REPORT

on

Studies Concerning Added Value of eHealth/mHealth Services

Document Information:

<table>
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<tr>
<th>Document status:</th>
<th>Submitted for information to the members of the eHealth Network at their 12th meeting on 28 November 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved by JAseHN sPSC</td>
<td>Yes</td>
</tr>
<tr>
<td>Document Version:</td>
<td>v1.5</td>
</tr>
<tr>
<td>Document number:</td>
<td>D7.3</td>
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</tbody>
</table>
| Document produced by: | Joint Action to support the eHealth Network  
  - WP7 Exchange of knowledge  
  - Task 7.3 Research on added value of eHealth Tools |
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| Stakeholder Contributor(s): | EHTEL |
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## LIST OF ABBREVIATIONS

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<thead>
<tr>
<th>ACRONYM</th>
<th>DEFINITION</th>
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<tr>
<td>AI</td>
<td>ARTIFICIAL INTELLIGENCE</td>
</tr>
<tr>
<td>CEA</td>
<td>COST-EFFECTIVENESS ANALYSIS</td>
</tr>
<tr>
<td>CEF</td>
<td>CONNECTING EUROPE FACILITY</td>
</tr>
<tr>
<td>CIP</td>
<td>COMPETITIVENESS AND INNOVATION FRAMEWORK PROGRAMME</td>
</tr>
<tr>
<td>DSI</td>
<td>DIGITAL SERVICE INFRASTRUCTURE</td>
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<tr>
<td>DSM</td>
<td>DIGITAL SINGLE MARKET</td>
</tr>
<tr>
<td>EC</td>
<td>EUROPEAN COMMISSION</td>
</tr>
<tr>
<td>eHDSI</td>
<td>EHEALTH DIGITAL SERVICE INFRASTRUCTURE</td>
</tr>
<tr>
<td>eHN</td>
<td>EHEALTH NETWORK</td>
</tr>
<tr>
<td>EHR</td>
<td>ELECTRONIC HEALTH RECORD</td>
</tr>
<tr>
<td>eP</td>
<td>ELECTRONIC PRESCRIPTION</td>
</tr>
<tr>
<td>EU</td>
<td>EUROPEAN UNION</td>
</tr>
<tr>
<td>HCPs</td>
<td>HEALTHCARE PROFESSIONALS</td>
</tr>
<tr>
<td>HIT</td>
<td>HEALTH INFORMATION TECHNOLOGY</td>
</tr>
<tr>
<td>HPO</td>
<td>HEALTHCARE PROVIDER ORGANIZATIONS</td>
</tr>
<tr>
<td>ICT</td>
<td>INFORMATION AND COMMUNICATION TECHNOLOGY</td>
</tr>
<tr>
<td>IoMT</td>
<td>INTERNET OF MEDICAL THINGS</td>
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<tr>
<td>IoT</td>
<td>INTERNET OF THINGS</td>
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<tr>
<td>JAseHN</td>
<td>JOINT ACTION TO SUPPORT EHEALTH NETWORK</td>
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<tr>
<td>OECD</td>
<td>ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT</td>
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<td>PM</td>
<td>PRECISION MEDICINE</td>
</tr>
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<td>WHO</td>
<td>WORLD HEALTH ORGANIZATION</td>
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<td>WP</td>
<td>WORK PACKAGE</td>
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Executive Summary

The use of information and communications technologies (eHealth) as well as the use of mobile and wireless technologies (mHealth) for health is growing rapidly and has the potential to transform the face of health service delivery across the globe. This document is deliverable D7.3 from WP7, “Exchange of knowledge”, with a focus on added value of eHealth/mHealth tools and services. The purpose of this document is to explore and report on the most up-to-date studies on the added value of eHealth services in a healthcare system. It is based on an extensive analysis of the literature regarding services in the eHealth/mHealth sector as well as on use cases of Member States (MS) indicating existing national frameworks, activities and perspectives.

mHealth/eHealth services are considered as a strategic area with a focus on patient orientation, personalisation of care, quality, security and increase of mobility. As the European Commission is recognising both the potential of as well as the issues arising from the growth of mHealth, several mHealth-specific initiatives have been launched. The primary focus of this report is to contribute to the sharing of good practices between MS on how eHealth tools are used in health promotion and disease management. It is a follow-up measure of the Green Paper on mHealth announced in the eHealth Action Plan 2012-2020\(^1\). In fact, it will cover broad areas of eHealth that are subject to greater impact in healthcare providers and patients.

Section 1 will describe the purpose and objectives of the report, while in Section 2 there will be an extensive description of the state of eHealth and mHealth services in the European Union (EU). Section 3 will focus on use cases, describing various eHealth solutions running in the MS, and then in Section 4 an overview of the overall benefits that can be generated from eHealth services will be discussed. This report will then highlight the current trends of value-added services in the eHealth/mHealth sector (Section 5), such as cloud computing, 5G (the next generation of mobile communication technology), the impact of genomics and others, which will provide the material necessary for the evaluation of all these existing approaches and trends by focusing on strategic guidelines that will move to a paradigm change in healthcare with a truly individualised care and disease prevention system in Europe (Section 6).

Taken together, deliverable D7.3 will be a core knowledge framework that will contain the relevant information to initiate and propel, over the next decade, the development of an eHealth strategy that has the citizen at its centre and will improve the efficiency of health systems in Europe.

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1. Introduction

Technology is a paradigm shift and successive waves of technological change have transformed human societies and economies. The current digital revolution has the power to do so again and transform the way healthcare is carried out through eHealth tools or solutions including systems and services for both health authorities and professionals as well as personalised health systems for patients and citizens. Examples include health information networks, electronic health records, telemedicine services, personal wearable and portable communication systems, health portals, and many other information and communication technology-based tools assisting prevention, diagnosis, treatment, health monitoring and lifestyle management.

The “Action Plan for a European eHealth Area” defines and describes eHealth as “the application of information and communications technologies across the whole range of functions that affect the health sector.”

1.1 Purpose

This report forms Task 7.3 of the Joint Action to Support the eHealth Network (JAseHN), which was established to “develop political recommendations and other instruments for cooperation”. It is part of the “Exchange of Knowledge” work package (WP) on eHealth between MS and will focus on presenting a report on the most up-to-date studies on the added value of eHealth/mHealth services. Whilst it identifies the added value of eHealth, the report aims to allow a varied set of technologies and innovative business models to rapidly meet demand and to benefit from the mobilising effect generated. It is essential to measure and assess the added value of innovative eHealth products and services to achieve wider evidence-based eHealth deployment and create a competitive environment for eHealth solutions.

The deliverable from this task is as follows:

- D7.3 Report on the added value of eHealth services.

The overall purpose of this document is to contribute as a follow-up of reports and studies by collecting information on mHealth and eHealth services, summarising some of the emerging technology trends and how they can play a part in the transformation of healthcare, empowering the patients and supporting healthcare professionals to treat patients more efficiently. The current report is based on extensive research into state-of-the-art references on the current state of implementation of eHealth and mHealth in Europe.

