Additional patients that could be treated*

168 mn Treatment and monitoring – Independent ageing

0.12 mn Treatment and monitoring: Chronic patients

.32 mn Wellness and prevention

Assumptions:
1. Each additional patient will need 3 visits per year
2. A doctor can conduct 18 patient visits per day
3. A doctor utilises only half of the time saved to see additional patients
*4. *A patient gets hospitalised for 6.9 days per year, the average length of stay in hospitals across the EU*

care, improved clinical decision-making, remote monitoring, reduced hospitalisation and better utilisation of doctors' time could allow healthcare systems to achieve the following:

- Save more than 40 million doctor days.

- Create systemic savings of 99 billion EUR, which account for the six billion EUR required to finance the 211,000 jobs required to support mHealth deployments.

- Reduce the annual per capita healthcare costs for the 185 million patients that could benefit from mHealth solutions by 537 EUR.

- Enable 185 million patients to save 75 EUR per year in out-of-pocket health expenses.
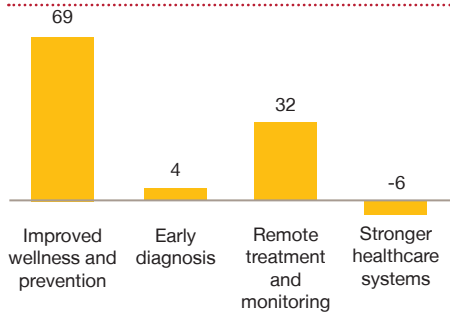
Of the 99 billion EUR savings created, public payers could save 76 billion EUR of this while private spending can be reduced by 23 billion EUR. These savings could help treat an additional 24.5 million patients, sustain capital costs for mHealth deployments and healthcare facilities and in the long term improve the access to care by reducing private healthcare premiums.

The reduction in per capita savings could also be a significant improvement in an environment where governments are asking people to support health expenses to a greater extent than before. Hence, the healthcare systems can achieve the opposing goals of ensuring access to care and limiting healthcare costs by using mHealth.

99 bn EUR Healthcare cost savings → **66.5 bn EUR** Cost savings spent on new patients → **24.5 mn*** Additional patients / **EUR 2,710** Avg. healthcare spend per patient

32.5 bn EUR Remaining cost savings → Sustain mHealth capital costs

Healthcare cost savings due to mHealth adoption in EU (bn EUR)

2013	8
2014	26
2015	55
2016	76
2017	99
Total	265

Source: HOPE-European hospital and healthcare federation, PwC analysis

99 bn EUR healthcare costs saved

Improved wellness and prevention	69
Early diagnosis	4
Remote treatment and monitoring	32
Stronger healthcare systems	-6

Source: HOPE-European hospital and healthcare federation, PwC analysis

To ensure that capital costs incurred in mHealth deployments in the near-term are covered through future healthcare savings, it is important to appreciate that 265 billion EUR can be saved in healthcare costs from 2013 to 2017 through the use of mHealth. While the savings in 2017 alone are significant, the healthcare expenses that can be saved or avoided using mHealth over this five-year period will be extremely relevant to ensure that future gains are sufficiently large for healthcare providers to justify an immediate investment in mHealth.
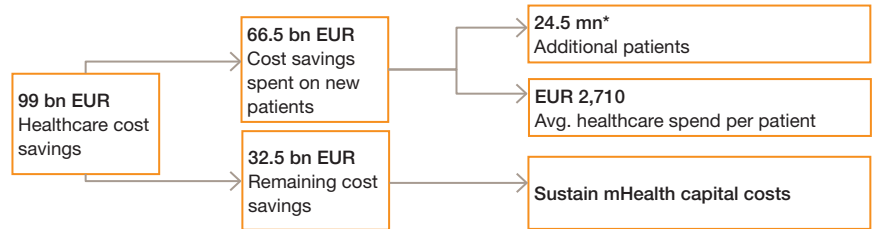
Boosting economic growth

