

# *Personalised Medicine in European Hospitals*



PwC and the European Hospital and Healthcare Federation (HOPE) have joined forces to identify key elements in the development of personalised medicine in European hospitals. This collaboration will help determine of the current state and the desired future state of personalised medicine practices within European hospitals, and will thoughtfully facilitate the creation of a culture of customised healthcare.

Personalised medicine can be defined as products and services that leverage the science of genomics and proteomics (directly or indirectly) and capitalise on the trends towards wellness and consumerism to enable tailored approaches to prevention and care.

The dawn of personalised medicine brings not only new advances to our healthcare system today, but also key challenges. This new science has led many participants in the healthcare industry, such as providers, to consider how best to adapt to these challenges and foster a consumer-focused culture. Hospitals have a clear opportunity to adapt to the new healthcare paradigm and provide services that are targeted to the individual patient. It is important to recognise, however, that different hospitals operate and require different models. Just as doctors will no longer be able to apply the same forms of treatment to patients, hospitals will not be able to apply the same approach to addressing the challenges brought on by personalised medicine. Hospitals and providers have many options for how they respond to the changing market. And as evidenced in the interviews we completed with several European hospitals, personalised medicine can be designed and implemented into a hospital model in a variety of ways.

Many European hospitals have already begun to define what personalised medicine means to their hospital and have developed their strategies for implementation. And as hospitals solidify their definition and vision of personalised medicine as well as their approach for implementation to create a culture of customised healthcare, leading practices will continue to emerge.

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## ***Table of contents***

|   |    |
|---|----|
| The impact of personalised medicine today   | 4  |
| <hr/>   |    |
| <b>Part I. Personalised Medicine in European Hospitals</b>                                |    |
| 1. General overview of personalised medicine  | 7  |
| <hr/>   |    |
| 2. The pressure to be personalised – Key trends that have changed the healthcare paradigm | 8  |
| <hr/>   |    |
| 3. Next steps for hospitals and providers   | 11 |
| <hr/>   |    |
| 4. Conclusions  | 15 |
| <hr/>   |    |
| <b>Part II. Hospitals in focus</b>  |    |
| List of Participating Hospitals   | 18 |
| <hr/>   |    |
| Herlev Hospital / Copenhagen University Hospital at Herlev, Denmark                       | 19 |
| <hr/>   |    |
| Kuopio University Hospital, Finland   | 25 |
| <hr/>   |    |
| University Hospital of Dijon, France  | 29 |
| <hr/>   |    |
| Medical and Health Science Center University of Debrecen, Hungary                         | 34 |
| <hr/>   |    |
| University Medical Centre Ljubljana (UMCL), Slovenia                                      | 38 |
| <hr/>   |    |
| Hospital Clinic de Barcelona, Spain   | 42 |
| <hr/>   |    |
| The impact of personalised medicine tomorrow  | 46 |
| <hr/>   |    |

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## *The impact of personalised medicine today*

Personalised medicine aims to provide the timely, precise, personalised diagnosis and treatment of patients, with a particular emphasis on wellness and disease prevention. Although personalised medicine has already been introduced into practice, it is still in its early stages of implementation in the European healthcare market. This report outlines the move towards personalised medicine in six European hospitals — located in Denmark, Finland, France, Hungary, Slovenia and Spain — compares the path each is taking, and discusses the following commonalities:

- **Most of the European hospitals are focused on initiatives related to diagnostics and therapeutics.** The European landscape is working in several ways to develop new imaging technology and genetic tools, such as biomarkers and biochips.
- **Genetic screening is widely used for treatment in cancer patients.** Cardiology, neurology, radiology, and the treatment of diabetes are among the key disciplines that benefit from the genetics field. Advances in genomic and proteomic science have led to more cost-efficient discoveries, with doctors more inclined to use targeted treatments.
- **Stem cell programs and treatments are still relatively new.** Although there are several programs underway, most of the hospitals surveyed are not yet applying this field in the clinical setting.
- **Telemedicine services are not yet fully deployed.** Devices for monitoring chronic diseases are currently being developed and implemented in various clinical services, such as cardiology and neurology.