1.2 Objectives

The main objectives of this report are:

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To collect information on the studies of eHealth and mHealth services according to the Digital Single Market (DSM) strategy reports from the Commission\(^4\)

- To define the added value of eHealth and its impact on the democratisation of healthcare

- To provide the value proposition of eHealth and mHealth solutions

- To introduce current trends, with a brief overview of the main characteristics and examples of implementation

- To explore business models for the implementation of value-creating and sustainable eHealth systems in Europe

While the first eHealth Action plan was adopted as early as 2004, the implementation of electronic health records, ePrescriptions and comprehensive nationwide eHealth programmes varies significantly across Member States. In an effort to establish a common eHealth vision and develop targeted policy initiatives aimed at fostering widespread adoption of eHealth throughout the EU, this document focuses on the solutions and systems that use electronic health information to satisfy the needs of the several stakeholders, in order to deliver healthcare activities in a scalable and sustainable manner.

2. State of eHealth and mHealth in the European Union

eHealth and mHealth are two connected yet different tools enabled by enhanced connectivity. In this section, we will evaluate the current studies and plans within the European Union for the two tools in order to develop systems and services that could address the various health needs of society. Section 2.3 reports a list of Horizon 2020 eHealth/mHealth projects and the added value to patients and health providers. Relevant global resources and initiatives for the adoption of health information technology (HIT) infrastructure in the form of electronic health records (EHRs) and agreed standards for interoperability and schemes for privacy and consent can be found in Table 1 (ANNEX 1).

2.1 Overview of eHealth services

eHealth services include a variety of digital applications, processes and platforms. They include tools for health authorities, healthcare provider organisations (HPO) and healthcare professionals at all levels, as well as personalised health systems for patients and citizens. Examples include EHR systems, TeleHealth (remote medical consultation)\(^5\), smartphone apps, personal wearable and portable communication systems, remote monitoring devices and biosensors, computer algorithms and analytical tools and many other information and communication technology-based tools assisting prevention, diagnosis, treatment, health monitoring and lifestyle management (Belle et al., 2015; Haghi et al., 2017).

The eHealth Action Plan 2004-2011 was the first EU project to cover areas from ePrescriptions and health cards to new information systems that reduce waiting times and errors, in order to facilitate a more harmonious and complementary European approach to eHealth, empowering both patients and healthcare professionals (HCPs). Since then, the European Commission has been developing targeted policy initiatives aimed at fostering the

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\(^{4}\) https://ec.europa.eu/digital-single-market/en/newsroom/reports-studies-etc/ehealth/all/all/ec?page=1

widespread adoption of eHealth throughout the EU. In 2011, with a focus on patients’ rights in cross-border healthcare, the European Commission launched the eHealth Action Plan 2012-2020, a major policy initiative which:

- Focuses on supporting research and development, innovation and competitiveness through funded projects under the Seventh Framework Programme for Research (FP7), the Competitiveness and Innovation Framework Programme (CIP) and Horizon 2020. The main research priorities include health and wellbeing solutions for citizens and HCPs, and better quality of care, including for chronic diseases, while increasing citizens’ autonomy, mobility and safety (http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52012DC0736).
- Achieves interoperability of eHealth services and
- Promotes international cooperation to support an innovative and collaborative community at global level.

In 2012, an eHealth stakeholder group was formed from experts of the European Parliament, European Commission, universities and local health policy-makers to contribute to the development of legislation and policy related to eHealth. Out of this initiative, key recommendations to move forward eHealth in the EU were generated by reports related to patients’ access to EHRs, eHealth inequalities, interoperability and telemedicine deployment.

Today, the European Commission (EC) manages around 100 eHealth projects with the vision to utilise and develop eHealth to address several of the most pressing health system challenges of the 21st century, such as:

- Improving chronic disease (such as diabetes, mental illness, cardiovascular disease and strokes) and multimorbidity management so as to strengthen effective prevention and achieve better quality of care;
- Unlocking innovation, with strong user involvement, focusing on interoperability and the integration of emerging patient-centric technologies for cost-effective healthcare;
- Fostering cross-border healthcare, health security, solidarity, universality and equity;
- Improving legal and market conditions for developing competitive eHealth products and services.

Of note are the studies from the Digital Single Market (DSM) strategy, which demonstrate how eHealth can improve treatment quality, providing better access to care, and how it can enhance patient safety and risk management in healthcare as well as presenting the economic impact of eHealth in Europe. Of interest is also deliverable 8.1.1 from JAseHN that describes OECD studies in order to identify eHealth-related policy goals and study results. According to the studies, ICT’s role in policies is as a provider of data for healthcare system measurement and quality improvement as well as a tool for patient empowerment and

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7 http://ec.europa.eu/cip/
integrated care. Similar eHealth policy targets, such as those in OECD reports, are found in various countries such as the Nordic countries (Hyppönen et al 2017). While eHealth may not yet have changed the underlying principle of healthcare, it has contributed to a fundamental shift in the structure and organisation of healthcare systems, increasing the safety and quality of healthcare throughout the EU. The added value of eHealth services could have an impact on both HCPs and patients and could be summed up as:

- Improved quality of care,
- Better planning and resource allocation,
- Cost efficiency – more efficient health landscape,
- Enhancing the evidence base for health service delivery and policy-making,
- Real-time monitoring,
- Providing better, tailored and personalised services
- Improving patient empowerment

2.2 Overview of mHealth services

According to the Green Paper on mobile health (mHealth) published by the European Commission in 2014, mHealth is an emerging field that covers various technological solutions. mHealth is a sub-segment of eHealth and includes the use of mobile communication devices in health and wellbeing services covering various technological solutions, which inter alia measure vital signs such as heart rate, blood glucose level, blood pressure, body temperature and brain activities (Peterson et al., 2016). The World Health Organization (WHO) defines mHealth as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices”.

Over 97,000 mHealth apps are currently available across multiple platforms on the global market. However, mHealth in Europe is insufficiently widespread and remains largely in an experimental phase due to issues such as data protection and security of health data, big data, legal framework, patient safety and transparency of information. Given the rapid developments in the area and potential need for coordinated approaches, it is important to follow closely the deployment of mHealth solutions in healthcare and reinforce the cooperation among Member States in this field. Alongside the Green Paper, the Commission published a Staff Working Document on the existing EU legal framework applicable to lifestyle and wellbeing apps in order to provide software developers and medical device

manufacturers with legal guidance on the EU legislation. In 2015 a stakeholder subgroup on mHealth was established by the European Commission (EC) to work on actions to support mHealth as an engine for health system transformation. The mHealth subgroup carried out a mapping of possible actions and related existing initiatives with a focus on:

- **Common assessment framework**: harmonise the practices in different Member States as much as possible in order to reduce market fragmentation and the administrative burden for both the MS competent authorities and the app developers.

- **A collaboration platform**: include knowledge exchange supporting best-practice dissemination on personal data and consumer protection in mHealth, including technical solutions for authentication and authorisation, data governance, etc.

- **Interoperability and standards development**: mapping of existing standards (HL7 FHIR, ISO, PAS) to facilitate their use and to exchange information among Member States on important developments and best practices to facilitate the interoperability of the mobile devices and mobile health apps.

- **Training and education**: raise awareness about the benefits of mHealth to improve digital skills and digital health literacy.

- **Health system outcome monitoring**: A systematic overview of existing evidence on the cost/benefits of mHealth.

- **Funding instruments**: funding instruments and reimbursement models that support system-wide implementation of mHealth.