In 2017, an enhanced quality of life and prolonged professional lives could add 93 billion EUR to the EU GDP.
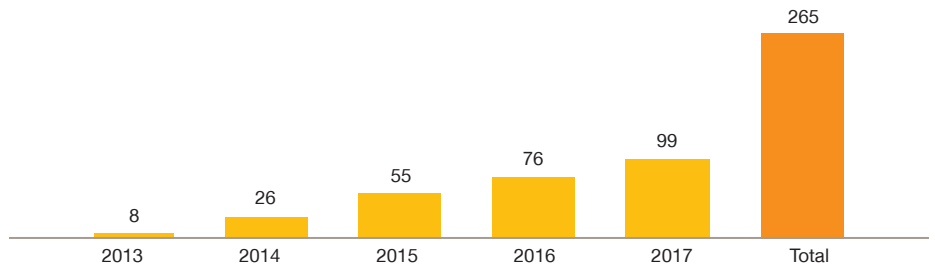
The enhanced productivity of 185 million patients benefitting from mHealth could create a positive economic impact on society.

- A total of 6.9 million patients at risk of developing chronic diseases would be able to avoid 1.6 billion hours in otherwise unpaid absenteeism due to ill health.

- A total of 11.2 million chronic patients will be able to avoid 508,000 instances of premature retirement and collectively extend their professional lives by 4.3 billion work hours.

- As a result, the disposable wages of these 18.1 million patients can increase by 66 billion EUR and enabling the government to collect an additional 27.1 billion EUR in taxes.
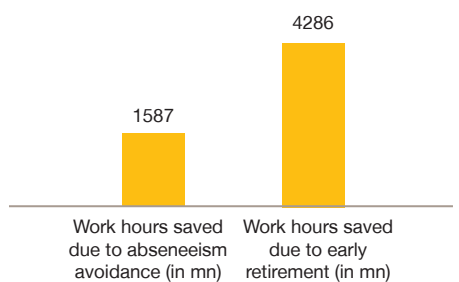
- Chronic patients who would have successfully avoided premature retirement up to 2017 by using mHealth to manage their diseases could add 4.3 billion work hours to their lives in 2017.

- Due to avoidance of unpaid absenteeism and premature retirement, the disposable wages of patients who successfully extend their professional lives can increase by 66 billion EUR and the government can collect an additional 27.1 billion EUR in taxes.

mHealth could, thus, help create greater safeguards in challenging economic times, increase investments and enhance availability of funds to finance healthcare costs.
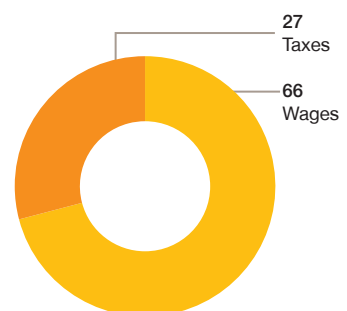
Avoidance of early retirement and absenteeism

6.9 Reduction in unpaid absentees (in mn)

0.5 Early retirements avoided (in mn)
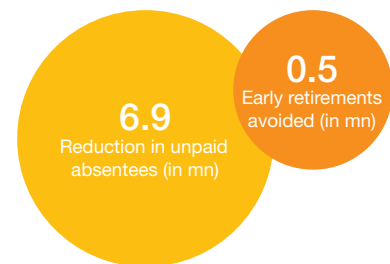
Extending professional lives for citizens

Work hours saved due to abseneeism avoidance (in mn)	1587
Work hours saved due to early retirement (in mn)	4286

93 bn EUR can get added to EU GDP

27 Taxes
66 Wages

Source: PwC analysis
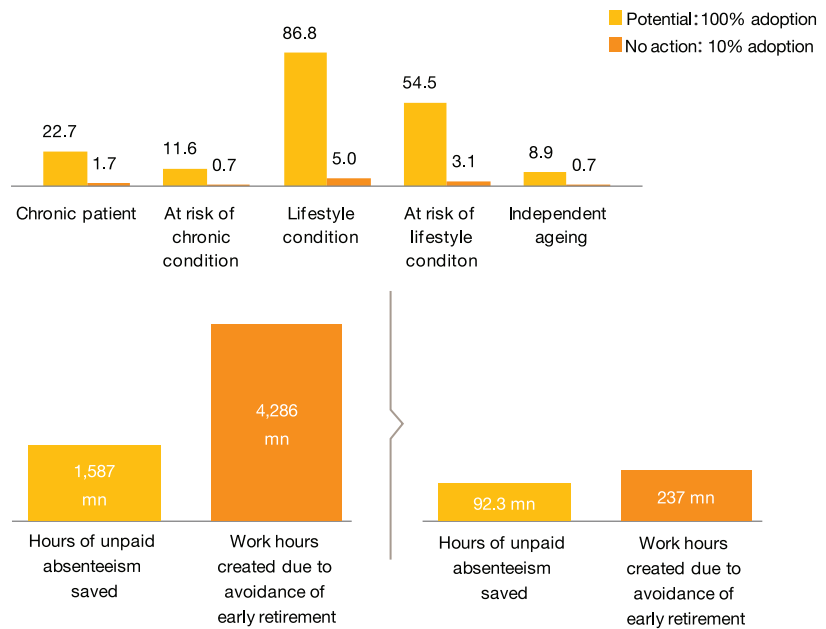
Overcoming barriers to adoption