- **Only a few European hospitals focus on nutrition and physical activities to encourage wellness and improve the treatment of patients; most do not tackle prevention as part of their approach.** The reason could be that other factors, such as primary care providers and public health media campaigns, already encourage patients to monitor their own health status and maintain a healthier lifestyle.

- **Developing relationships or affiliations with other sector organisations is a usual practice within the European hospital market.** Public and private hospitals (EU and US hospitals), public entities such as the National Health Service (NHS) and laboratories, universities and biotech and pharmaceutical companies, are among the main partners to undergo personalised medicine projects. Cooperation between the many stakeholders in

the life science and medical sectors is essential in fostering innovation in the field of personalised medicine.

- **The main barriers for the implementation of personalised medicine within the European hospital environment are: lack of research funding, lack of strong scientific evidence in some fields, lack of knowledge among doctors, and lack of a clear reimbursement system for related services.**

Our study revealed that, although Europe is starting the paradigm shift towards personalised medicine, many barriers still need to be addressed. To keep the process on track, healthcare professionals and policy makers must aim to ensure that personalised medicine contributes to the improvement of population health with clear and robust evidence of patient value, and they must remember that the shift towards personalised medicine is a process rather than an endpoint.

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***Part I. Personalised Medicine  
in European Hospitals***

# 1. General overview of personalised medicine

Personalised medicine is broadly defined by PwC, as “products and services that leverage the science of genomics and proteomics (directly or indirectly) and capitalise on the trends towards wellness and consumerism to enable tailored approaches to prevention and care”. This definition encompasses everything from high-tech diagnostics to low-tech foods, technologies that enable storage, and analysis and linking of patient and scientific data.

Personalised medicine or the “new science”, also referred to as “P4 Medicine” by Dr. Leroy Hood, co-founder of the Institute for Systems Biology, encompasses the following principles:

- “It is personalised; it is based on an understanding of how genetic variation drives individual treatment.
- It is predictive; it is able to identify what conditions a person might

develop in the future and how the person will respond to a given treatment, enabling the development of a tailored health strategy.

- It is preventive; it facilitates a proactive approach to health and medicine, which shifts the focus from illness to wellness.
- It is participatory; it empowers patients to make informed choices and take responsibility for their own health<sup>1</sup>”.

The human genome project and dwindling costs in genomic and proteomic sequencing is creating this “new science” that focuses on the consumer. New science is no longer a concept of the future; it is here today. Key trends over the past decade have challenged the healthcare environment, payers, pharmaceutical and life sciences companies, and providers to become more consumer focused in their own right. Providers have their own unique set of challenges that will need to be addressed in order to successfully create a culture of personalised healthcare for the patient. Correspondingly, it is important to understand the key trends that have pushed healthcare to be more personalised, the challenges that providers face, and how hospitals are adapting to this new environment.

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<sup>1</sup> PwC, “The new science of personalized medicine: Translating the promise into practice”, 2009.

## 2. The pressure to be personalised – Key trends that have changed the healthcare paradigm

The shift in the healthcare paradigm to personalised medicine did not happen overnight. Over the last decade, advances in genomics and technology as well as the patients' inclination towards care that is consumer focused have contributed to this development. The dawn of personalised medicine brings not only new advances to our healthcare system, but also distinct challenges. This new science has led many players in the healthcare industry, such as providers, to consider how best to adapt to these challenges and foster a consumer-focused culture. But before the industry can address these challenges, it must first understand the trends that have pushed healthcare to evolve towards a more personalised

model. These trends can be grouped into four categories:

- Genetic trends
- Patient trends
- Technology trends
- Wellness trends

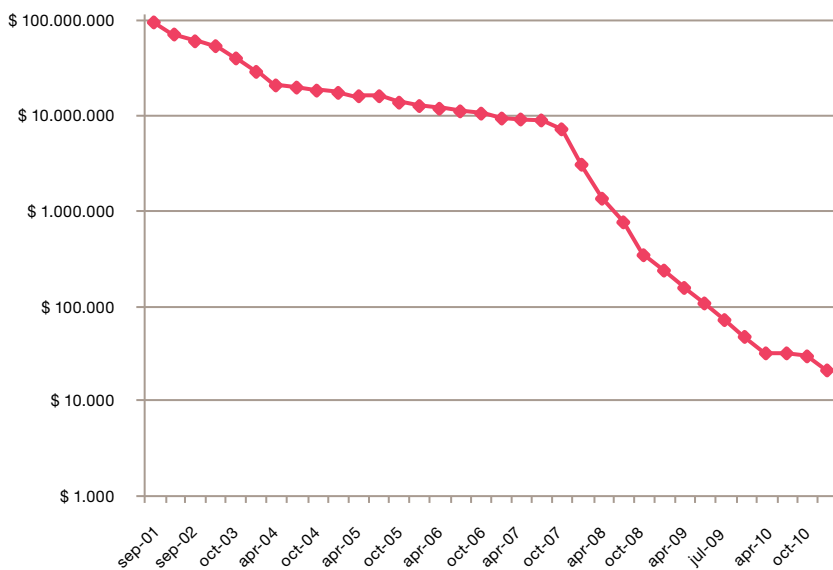
### **Genetic trends — Advances in genomic and proteomic sequencing have resulted in cost-efficient discoveries that are bending the cost curve**

Advances in genomic and proteomic sequencing over the past decade have led to the development of “targeted” diagnostics and therapeutics that leverage knowledge of an individual's genetic makeup to create a more

personalised treatment regimen and cost-efficient approach to healthcare. By identifying the optimal point of intervention for treatment, healthcare providers can improve quality of care and reduce costs by effectively timing treatment intervention and eliminating waste from insufficient or excessive treatment regimens.

As genome sequencing costs decline, doctors and patients alike are more inclined to seek treatments that are targeted to the patient's illness. Today, genome sequencing costs are approximately \$20,000 per genome, a stark contrast to 2001 sequencing costs of almost \$100,000,000 per genome (see Figure 1).

Figure 1:  
**Cost per genome from the National Human Genome Research Institute**



Source: Wetterstrand KA. DNA Sequencing Costs: Data from the NHGRI Large-Scale Genome Sequencing Program available at: [www.genome.gov/sequencingcosts](http://www.genome.gov/sequencingcosts). Accessed 19 April 2011.



### **Patient trends — Accessibility creates consumer-focused healthcare**

Patient empowerment is part of a broader trend towards consumer-focused healthcare, enabled by easy access to health information that was previously available only to medical professionals.<sup>2</sup> Not surprisingly, patients are looking to various online resources for medical advice or diagnosis. In fact, global consumers surveyed online by PwC said their top information source on health was online websites (See Figure 2).<sup>3</sup> Social networking sites ranked eighth in this survey. Physicians and providers are no longer viewed as the primary source for medical information as online resources create educated patients that can now form their own opinion on how to handle their health. Online websites allow patients to feel as if they are in control of their health and that advice is targeted to their needs. With more medical

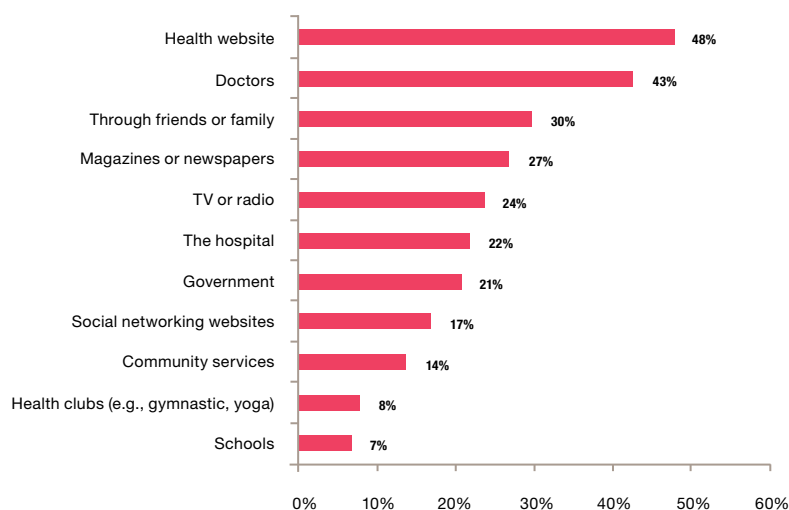
advice available online and more patients/consumers becoming well educated on health management, individuals will expect one-on-one customised service from physicians.