In February 2016, the Commission established another mHealth stakeholders working group, including representatives of patients, health professionals and providers, payers, industry, academia and public authorities to include an overview of the mHealth developments in Member States, mHealth assessment guidelines on data validity and reliability as well as areas for collaboration. A consensus agreement by all stakeholders concluded in the following criteria being considered important for the assessment of mHealth applications to be used and integrated into the health and social care systems:

1. **Privacy**: compliance with applicable laws and guidelines
2. **Transparency**: identification of the originators/sponsors of apps
3. **Reliability**: consistency in the functioning of an app
4. **Validity**: the app needs to be evaluated against any claimed health benefit or improved health outcome, clinical validation to gold standards
5. **Interoperability**: the need for an app to function on multiple platforms.

Following the views of various stakeholders and working documents from the Commission, in several countries initiatives are underway to set up schemes for mHealth app assessment in order to provide guidance to the professionals and general public on “good apps” or to integrate them into mainstream healthcare provision by linking them to the public health platform.

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The *added value of mHealth* is that it can support new models of care by surpassing geographical, temporal and organisational barriers (Silva et al., 2015) and can contribute to the sustainability of healthcare systems. In particular, the main perceived benefits of mHealth include:

- a reduction of healthcare costs
- patient-centred care
- greater empowerment of individuals to manage their health more effectively and proactively
- an opportunity to deliver more consistency
- disease prevention and control
- coordinated and efficient healthcare when and where needed
- increased access to health services for remote or under-served communities
- more accessible treatment

### 2.3 Horizon 2020 eHealth/mHealth projects

A list of example projects related to eHealth or mHealth that are currently running in the EU under Horizon 2020 are shown in Table 1. Some of these are developing decision-support systems or computer models, others biosensors to detect and quantify biomarkers, while others are developing computational platforms to improve the management of different diseases. A more detailed review of some of these projects is discussed below:

The **SMARTTool** project aims to develop a platform based on cloud technology for clinical decision support for the management of patients with coronary artery disease. The computational models are based on the available multiscale and multilevel ARTreat models for coronary plaque assessment and progression over time using non-invasive imaging by coronary computed tomography angiography (CCTA) and are extended with functional site-specific assessment (haemodynamically significant plaques by non-invasive FFR computation) and additional heterogeneous patient-specific non-imaging data (history, lifestyle, exposome, biohumoral data, phenotyping and genotyping). During the development of the project some of the main objectives are to create a patient-specific non-imaging based predictive model for CAD stratification score and to develop a microfluidic device for on-chip blood assay directly exploitable in the SMARTool platform, which will characterise the patient-specific cellular/molecular inflammatory phenotype. The final aim of the study is to enable clinicians to predict the individual evolution of heart disease, diagnose it early and assess any future risks.

**PEPPER** is another study with a focus on developing a decision support system for type 1 diabetes management, with the difference that it will empower patients to participate in the self-management of their condition. The design involves users at every stage to ensure that the system meets patient needs and raises clinical outcomes by preventing adverse episodes and improving lifestyle and monitoring and boosting quality of life. The resulting architecture will provide a generic framework for providing adaptive mobile decision support, which will also improve interactions with healthcare professionals.

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21 [http://www.smartool.eu](http://www.smartool.eu)
22 [http://www.pepper.eu.com](http://www.pepper.eu.com)
**HEARTEN** targets heart failure, which is a chronic disease that occurs when the heart is unable to pump sufficiently to maintain the blood flow to meet the needs of the body. During the project, a mobile platform will be developed which will integrate a breath and a saliva sensor from the patient’s cup to monitor the changes in the patient’s health status, the activity of the heart, the blood pressure and the physical activity of the patient. The added value of this study is to improve adherence and intervene before frailty incidences occur.

**RELIEF** develops innovative ICT solutions to improve self-management of chronic pain patients. Individuals experiencing chronic pain should be able to access self-management therapies away from expert healthcare centres, and be enabled to sustain self-management over the long term. These innovative self-management solutions should mainly address personalised guidance to patients based on the use of wearable/portable devices and improved individual/healthcare-professional interaction as well as involving patients in managing their diseases.

**MAGIC** is another project designed to enable changes in the delivery of health and care services in order to empower patients. Due to the significant gap in care associated with the recovery of post-stroke patients, the study aims to develop new, innovative technology-based solutions that improve physical function and thus personal independence within the first six months following the onset of stroke. The added value of this project is to develop technology that will assist in the self-management of patients and empower them, similar to the PEPPER project focusing on type 1 diabetes.

Taking all the above into consideration, one can conclude that the expected benefits and impact of these projects focus on:

- Improving the participation of the patient in the care process.
- Improving the management of a disease.
- Increasing the level of education and adherence of individuals, patients and caregivers.
- Improving interaction between patients, their relatives, healthcare providers and social caregivers.
- Strengthening the evidence base on health outcomes, quality of life, care efficiency gains and economic benefits from the use of ICT in new care models.
- Increasing confidence in decision support systems for disease/patient management.
- Involving healthcare providers/authorities with increased commitment in the deployment of innovative services empowering the patient.