Lack of adoption can severely limit the realisation of mHealth's potential

The initial estimates of the socio-economic impact of mHealth as described in this report present a compelling case to accelerate the adoption of mHealth. However, at present there are multiple barriers that prevent mHealth solutions from being adopted and achieving scale. According to expert opinion[19], only 10% of the potential users in 2017 could adopt mHealth due to these barriers, and, as a result, only 5% of the potential benefits might get realised.
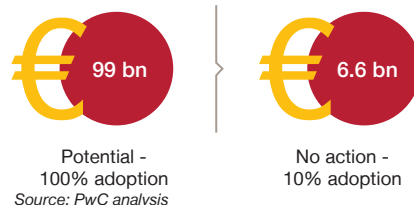
There are four sets of active barriers that limit the adoption of mHealth. These barriers are:

- **Regulatory:** An absence of adequate regulatory mechanisms that enable innovative health services to be deployed whilst ensuring patient safety and trust is delaying services reaching patients and healthcare professionals.

  - *Lack of clarity on mHealth certification:* Clarity needs to be provided on how medical device regulations apply to mHealth, providing a clear pathway for certification.

  - *Lack of interoperability standards:* The absence of regulations or standards that mandate interoperability amongst mHealth solutions and devices limit the scope of innovation and economies of scale to be achieved as well as negatively impacting ease of use.
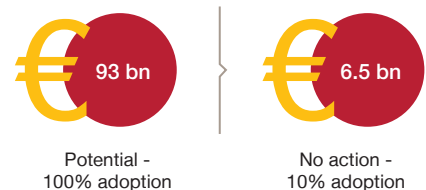
Regular mHealth users subjected to benefit by 2017 (in mn)

Potential: 100% adoption
No action: 10% adoption

	Chronic patient	At risk of chronic condition	Lifestyle condition	At risk of lifestyle conditon	Independent ageing
Potential	22.7	11.6	86.8	54.5	8.9
No action	1.7	0.7	5.0	3.1	0.7

Hours of unpaid absenteeism saved	Work hours created due to avoidance of early retirement	Hours of unpaid absenteeism saved	Work hours created due to avoidance of early retirement
1,587 mn	4,286 mn	92.3 mn	237 mn

Total healthcare cost savings in 2017 (in EUR)

€ 99 bn — Potential - 100% adoption
€ 6.6 bn — No action - 10% adoption

Source: PwC analysis

Total GDP addition in 2017 (in EUR)

€ 93 bn — Potential - 100% adoption
€ 6.5 bn — No action - 10% adoption

19 Primary interview with OnMobile

"Regulation is lagging behind adoption."

**Adesina Illuyemi,
University of Portsmouth**

"mHealth will generate data but no common framework to host that data currently exists. A common framework is needed within the EU region to ensure that mHealth can provide real benefits."

Yannis Nahal, Orange

"There is currently a lack of decision-making from the government in the form of delay in procedures, absence of correct economic incentive to use such solutions – to keep healthcare organisations attracted towards such solutions."

Stefano Roscini, Telecom Italia

"Lack of payment mechanisms is a major limitation. Technologies paid for are adopted quickly."

Dr. Annette Kroettinger, German Foundation for the Chronically ill

"Successful business models could consist of getting data from cloud-based services and collaborating with other stakeholders so that the data could be analysed and used."