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23 http://www.hearten.eu  
24 http://relief-chronicpain.eu  
25 http://magic-pcp.eu
<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Value</th>
<th>Website</th>
<th>Duration</th>
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<tbody>
<tr>
<td>NEVERMIND</td>
<td>The envisaged system works via a smartphone and a light-sensitive shirt. It predicts the severity and onset of depression related to a serious somatic disease. The data will trigger a response encouraging the patient to seek help.</td>
<td>empower people who suffer from symptoms of depression</td>
<td><a href="http://www.nevermindproject.eu/nevermindproject.eu">www.nevermindproject.eu/nevermindproject.eu</a></td>
<td>2016-2019</td>
</tr>
<tr>
<td>RELIEF</td>
<td>In its first phase, the RELIEF experts will conduct a preliminary solution exploration to determine different solutions to explore. A second phase will also include prototype development.</td>
<td>help improve chronic pain relief through innovative ICT self-management solutions.</td>
<td>relief-chronicpain.eu</td>
<td>2016-2019</td>
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<tr>
<td>SELFBACK</td>
<td>Development of a decision support system that, through a smartphone app, will assist the patient in deciding and taking the appropriate actions to manage their low back pain.</td>
<td>decision support system for self-management of back pain</td>
<td><a href="http://www.selfback.net/">http://www.selfback.net/</a></td>
<td>2016-2020</td>
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<tr>
<td>PD-manager</td>
<td>This project will allow people with Parkinson’s Disease followed by a multidisciplinary team, using the use of accessible technologies: A smart watch, an insole to measure foot and balance, an electronic pillbox and a set of applications connected to smartphone and/or tablet.</td>
<td>remote monitoring</td>
<td><a href="http://www.parkinson-manager.eu">www.parkinson-manager.eu</a></td>
<td>2015-2018</td>
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<tr>
<td>myAirCoach</td>
<td>Development of a non-invasive compact inhaler that will be in continuous communication with the patient’s adherence to the treatment and the outcome of nutritional interventions.</td>
<td>monitor and self-control of the disease</td>
<td><a href="http://www.myaircoach.eu">www.myaircoach.eu</a></td>
<td>2015-2018</td>
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<tr>
<td>MyCyFAPP</td>
<td>Help Cystic Fibrosis patients and caregivers to manage their disease with an innovative app. An individualized therapy with replacement can relieve many of the life-shorteningSymptoms.</td>
<td>patient’s adherence to the treatment and outcome of nutritional intervention</td>
<td><a href="http://www.mycyfapp.eu">www.mycyfapp.eu</a></td>
<td>2015-2019</td>
</tr>
<tr>
<td>Do CHANGE</td>
<td>Experts will link inputs from medical devices, nutritionists, doctors and consultants, thus creating a new health environment.</td>
<td>remote monitoring</td>
<td><a href="http://www.do-change.eu">www.do-change.eu</a></td>
<td>2015-2018</td>
</tr>
<tr>
<td>HEARTEN</td>
<td>Researchers are developing biosensors that detect and novel breath and saliva HF biomarkers that can reflect the health of patients.</td>
<td>monitoring and patient adherence to drugs</td>
<td><a href="http://www.hearten.eu">www.hearten.eu</a></td>
<td>2015-2018</td>
</tr>
<tr>
<td>HeartMan</td>
<td>The system will involve medication management, monitoring fluid intake and weight, exercise and lifestyle changes.</td>
<td>patient remote monitoring</td>
<td>heartman-project.eu</td>
<td>2016-2018</td>
</tr>
<tr>
<td>PATHway</td>
<td>Experts are developing an individualized programme for internet-enabled, sensor-based home exercise platforms.</td>
<td></td>
<td><a href="http://www.pathway2health.eu">www.pathway2health.eu</a></td>
<td>2015-2018</td>
</tr>
<tr>
<td>SMARTool</td>
<td>SMARTool models are based on the extension of the traditional available multiscale and multilevel ART-treat models for plaque assessment and progression over time using novel technology.</td>
<td>clinical decision support system</td>
<td><a href="http://www.smartool.eu">http://www.smartool.eu</a></td>
<td>2016-2019</td>
</tr>
<tr>
<td>PAL</td>
<td>It will use, refine and extend the knowledge-base and models of ALIZE-E to improve child’s diabetes regimen in the child, health professional and parent. The PAL system is composed of a social robot (NAO), its (mobile) avatar, extendable set of (mobile) health applications (diabetes educational quizzes, sorting games, etc.), which can common knowledge-base and reasoning mechanisms.</td>
<td></td>
<td></td>
<td>2015-2019</td>
</tr>
<tr>
<td>BD2Decide</td>
<td>Aims to develop a more precise prognostic prediction of tumors currently used in Cancers of Head and Neck Region.</td>
<td>clinical decision support system</td>
<td><a href="http://www.bd2decide.eu">http://www.bd2decide.eu</a></td>
<td>2016-2019</td>
</tr>
<tr>
<td>DESIREE</td>
<td>A web-based collaborative system will bring together the information of breast cancer cases, will provide a more informative decision support system that predicts the extent of breast cancer case by case.</td>
<td></td>
<td><a href="http://www.desiree-project.eu">www.desiree-project.eu</a></td>
<td>2016-2019</td>
</tr>
<tr>
<td>iManageCancer</td>
<td>The iManageCancer project will provide a cancer disease management platform designed according to the specific needs of patients and focusing on their well-being. It partners from healthcare providers and patients to manage their symptoms using computer technology.</td>
<td></td>
<td>iManageCancer.eu</td>
<td>2015-2018</td>
</tr>
<tr>
<td>EmERGE</td>
<td>The platform will provide users with web based and mobile applications which interface securely with relevant medical and healthcare providers, and facilitate remote access to key healthcare providers.</td>
<td></td>
<td><a href="http://www.emergeproject.eu">www.emergeproject.eu</a></td>
<td>2015-2020</td>
</tr>
<tr>
<td>ELECTOR</td>
<td>Small, mobile blood testing device for home use.</td>
<td>self-management</td>
<td><a href="http://www.elector.eu">www.elector.eu</a></td>
<td>2015-2018</td>
</tr>
<tr>
<td>NYMPHA-MD</td>
<td>Implementation of a Pre-Commercial Procurement of eHealth services for supporting physicians and patients.</td>
<td></td>
<td><a href="http://www.nympham-d-project.eu">www.nympham-d-project.eu</a></td>
<td>2014-2017</td>
</tr>
<tr>
<td>RELIEF</td>
<td>The project will use pre-commercial procurement to improve chronic pain relief through innovative ICT self-management solutions.</td>
<td></td>
<td>relief-chronicpain.eu</td>
<td>2016-2019</td>
</tr>
<tr>
<td>Digi-NewB</td>
<td>The system will assist the clinician in his decision-making process.</td>
<td>clinical decision support system - improve care for newborns in neonatal units</td>
<td><a href="http://www.digi-newb.eu">http://www.digi-newb.eu</a></td>
<td>2016-2020</td>
</tr>
</tbody>
</table>

Table 1: List of examples of eHealth or mHealth projects running in the EU under Horizon 2020

3. Sharing good practices

European countries are making substantial progress towards modern eHealth infrastructures and implementations. However, the infrastructure, workforce, legislation, policy and compliance vary throughout the EU and thus eHealth services develop differently in different European countries.
This section gives a brief overview of eHealth systems of selected MS as use cases to have a better understanding of the vast variety of possible solutions across the EU, and to illustrate the added value of those services and how they satisfy the needs of the several stakeholders and key users of health information. People’s attitudes towards data protection and privacy differ greatly across Europe, which is reflected in the different eHealth services and tools to be developed. According to the reports (i) “Mapping out the obstacles of free movement of electronic health records in the EU in the light of the single digital market”26 and (ii) “Study on Big Data in Public Health, Telemedicine and Healthcare”27 there are several national strategies but we focused on some of those that implement the eHealth systems and the respective laws by supporting the movement and the safe use of health data as well as evaluating them according to their impact – core and economic – on:

- Citizens
- Health provider organisations (HPOs), including physicians in private offices and other professionals
- Third-party payers, including insurance funds
- Other parties, if relevant.

The eHealth services of the following countries are described:

- **Denmark**: The Shared Care Platform
- **Estonia**: E-Estonia – National Identity Scheme
- **Italy**: ARNO Observatory
- **Spain**: Spanish Rare Diseases Registries Research Network (SpainRDR)
- **Greece**: e-Prescription System
- **Finland**: Kanta (national repository for electronic health records)
- **Austria**: Electronic Health Records – ELGA

A common, clear and simple set of rules for the use of eHealth solutions must be applied in order to ensure an EU single market that works on eHealth to support secure data exchange and portability.

### 3.1 Denmark – The Shared Care Platform

This is an eHealth system for chronic disease patients that facilitates coordination between the general practitioner, the municipality and the hospital. The platform collects data from the health and social care providers’ individual IT systems, which represents the basis for a common treatment plan for the patient. Moreover, patients have access to their own data on their computer, tablet or smartphone and can add additional data to the system, e.g. by answering questionnaires or sending their vital monitoring information collected at home. The Shared Care Platform ([http://healthcaredenmark.dk/profiles/syddansk-sundhedsinnovation.aspx](http://healthcaredenmark.dk/profiles/syddansk-sundhedsinnovation.aspx)) enables health and social care providers to offer a coherent course of treatment for patients. The added value of this service is reflected by combating chronic


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disease and improving the quality and effectiveness of treatment by achieving better-informed patients and well-coordinated treatment\textsuperscript{28, 29}.

3.2 E-Estonia – National Identity Scheme

Since 2005, Estonia has established national e-solutions within the health care system. In 2010, e-prescription (https://e-estonia.com/solutions/healthcare/e-prescription) and e-Health Record (https://www.digilugu.ee/login?locale=en) were implemented as part of E-Estonia\textsuperscript{30} throughout Estonia, with 95% of health data and 97% of prescriptions being digitised.