Horst Merkle, Roche Diagnostics

"Changes are not coming from within as existing hospitals are governed by an economic model which works on adding resources. This is not sustainable."

John Grumitt, Vice President, Diabetes UK

– *Lack of clarity on data protection legislation:* Health data in the EU is a sensitive issue and requires a high level of protection. As a result, the legislation for data protection in the EU places individual right to privacy above the use of such data for the larger benefit of society, thereby restricting healthcare providers from sharing such data[20]. This localises mHealth deployments and limits their effectiveness in analysing patient data.

- **Economic:** These barriers restrict the adoption and scalability of mHealth solutions by either limiting their affordability or making their use commercially unviable for healthcare providers and patients.

  – *Need for further evidence:* Healthcare providers and policy makers require further evidence of clinical and economic benefits that mHealth can provide to increase its adoption.

  – *Conflicting financial incentives for healthcare providers:* Across a few healthcare systems in the EU, healthcare providers are allocated budgets according to the number of patients treated

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20   The European data protection legislation and its consequences for public health monitoring: a plea for action (http://eurpub.oxfordjournals.org/content/18/6/550.long)

Flow of information	Regulatory	Economic	Structural	Technological
Healthcare provider		Need for further evidence / Conflicting incentives / Change mgmt	Low cohesion across levels and regions / Low competition	Late involvement of doctors in solution design
Solution vendor	Lack of clarity on mHealth certification			Interoperability
Mobile service provider	Lack of interoperability standards	Lack of reimbursement mechanisms		Standardisation / Interoperability
Medical device vendor	Lack of compensation mechanisms			Standardisation / Interoperability
Doctors / Patients		Lack of awareness of mHealth benefits		Significant training needs

in hospitals. Such financial incentives are in direct conflict with the overall goal of mHealth or other similar technologies that could keep patients away from hospitals.

– *Lack of reimbursement mechanisms for patients:* A lack of reimbursement or funding mechanisms that could cover patients for the cost of mHealth solutions and associated devices limits the adoption of these solutions, especially amongst the low income groups.

– *Limited awareness of benefits of mHealth:* Quite often, healthcare providers and patients are unaware of the benefits of mHealth solutions, which can slow down their adoption and increase the selling expenses for mHealth vendors.

• **Structural:** The existing structure of healthcare systems could either restrict or discourage cohesion and competition amongst various healthcare providers, preventing solutions that enable efficiency from being adopted.

– *Lack of cohesion:* Healthcare systems could be better integrated functionally and electronically across the EU member states[21]. The resulting lack of cohesion across levels of care and regions, limits the scale and effectiveness of mHealth deployments.

– *High change management needs:* The significant change management associated with deployment and use of mHealth solutions requires allocation of time and resources, which may lower the efficiency and profitability of healthcare delivery during the transitory period.

• **Technological:** The absence of technological standards that promote the efficient development and use of mHealth solutions prevent mHealth investments from being utilised well and limit the deployment of mHealth.

– *Absence of protocols to standardise solutions:* Standardising the data definitions across mHealth solutions is necessary to allow a seamless exchange of data across solutions and platforms. The absence of such data protocols could limit the efficient use of these solutions and restrict their benefits.

– *Lack of interoperability:* The absence of regulations that mandate the solutions and devices capable of working with each other can localise the applicability of these solutions and limit their scalability.

– *Late involvement of doctors in solution design:* Quite often, doctors are involved in the development of a mHealth solution in the later stages of the design process. This late involvement results in a mismatch between the actual healthcare workflows and the ones incorporated in the mHealth solution. Hence, healthcare providers avoid adopting these due to the significant change management needs.

Actions needed to drive adoption

Immediate actions from policy makers, regulators and payers can help lower the barriers and drive adoption

Many mHealth benefits are system-oriented and may be visible over the longer term. Immediate action on the key adoption barriers is needed to ensure that these benefits can be attained in time to meet the current and imminent healthcare challenges adequately.

Various initiatives, such as the eHealth Action Plan, have been taken by the European Commission and some EU member states to better leverage eHealth. Similarly, to better harness the potential of mHealth, the regulators and policy makers across the European Commission and various EU member states need to formulate policies that can drive adoption of mHealth solutions. The national and regional payers need to support these policies by creating facilitative reimbursement mechanisms that ease the adoption of mHealth solutions across patients and healthcare providers. In the following paragraphs, we describe a few actions that could be taken to maximise the potential of mHealth.

Collaboration across the ecosystem

Healthcare and telecoms policy makers and regulators need to work with other stakeholders in the mHealth ecosystem to design facilitative policies that streamline the development of mHealth solutions and support their commercialisation by providing solid economic reasons that encourage adoption:

- Integrate mHealth within national healthcare strategies and policy initiatives.

- Align the development of mHealth solutions with the immediate healthcare priorities of each member state.

- Help create policies that encourage competition between regional healthcare providers, making the healthcare systems more performance oriented and less hospital-centric.

- Continue building the evidence base of mHealth benefits with relevant industry associations and solution providers.

- Leverage cloud-based solutions to aggregate the statistics from active mHealth deployments to measure and demonstrate the impact of these solutions on clinical outcomes and care costs.

Bridge regulatory gaps

The facilitative policies need to be supported by a solid regulatory framework that adequately addresses the key concerns of various stakeholders around safety and trust. The following actions can not only help address the regulatory barriers adequately but also the technological barriers, since these actions will facilitate the development of standardised and interoperable mHealth solutions:

- Raise clarity on EU medical device regulation based on a proportionate risk-based approach that ensures safety and quality while stimulating innovation and patient access.

- Clarify data protection legislation as it applies to mHealth, ensuring end-user trust and ease of use.

- Introduce regulations that address the gaps in General Data Protection Regulation (GPDR) and mandate different healthcare providers to share patient data, facilitating optimisation of references across different levels of care and the regional healthcare providers.

- Promote technology and data standards to ensure development of interoperable and standardised solutions.

Create economic incentives

In order to overcome the barriers created by conflicting incentives that healthcare providers are provided with, the policy makers, regulators and payers need to work together to:

- Create incentives that reward healthcare providers for gains achieved from the efficient utilisation of resources enabled by mHealth solutions across populations.

- Develop innovative and sustainable reimbursement or funding mechanisms that cover the cost of using mHealth solutions and associated devices, thereby-enabling equal access.

Support the use of mHealth

While the key barriers may be addressed directly or indirectly by executing the steps mentioned above, policy makers, regulators and payers need to ensure that the development and deployment of solutions are optimized and that healthcare providers have adequate support in leveraging mHealth solutions better. To achieve this, they might:

- Engage patients and healthcare professionals earlier during solution design to continue refinements of exact needs for mHealth solutions and lower change management requirements.

- Work together with medical universities, healthcare professionals, patient organisations, and relevant social media channels to educate the healthcare providers and patients on the use of mHealth solutions and their benefits.

- Identify medical universities and hospitals or pioneers in mHealth's implementation to optimise change management and set up training processes that wider healthcare delivery systems can follow.

- Identify medical universities and hospitals as pioneers in mHealth implementation in order to optimise change management and set up training processes that the wider healthcare delivery systems can follow.

- Centralise the procurement of mHealth solutions to ensure that compliance with established technology and data standards is attained.

Driving collaboration

While the various initiatives listed above could drive adoption and make investments in mHealth more efficient, significant collaboration among stakeholders is required to ensure that these steps are executed efficiently and coincide with each other as required. Clearly, policy makers, regulators and payers are best placed to catalyse the actions and involvement of the stakeholders. Hence, they need to lead the initiatives and drive urgency of action.

A lack of action and coordination in the form of policies, frameworks and supporting initiatives can either leave the benefits of mHealth underutilised or pushed out too far in time to help the healthcare systems to bridge the gaps that they are at risk of developing.

"Regulators can ensure that there is public access to data around quality and cost of care so that patients can make decision about their care. They should increase the focus on success and put in place a failure regime. Along with that, they need to create data standards so that information can flow."

John Grumitt
Vice President, Diabetes UK

"Successful business models could consist of getting data from cloud based services and collaborating so that the data could be analysed and used."

Horst Merkle, Roche Diagnostics

"Governance of mobile health is one area where government needs to work and invest."