The **e-Health Record** is a nationwide system that integrates data from different healthcare providers into a common patient record. The e-Health Record comprises information on diagnoses, physician’s visits, tests (including image files), inpatient treatments as well as medication prescribed. In addition, data is compiled for national statistics in order to measure health trends, track epidemics and ensure wise spending of resources. Beneficiaries of the system are both patients and healthcare providers. Doctors are able to access a patient’s records easily from a single electronic file and patients can access their own records as well as those of their children through an online patient portal to review doctor’s visits and current prescriptions, and check which doctors have had access to their files.

**E-Prescription** is a centralised system for issuing and handling medical prescriptions. All hospitals and pharmacies are connected to the system. Prescriptions are filled by presenting an ID card. Routine refills can be issued via e-mail, Skype or phone, without a prior visit to the physician. Furthermore, state medical subsidies to which patients are entitled are discounted automatically, as the system has access to data from the national health insurance fund. The main beneficiaries of the system are both doctors and patients, since this frees up their time and reduces the administrative strain on hospitals.

The added value of both services in the country lies in improved sustainability of health systems\textsuperscript{31}.

3.3 Italy – ARNO Observatory

The ARNO Observatory is a system designed to provide Italian local health units with a clinical data warehouse, with homogeneous data derived from different geographical areas. The database combines and aggregates huge masses of administrative patient data: pharmaceutical prescriptions, hospital discharges, medical home services, diagnostic examinations and laboratory analyses. This information is linked to other data flows from different databases (e.g. the GP’s registry, population registry, pharmacies’ registry, National

\textsuperscript{30} https://e-estonia.com/
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Vital Statistics, National Drugs Formularies). The way that the network system and service works is shown in Figure 1.

![Figure 1: ARNO integrated database](image)

The added value of this network system lies in improving the sustainability of health systems as well as the quality and effectiveness of treatment by monitoring and verifying the impact of interventions on quality and costs.

3.4 Spanish Rare Diseases Registries Research Network (SpainRDR)

SpainRDR (https://spainrdr.isciii.es) is developing a central platform to provide integrated health and social care for rare disease patients. The data is collected and integrated from two types of sources: patient registries and population-based registries, such as mortality registries, health insurance card databases and electronic hospital records. Moreover, the national rare diseases registry is linked to the national biobank of rare diseases. Such a registry will facilitate the implementation of rare disease-oriented health and social policies and the promotion of translational research. More details on the way in which the registry is structured are shown in Figure 2.

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33 https://www.cineca.it/en/content/arno-observatory
The development of a comprehensive integrative registry platform can improve the health of rare disease patients due to the quality of information making treatment more effective and improving prevention, diagnosis and prognosis. Due to insufficient use of information systems and medical records by clinicians and policy-makers as well as the lack of standardized approaches for secure data transmission, the added value of data registries such as the one in Spain for rare disease patients is to enhance patient care and health planning, and improve social, economic and quality-of-life outcomes.

### 3.5 Greece – e-Prescription System

The Greek e-Prescription System ([https://www.e-prescription.gr/](https://www.e-prescription.gr/)) was introduced in 2010, aiming to effectively control and rationalise expenses and to improve transparency in the social insurance system. It is a tool to combat challenges such as over-prescribing and fraud, while being compatible and interoperable with other national eHealth applications and third-party information systems. The system is web-based and provides access for authorised users (i.e. physicians, pharmacists). It begins with the drugs prescription or laboratory test referrals, from monitoring their issuance until payment of the final beneficiaries and encompasses the clearance of the transactions of all national social insurance funds, doctor’s visits and electronic medical act referrals. In 2014, the e-Prescription System covered more than 95% of all prescriptions prescribed monthly in Greece, as 95% of Greek pharmacies and 90% of prescribing doctors used the system for electronic prescriptions. The main benefits for the patients and doctors are:

- reduced difficulties with prescription insurance coverage
- fewer mistakes caused by prescriptions being misread
- less paperwork for the health authorities and less unproductive time spent on bureaucratic procedures.

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In general, the added value of the system in the country was a reduction of unnecessary healthcare costs and better monitoring, improving the sustainability of health systems in the country.

3.6 Finland – Kanta (national repository for electronic health records)

Kanta (http://www.kanta.fi/en/omakanta) is a national repository for electronic health records used by medical professionals and patients. In Finland, the national plan includes secondary uses such as monitoring public health and the healthcare system, facilitating clinical trials and supporting care. Kanta enables patients to easily examine their own medical records on their computer and to benefit from the national service as they move around different parts of the country, or when they need services from other healthcare specialists in addition to their own familiar service provider. In addition, the system enables doctors and other healthcare professionals at hospitals, care facilities and pharmacies to access medical records easily whenever needed.

The added value of this system is the improvement in monitoring, facilitating a better quality and effectiveness of treatment.

3.7 Austria – Electronic Health Records (ELGA)

Due to the federal organisation of the healthcare system in Austria, the Electronic Health Record ELGA (https://www.bmgf.gv.at/home/EN/Health_care_services/ELGA/) is designed as a distributed system with central components for patient and healthcare provider identification and authorisation management. A special legal basis entered into force on 1 January 2013. As of today, 160 health institutions (mainly hospitals) are connected with the central components of ELGA. Eight of the nine provinces provide the affinity domains necessary for the connection of healthcare providers. Further affinity domains are provided by social security and the private sector. More than 8.2 million medical documents (test results and patient summaries) have been registered since ELGA went live in December 2015 in the provinces of Vienna and Styria. Only 3% of potential ELGA users have opted out of the system.

ELGA enables patients and doctors, as well as other healthcare professionals at hospitals, care facilities and pharmacies, to access health data easily whenever and wherever needed. Health data is generated and stored by a variety of health institutions. ELGA provides a safe and secure network by linking those institutions and providing access only to authorised and unambiguously identified persons.

In the future ELGA will be able to provide the basic IT infrastructure for further applications such as an electronic certificate of vaccination, or registries for implants or patient’s provisions. Enlarged collaboration e.g. with telemedicine will also be possible. The principal challenge lies in organisational and procedural questions: ELGA triggers new forms of nationwide collaboration and communication and thus has the potential to contribute to a fundamental modernisation of the Austrian healthcare system.

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4. Value proposition

eHealth and mHealth can benefit citizens, patients, health and care professionals but also health organisations and public authorities. Both tools deliver more personalised ‘citizen-centric’ healthcare, which is more targeted, effective and efficient and helps reduce errors as well as the length of hospitalisation. They facilitate socio-economic inclusion and equality, quality of life and patient empowerment through greater transparency, access to services and information and the use of social media for health. Examples of such benefits of eHealth services are detailed for different projects in Section 2. Taking into account the interests of different customer segments, this section provides an in-depth presentation of the value proposition of eHealth and mHealth services.