Prof Devaka Fernando, Diabetes expert
Sheffield Hallam University

Appendices

A.1 Assumptions

Areas of assumption	Assumptions
Health conditions	Chronic conditions: T2DM, CVD and COPD are the conditions considered for assessment.
	Lifestyle conditions: Obesity, smoking and hypertension have been analysed as these lead to chronic conditions.
	Ageing population: This has also been analysed as a significant proportion of the EU population is above 65 and it poses a major challenge to the region.
Criteria for disease selection	Chronic and lifestyle conditions have been selected based on factors such as prevalence, Disability Adjusted Life Years (DALY) loss and mortality contribution to the EU region.
	Ageing population was found relevant because it poses a significant cost burden to the healthcare systems and patients.
	Our study omitted certain diseases such as cancer and asthma because our healthcare experts opined that mHealth will not be able to create any significant clinical improvement in the short term.
Areas of mHealth intervention	Two broad areas of intervention considered include solutions across the patient pathways and the healthcare systems.
	Solutions across patient pathways: Areas considered include wellness, prevention, diagnosis, treatment and remote monitoring.
	Solution across healthcare systems: Areas considered include healthcare practitioner support, healthcare administration and emergency response.
Relevant population	Wellness and prevention: Population at risk of developing conditions and pouplation with conditions being assessed.
	Diagnosis: Population at risk who do not have access to diagnosis and population with conditions who are not diagnosed.
	Treatment and monitoring: Population with conditions who are non-compliant to treatment.
	The above-mentioned population base has been segmented into basic mobile phone user base and smartphone user base.
Adoption factors	Telecom penetration rate is used to arrive at the population that could be reached by mHealth. Here, penetration rates for both basic mobile phones and smartphones have been applied on the relevant population.
	Adoption rate reflects the percentage of the relevant population who will adopt such mHealth solutions. Two scenarios have been considered here which are as follows:
	• Adoption rate would be 10% in 2017 if no action is taken to encourage it.
	• Potential adoption rate in 2017 is taken to be 100%, assuming that full adoption will be realised once the mHealth framework, policies and business models will be put in place.
	Adoption rates have been arrived at through primary interviews with healthcare experts.
	Repeat usage rate has been accounted for based on the assumption that the mHealth application will take six to 12 months to have meaningful healthcare impact. It has been validated by healthcare experts in relevant geographies.
mHealth benefits	Finding across the following areas have been used to quantify and estimate mHealth related benefits:
	• Pilot mHealth projects and their benefits.
	• Tele-health projects and their benefits.
	• e-Health project and their benefits.
	Final numbers obtained from these findings were further validated and modulated through primary interviews in the relevant geographies.
Age group for health conditions	Lifestyle conditions: Relevant age groups have been considered for each disease or medical conditions. E.g. 15+ years for smoking, hypertension and obesity.
	Chronic conditions: The age group of 20 to 79 years has been considered for T2DM, whereas for COPD and CVD, 15 years and above have been considered.
	Ageing population: The age group of 65 years and above has been considered.
Treatment cost	Historical treatment costs have been inflation adjusted in order to arrive at current costs where required.
Productivity loss	Due to absenteeism, productivity loss has been computed over unpaid sick days beyond entitled sick leaves.
	Due to early retirement, productivity loss has been computed on the years by which a chronic patient retires early.
	Daily wages and tax rates of each country have been taken into account to calculate productivity loss and loss on government taxes due to absenteeism and early retirement.
Hospitalisation days	Percentage of hospitalisation and ALOS have been captured from secondary sources. This was further validated by primary interviews from healthcare experts in relevant geographies.
Job creation	Jobs will be created for paramedics, trainers and technical support staff for each mHealth deployment in hospitals.
Adverse drug events	Preventable adverse drug events cause a major cost burden on the healthcare system. This can be reduced by effective mHealth deployments across hospitals.
Extrapolation of benefits for EU 27 countries	Calculations have been explained under the Methodology appendix which highlights the factors and steps used for extrapolation.
	Grouping: EU 27 has been divided into three country grouping based on factors such as type of healthcare systems, healthcare spend as a % of GDP and government spending on healthcare. Three countries were then chosen to represent each grouping.
	Clinical benefits: The benefits estimated for the representative country of each country grouping have been used for the remaining countries in the grouping.
	Treatment cost savings: These have been extrapolated and adjusted based on the ratio of per capita healthcare spend in the relevant country and the representative country of that country grouping.
	Increase in earnings: These have been extrapolated by capturing hourly wages and taxes of each country.

A.2 Methodology

Understanding and quantifying region-specific healthcare challenges

To arrive at the socio-economic impact of mHealth, we started with the view that for mHealth to be effective, it needs to address the challenges and needs of the EU region. We gathered data points on relevant challenges such as disease incidence, prevalence, disease related mortalities and the number of people at risk. These healthcare challenges and data points were further validated by primary interviews with healthcare experts in the regions.

Further, to identify the socio-economic impact of the disease, we looked into parameters like treatment costs of each disease in each region and the cost burden of early retirement and absenteeism caused by those diseases. We also looked into disease-specific hospitalisation frequency and hospitalisation days to quantify the socio-economic challenge.

Identifying the scope of mHealth and capturing benefit data

The relevance of mHealth was established against these challenges. We identified two broad areas of interventions such as solutions across the patient pathway and the healthcare system strengthening. These two broad categories were further sub-divided into six areas of intervention– solutions across the patient pathways (wellness and prevention, diagnosis, treatment and monitoring) and healthcare systems (emergency response, healthcare practitioner support and healthcare systems strengthening).

The following key steps were taken to arrive at the quantified healthcare benefits of mHealth

- A relevant population base was selected for each condition being assessed.

- The smartphone and basic user phone penetration was applied to this population to arrive at the total potential users of mHealth solutions.

- Since mHealth solutions benefit only if used regularly, the percentage of total potential users who would regularly use such mHealth applications was determined to arrive at the relevant number of mHealth users.

- Further, the percentage of regular mHealth users that could benefit was computed for each solution type and condition.

- The potential benefits estimated for each solution type and condition were then applied to arrive at the overall benefit.

Each area and type of benefits of mHealth were estimated based on existing studies, pilots and expert opinion.

Arriving at socio-economic estimates

To analyse the benefits across the EU, representative countries of the region were selected. Multiple criteria such as geographic representation, healthcare system type and healthcare funding systems, were used to identify such representative countries. An economic model was then developed to quantify healthcare challenges and mHealth induced socio-economic benefit in these representative countries.

Extrapolation of socio-economic benefits across EU 27 countries

Each benefit type calculated for a representative country was then extrapolated to the entire EU region.

- We created three country groupings, each grouping represented by the previously selected representative country.

- Relevant countries were then identified and grouped under each representative country grouping.

- Criteria such as healthcare spend as a % to GDP, public and private healthcare spend, per capita healthcare spend, healthcare system type were used to identify and group EU27 countries within those groupings.

- Incidence and disease related healthcare benefits were extrapolated as per the representative country. However, treatment cost savings were calculated based on healthcare expenditure parity between the focus and representative country.

- Similarly, while computing increase in earnings related benefits, wages and taxes in each country were used to accurately capture socio-economic impact.

Approach to quantify socio-economic benefits				
	Quantify major health challenges in the region	Identify scope of mHealth	Analyse potential benefit of mHealth	Translate healthcare benefits to socio-economic benefits	Scenario analysis
Area covered	• Data analysis to profile healthcare challenges of the region • Translation of these challenges to socio-economic challenges	• Analysis to identify relevant areas for mHealth interventions based on the challenges • Prioritisation of these areas based on the goals of multiple players in the mHealth ecosystem of the region	• Analyse case studies and pilot projects to arrive at estimates of benefits • Conduct primary interviews to verify the estimates	• Convert the healthcare benefits to socio-economic benefits through econometric modeling	• Parameters varied to under-analyse socio-economic impact of various scenarios of mHealth adoption
Source of data	• Primary interview • Secondary sources	• PwC analysis • Primary interview	• Primary interview • Secondary sources	• PwC analysis	• PwC analysis

Logic used for extrapolation		
	Choose representative countries in each grouping and group EU countries in groupings	Extrapolate mHealth benefits
Area covered	• Group EU countries into groupings based on status of healthcare systems in various countries	• mHealth benefits from representative country taken as a reference for each grouping • Corresponding benefits extrapolated for each member country in each grouping
Source of data	• PwC analysis • Primary interview • Secondary sources	• PwC analysis

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