It is essential to measure and assess the added value of innovative eHealth products and services to achieve wider evidence-based eHealth deployment and create a competitive environment for eHealth solutions with safer, more accessible, higher-quality healthcare services. Here we take as an example the VALUeHEALTH project, which developed a business model in order to support cross-border eHealth services. This project is a means of interoperable health information and health knowledge flows, exchanging patient-related data and supporting healthcare professionals to maintain some degree of continuity of care in potentially multiple locations. According to VALUeHEALTH, value is defined as the overall benefits that can be generated from the eHealth Digital Service Infrastructure (eHDSI) by increasing the efficiency of health systems and accelerating the implementation of interoperable digital eHealth services. To further assess the value of interoperable eHealth services to healthcare providers and other stakeholders, the Business Model Canvas was used to model more formally the ways in which the value propositions could be realised: who are the customers, who are strategic partners to help co-create the solution and ensure its acceptance, and what are the main activities that need to be undertaken to deliver collective value.

As described in the deliverables of the project (deliverables 2.2 and 2.3 from WP 2 of VALUeHEALTH), members used a cost-effectiveness analysis (CEA) to design a sustainable business model for the continuous development and implementation of eHealth services, according to which the customer segments can be categorised into three tiers as shown below:

**Tier I: Investing in the provision/maintenance of the eHealth infrastructure**

- Member States via their eHealth competence centres or equivalent
- The EC

**Tier II: Developing and providing (interoperability-)enabled third-party services**

- eHealth service providers
- ICT industry

**Tier III: Exploiting de-identified data and analytics**

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38 http://www.valuehealth.eu
39 This refers to the potential market for third parties to develop innovative client-facing services and applications enabled through the eHDSI and its data. It does not refer to the contracting to the health ICT sector that the eHBU might put in place to deliver its core services.
- Industry research sponsors (e.g. the pharmaceutical industry for gaining research access to multi-country de-identified data to be managed by third parties)
- Health and travel insurers (e.g. to better understand cross-border unplanned and planned care needs)

These adapted value propositions include up to four expected benefits for each tier of actors, as shown in Figure 3:

<table>
<thead>
<tr>
<th>Tier I</th>
<th>Tier II</th>
<th>Tier III</th>
</tr>
</thead>
<tbody>
<tr>
<td>• facilitation of continued MS co-operation on the eHealth agenda</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Enabling of cross border eHealth services based on a collaboratively set up and maintained infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Integrated care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Timely diagnosis, seamless care services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Improving patients’ health outcomes, quality of care, population health and patient safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increasing the efficiency of health systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Enable ERNs to provide timely access to specialized services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Empower citizens to self-manage their own health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• eHealth as an enabler of change that facilitates healthcare reform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Improved patient safety and satisfaction, with safer use of medicine, and the avoidance of re-admissions and adverse patient safety events through incorrect prescriptions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Facilitate alignment of national eHealth agendas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increased certainty for industry investors that will boost innovation in the health care and ICT sectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A borderless market for national health and social care innovation and the ICT industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Facilitate shared care networks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The advance of scientific knowledge through clinical and public health research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Enabling evidence based decision-making that improves the provision and resourcing of health and care systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provision of added value information services to citizens and agencies (scale up population level research)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduced healthcare costs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Value propositions by customer segment for eHealth services

Source: VALUeHEALTH D2.3, page 18

By taking into account the interests of different customer segments, defined in three tiers (investors; developers and providers; and exploiters of de-identified data), the business model framework is defined as shown below in Figure 4.
### Key Partnerships
- Strategic collaborators e.g. eHealth Network, MS, EC
- Providers e.g. ICT industry
- Users e.g. health professional associations
- Beneficiaries e.g. patient associations

### Key activities
- Ensure strategic planning
- Maintain the existing EU-level infrastructure, services, interoperability assets
- Enrich connectivity to the infrastructure by application/service providers
- Develop and maintain extensions to new cross-border eHealth services
- Develop conformity assessment services
- Support the standardisation process for public procurement

### Value Propositions
- Facilitate MS co-operation on the eHealth agenda
- Accelerate the development and use of interoperable digital solutions
- Enable services for integrated care
- Improve patients’ health outcomes, quality of care, patient safety
- improving the efficiency of health systems
- Scale up population level research

### Customer Relationships
- Contractual relationships e.g. for operating the eHDSI
- Advisory role e.g. on new needs
- Trusted broker, facilitation, coordination role

### Customer Segments
- Tier I. Investing in the provision/maintenance of the eHealth infrastructure: e.g. Member States and EC
- Tier II. Developers and providers of interoperable eHealth services: e.g. ICT industry
- Tier III. Exploiting de-identified data and analytics e.g. pharmaceutical companies

### Customer Channels
- Customer Interface e.g. customer exchange forums
- Web-based channels e.g. customer management and support

### Customer Resources
- Core staff
- Technical expertise
- Legal and business expertise
- Clinical expertise
- Fixed assets

### Key Resources
- Staff and external experts
- ICT costs, licences and testing
- Office, facilities, marketing
- Travel, meetings

### Cost Structure
- Staff and external experts
- ICT costs, licences and testing
- Office, facilities, marketing
- Travel, meetings

### Revenue Streams
- Annually allocated budget
- Direct sales to (or contributions from) MS
- Service fee(s)
- Annual membership fee
- User fee(s)
- PPP financing

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Figure 4: The VALUeHEALTH business model canvas, source: VALUeHEALTH D2.3, page 27-28
5. Current trends for eHealth services

Technology evolves exponentially and new applications and trends are being invented which influence the way we develop eHealth and mHealth services. This can result in better, more efficient healthcare at lower costs and economic growth.

Emerging trends in federated architectures will establish the future potential for rapid change and innovation in healthcare. The report “State of Play of Interoperability in Europe 2016” identified technology trends concerning interoperability initiatives; these are:

- Open data and open technologies
- Cyber security
- Cloud computing
- Social media
- Mobile technologies
- Big data and analytics

In addition to the above trends, changes in the computing landscape give rise to several other developments that are critical for healthcare, technological and scientific trends, such as:

- 5G
- Genomics and personalised/precision medicine
- Blockchain technology and security
- Artificial intelligence and predictive analytics
- Internet of Things

All of the above technologies were further evaluated in order to be defined as emerging trends for healthcare by looking at the following criteria:

- Whether they create new market opportunities
- Whether they significantly transform the way in which healthcare services are delivered
- Whether they facilitate complete physician access to patient information and
- Whether they support open, fast communication for the development of a coordinated care model

According to these criteria, the main trends that could potentially have an impact on eHealth are:

- Cloud computing
- Mobile technologies – 5G
- Blockchain technology and security
- Genomics and personalised medicine
- Big data and analytics – artificial intelligence (AI)
- Internet of Things

For each technology trend, a brief overview of the main characteristics is presented.
5.1 Cloud computing

Cloud computing is a crucial driver for growth in Europe with increasingly widespread adoption in business but also personal usage. According to the National Institute for Standards and Technology (NIST), cloud computing is “a paradigm for enabling network access to a scalable and elastic pool of sharable physical or virtual resources (e.g. networks, servers, storage, applications, and services) with rapid self-service provisioning and administration on-demand and released with minimal management effort or service provider interaction”.

Since 2011, the European Commission (EC) has shown an interest in the cloud computing industry and endeavoured to understand the costs and benefits of cloud technologies, and in 2012 committed to facilitate the adoption of cloud computing in Europe through a comprehensive policy and strategy. During those years, various projects were underway that highlighted the risks and disadvantages of using the cloud in health, but recent developments with the EHR4CR project detailed multiple benefits and opportunities of this technology for the healthcare sector due to it providing service efficiency and ease and speed of information access.

More information about cloud computing in healthcare can be found in Task 7.2.1. This deliverable addresses the value of cloud technology being applied by using healthcare data for clinical research and public health. Characteristics and operating models of cloud computing are presented and the policy background for the use of cloud computing is discussed.

5.2 Mobile technologies – 5G technology

Mobile communication systems are evolving, with 5G technology being a catalyst to trigger the innovation of new products and services. 5G will be significantly faster with the ability to run more complex applications, and will bring together improved connectivity, cloud-based storage and an array of connected devices and services. An EC study estimates that the socio-economic benefits of the introduction of 5G by 2025 could reach €113.1 billion per year in four key sectors, which will be the first users of 5G connectivity: automotive, health, transport and energy.

5G technology is an end-to-end system that collects data from billions of devices and can move those communication packets seamlessly to the right device, using the appropriate processing platform. Within healthcare 5G networks can open up new avenues for better delivery of care. Patients and health practitioners can connect faster-linking medical devices to the Internet of Things (IoT) in order to remotely monitor patients by transmitting vital statistics to doctors and alert them to changes immediately. This can provide medical researchers with more data on how diseases impact individuals so they can customise treatments to specific cases. Some of the future research directions for 5G-enabled healthcare can focus on (Latif et al. 2017):

- Mobile devices and tablets, which can help leverage AI, big data and connectivity
- 5G and universal coverage

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• In-home health monitoring
• Virtual reality + haptic/tactile Internet
• Internet of Medical Skills

This might change the trends in healthcare from reactive care to proactive care.

5.3 Blockchain technology and security

Blockchain is a distributed ledger technology that has emerged in the financial sector and helped to improve eServices for citizens and businesses\(^3\). It is an immutable system storing transaction records that relies on established cryptographic techniques to allow each participant in a network to interact (e.g. store, exchange and view information). Interactions require verification by the network before information is added, enabling trustless collaboration between network participants while recording an audit trail of all interactions.

A blockchain-based system has the potential to connect fragmented systems and enable interoperability. It is not yet fully mature, with several technical and behavioural economics challenges, but in the long term, a blockchain network for electronic medical records may improve efficiency and support better health outcomes for patients. Different countries and different health systems might adopt the blockchain technology differently but some use cases that could be applied are\(^4\):

• **Clinical health data exchange and interoperability**: a blockchain could enable data exchange systems that are cryptographically secured and irrevocable. In 2016, the Estonian eHealth Foundation’s collaboration with Guardtime\(^5\) to secure the health records of one million Estonian citizens using its proprietary Keyless Signature Infrastructure (KSI) is a classic example of blockchain technology.

• **Claims adjudication and billing management**: By automating the majority of claims adjudication and payment processing activities, blockchain systems could help to reduce administrative costs and time for providers and payers.

• **Drug supply chain integrity and provenance**: A blockchain-based system could ensure a chain-of-custody log, tracking each step of the supply chain at the individual drug/product level.

• **Pharmaceutical clinical trials and population health research**: Around 50% of clinical trials go unreported, which creates crucial safety issues for patients and knowledge gaps for healthcare stakeholders and health policy-makers. Blockchain-enabled, time-stamped immutable records of clinical trials, protocols and results could potentially address the issues of outcome switching, data snooping and selective reporting, thereby reducing the incidence of fraud and error in clinical trial records. Furthermore, blockchain-based systems could help drive unprecedented collaboration between participants and researchers around innovation in medical research in fields such as precision medicine and population health management.

• **Cyber security and healthcare IoT**: Blockchain-enabled solutions have the potential to bridge the gaps of device data interoperability while ensuring security, privacy and reliability around Internet of Medical Things (IoMT) use cases.

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\(^4\) https://www.forbes.com/sites/reenitadas/2017/05/08/does-blockchain-have-a-place-in-healthcare/
\(^5\) https://guardtime.com
5.4 Genomics and personalised medicine

Accelerated by the completion of the Human Genome Project, there is a shift of medicine to care based on a deep understanding of health and disease attributes unique to each individual (Joyner et al., 2015). With the declining cost of DNA sequencing, which has been accompanied by a proliferation of ‘direct-to-consumer genetic testing’ (DTC-GT) services (Hall et al., 2017), genomics has been a particularly active playground in medicine by empowering patients and doctors to make better health decisions by highlighting aspects of the genetic make-up. This change has been variably called genomic medicine, genomic health care, personalised medicine, precision medicine and precision health.

The National Institutes of Health currently states that precision medicine “is an emerging approach for disease treatment and prevention that takes into account individual variability in environment, lifestyle and genes for each person”. It can be defined as a predictive, preventive, personalised and participatory healthcare service delivery model (Bertier et al., 2016). The impact of genomics in the practice of medicine can be demonstrated from results in cancer. As cancer is one of the most prominent causes of death, governments have invested in making it the example of how precision medicine can be a reality. Significant improvements in prevention, survival and the quality of life of patients with certain type of cancers are a reality. Typical examples of the contribution of genomic information to precision medicine include (Bertier et al., 2016):

- Genetic testing of BRCA1/BRCA2 in hereditary breast cancer and ovarian cancer contributing to cancer risk reduction (Høberg-Vetti et al., 2015; Maas et al., 2016).
- Liquid biopsies for early detection of the disease (Cheng et al., 2016; Esposito et al., 2016).
- Accurate diagnosis by using molecular markers in tumour classification (Ross et al., 2015).
- Targeted therapy with examples such as EGFR inhibitors to treat EGFR mutation carriers; BRAF inhibitors to treat BRAF V600E carriers (Schwaederle et al., 2015).

Sequencing of the entire human genome might be a paradigm change in healthcare but key challenges, such as the creation of new standards, sharing of samples and data, and creation of new clinical trial designs, need to be addressed as a matter of priority in order to achieve a better integration of precision medicine into healthcare in the coming years (Bertier et al., 2016).

5.5 Big data and analytics – artificial intelligence (AI)

Personal mobile computing devices, digital social networks, scientific research, e-commerce and the Internet of Things are generating a vast amount of clinical data, and with the right analysis could improve financial efficiency but also patient outcomes. According to a study on big data in public health, telemedicine and healthcare47, an expert group gave the following definition: “Big Data in Health refers to large routinely or automatically collected datasets, which are electronically captured and stored. It is reusable in the sense of multipurpose data

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and comprises the fusion and connection of existing databases for the purpose of improving health and health system performance. It does not refer to data collected for a specific study.”

Storing, processing and analysing this data is challenging, but extremely useful for healthcare providers to deliver evidence-based and cost-effective healthcare. The type of analytics used will provide new advances in healthcare, for example:

- **Descriptive analytics**: quantify and report on past healthcare data
- **Diagnostics analytics**: improve pattern recognition and early diagnosis by learning and correlating multiple patient datasets
- **Predictive analytics**: predict upcoming events and what is likely to occur
- **Prescriptive analytics**: forecast what is likely to happen and recommend the best actions to undertake

Artificial intelligence (AI) and deep learning are positioned to revolutionise medicine by making changes across the healthcare industry and contributing to:

- Improving the quality and effectiveness of treatments
- Identifying risk factors for disease at population, subpopulation and individual levels, and improving the effectiveness of interventions
- Predicting outcomes

An interesting example of the application of AI in healthcare is IBM Watson. It has previously been used to help doctors correctly and quickly determine the best treatment options for an individual based on the vast amounts of data available. By scanning thousands of images and learning from correct diagnoses, Watson is able to increase diagnostic accuracy, supporting doctors in disease assessments. Another example of deep learning has shown that the algorithm did as well as board-certified dermatologists at identifying skin cancer (Esteva et al., 2017).

### 5.6 Internet of Things (IoT)

The Internet of Things (IoT) is a disruptive innovative technology building on the universal connectivity of things and people. It is an essential building block for the Digital Single Market (DSM), with a potentially significant impact on Europe’s prosperity and competitiveness in a globalised economy. According to a European Commission study the market value of the IoT in the EU is expected to exceed one trillion euros in 2020. Healthcare can benefit from the potential of the IoT to deliver real-time information to providers since thousands of people are connected to thousands of things creating millions of data points all day, every day. Wearable technology is part of the IoT and refers to smart electronic devices used by patients in the form of an implant or accessory such as fitness bands, blood pressure monitors, digital hearing aids or pain management systems. Data is transmitted to an application, allowing healthcare professionals to remotely monitor the status of patients. All these IoT technologies and applications create fundamental changes in

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individuals’ lives with the emergence of Smart Health, which has the potential to completely transform the healthcare sector\(^{51}\).

The EU is still testing the value of IoT-related technologies in order to further boost the related applications within healthcare. Since January 2017 the Commission has funded five IoT large-scale projects\(^ {52}\), with one covering the healthcare sector (smart living environments for ageing well (ACTIVAGE)).

6. Strategic guidelines for a sustainable eHealth system

A major obstacle within MS is the harmonization of systems and the uneven development of eHealth solutions. In order to achieve a sustainable eHealth system in Europe to satisfy access to better healthcare, a comprehensive nationwide eHealth programme needs to be implemented across MS\(^{53}\). The evidence suggests that a solid business model is required for developing and implementing a value-creating and financially and operationally sustainable eHealth service in the longer term. Taking into consideration the emerging technologies and the need for standardisation and sustainability of the healthcare system in order to achieve better care coordination with personalised medicine, prevention and wellness for European citizens, as well as to facilitate socio-economic inclusion and a better quality of life, a set of strategic guidelines are proposed:

- Universally deploy standardised electronic health records
- Create a new European registry of diseases (e.g. chronic) with the use of cloud computing
- Harmonise access to the internet with high bandwidth speed
- Have a clear understanding of the needs of patients and involved healthcare professionals
- Increase digital health literacy
- Raise awareness of data security and privacy regulations
- Enable the development of standards for privacy and security, jointly driven by technology and context
- Promote eHealth and mHealth in all age groups in urban and rural areas
- Ensure security for mobile European citizens through seamless data exchange and access to services throughout Europe – a priority for healthcare data and technology-enabled approaches
- Balance efforts between: (i) deep-omics and imaging technologies, data analysis (ii) wearable technologies and IoT, (iii) data integration and (iv) personalised medicine validations and field trials
- Integrate clinical, lifestyle and environmental datasets for population sub-profiling and stratification to enable molecular discoveries to find an appropriate place in routine healthcare.

Building on the above recommendations, a paradigm change in healthcare with a truly

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\(^{52}\) https://european-iot-pilots.eu

individualised care and disease prevention system in Europe could be achieved and benefit EU citizens, the European economy, European industry and public finances\(^{54}\) (an example of the state of play in ICT is shown in ANNEX 2\(^{55}\)).


7. References

7. Latif, Siddique; Qadir, Junaid; Farooq, Shahzad; Imran, Muhammad Ali, How 5G (and concomitant technologies) will revolutionize healthcare, 2017arXiv170808746L
## Annex

### Annex 1

<table>
<thead>
<tr>
<th>Resource type</th>
<th>Resource</th>
<th>Website</th>
<th>Description</th>
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<tr>
<td><strong>Standards development</strong></td>
<td>OpenEHR</td>
<td><a href="http://www.openehr.org">http://www.openehr.org</a></td>
<td>Open-source EHR standards initiative</td>
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<tr>
<td>CEN (TC 251)</td>
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<td>[<a href="http://www.cen.eu/cen/Facatory/TechnicalCom-intiesWorkshops/CENTechnicalCom-mitees/P">http://www.cen.eu/cen/Facatory/TechnicalCom-intiesWorkshops/CENTechnicalCom-mitees/P</a> apes/default.aspx](<a href="http://www.cen.eu/cen/Facatory/TechnicalCom-intiesWorkshops/CENTechnicalCom-mitees/P">http://www.cen.eu/cen/Facatory/TechnicalCom-intiesWorkshops/CENTechnicalCom-mitees/P</a> apes/default.aspx)</td>
<td>European Committee for Standardization</td>
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<td>HL7</td>
<td></td>
<td><a href="http://www.hl7.org/implement/standards">http://www.hl7.org/implement/standards</a></td>
<td>Health Level 7 HIT standards</td>
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<td>CDISC</td>
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<td>Integrating the healthcare enterprise</td>
<td></td>
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<td>UK National Health Service HIT strategy</td>
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<td><a href="http://www.himssanalytics.eu">http://www.himssanalytics.eu</a></td>
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</table>

| **Health research**          | I2b2      | [https://www.i2b2.org](https://www.i2b2.org) | Partners HealthCare (opt-in participation)       |
|                            | eMERGE Network | [https://www.mc.vanderbilt.edu/victor/ds/prime](https://www.mc.vanderbilt.edu/victor/ds/prime) | Cross-institutional EHR–DNA research network     |
|                            | Vanderbilt BioVU | [http://dbmi.mc.vanderbilt.edu/research/dna.stabbank.html](http://dbmi.mc.vanderbilt.edu/research/dna.stabbank.html) | Vanderbilt University (opt-out participation)     |
| **Integrated DNA–EHR research databases** | Stanford STRIDE project | [https://clinicalinformatics.stanford.edu/research/stride](https://clinicalinformatics.stanford.edu/research/stride) | Stanford University EHR research platform    |
| **EHR research databases**   | EHR4CR     | [http://www.dh4cr.eu](http://www.dh4cr.eu) | European EHR research framework initiative       |
|                            | IHI Health Network | [http://www.ihihealth.org](http://www.ihihealth.org) | Bridging the gap between research and medicine |
|                            | European Medical Information Framework | [http://www.ehri.org](http://www.ehri.org) | Under construction                           |

| **International initiatives** |                          | | |
| **Terminologies and ontologies** |                  | | |
| LOINC                      | [http://www.ihtsdo.org/research/loinc](http://www.ihtsdo.org/research/loinc) | Unified Medical Language System |
| SNOMED CT (from the IHTSDO) | [http://www.ihtsdo.org](http://www.ihtsdo.org) | International clinical terminology |
| ICD (from the WHO)         | [http://www.who.int/classifications/icd/en](http://www.who.int/classifications/icd/en) | International Classification of Disease |

| **Patient-focused initiatives** |                  | | |
| PatientCircleMe             | [https://www.patientcircleme.com](https://www.patientcircleme.com) | Patient disease monitoring community |
| 23andMe                    | [https://www.23andme.com](https://www.23andme.com) | Personal genotyping |

Table 2: Relevant resources and initiatives globally for the adoption of health information technology (HIT) infrastructure
Annex 2

Figure 5: Horizon 2020 Societal Change 1 Advisory Group – ICT for Health – State of Play