### **Technology trends — Connectivity fosters treatments in non-traditional settings and encourages the “anytime, anywhere” mind set**

Connectivity allows for customised solutions both inside and outside the home. Developments such as telehealth, home health, and web applications enable a new paradigm of personalised care outside the confines of a doctor’s office or clinic. Consumers are becoming empowered to predict their own medical risks, detect diseases, and track/manage their health status overall through genetic testing products for in-home use — furthering the concept of health management “anytime or anywhere”.

A few key examples of recent progress made in healthcare technology in Europe are described in Figure 3.

Figure 2:  
**Where do you go to find information to make decisions about your healthcare? (Select all that apply)**



Source: PwC’s Health Research Institute Global Consumer Survey. HealthCast 2010.

<sup>2</sup> PwC Health Research Institute, “Health Cast: The customization of diagnosis, care and cure”, March 2010.

<sup>3</sup> PwC’s Health Research Institute Global Consumer Survey in “HealthCast: The customization of diagnosis, care and cure”, March 2010.

Figure 3:  
**Examples of care-anywhere networks through technology**

| Territory      | Experience  |
|----------------|---|
| France         | The government is making a progressive attempt to mobilise care from the hospital to homes equipped with electronic monitoring devices.   |
| Netherlands    | Leading the trend towards home automation, where sensors, central locking systems, radio frequency identification (RFID), ringing-mats and cameras are used to monitor patients.  |
| Portugal       | P'ASMA is a web-based application that helps patients manage their asthma. The physician registers the patient's clinical data, asthma control data and a specific treatment plan. At home, the patient downloads his or her data and receives immediate graphic and written feedback based on the defined treatment plan. The system also delivers automatic messages and alerts online to each patient. |
| Sweden         | Capio Health Care has a daily dialogue with its psychiatric patients via email, for example, by using Montgomery-Åsberg Depression Rating Scale (MADRS) or comprehensive psychopathological rating scale (CPRS). And for orthopaedic rehabilitation patients, Capio sends their patients animated training programs via email.  |
| United Kingdom | Toumaz Technology is conducting a clinical trial with the Imperial College Healthcare NHS Trust to test a digital "patch", a disposable device with a wireless sensor that sticks to a patient's chest and can monitor, in real time, vital signs such as temperature, heart rate and respiration.  |

Source: PwC Health Research Institute, "Health Cast: The customization of diagnosis, care and cure", March 2010.

**Wellness trends — With greater focus on the consumer, healthcare is trending from diagnostics to wellness**

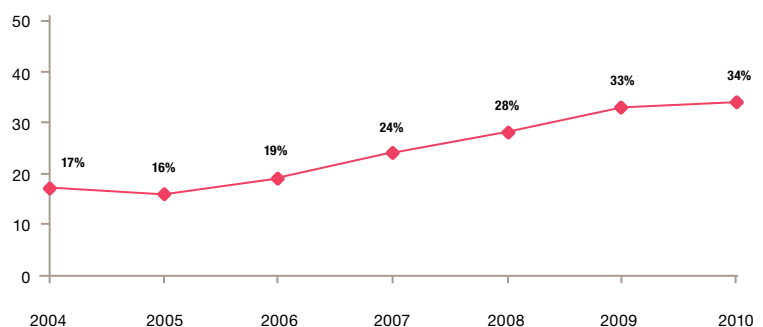
Personalised medicine encourages patients to be more active in the decision making responsibilities of managing their health, and therefore enables a consumer-focused market. Today, patients can search online for symptoms they are experiencing; find individuals who may share the same disease state; monitor their health within the confines of their own home; or become more knowledgeable on how to avoid, prevent, or treat a certain illness. These factors typically push healthcare decisions and treatments closer to the consumer and

allow them to feel greater ownership in the responsibility for their health.

Today's trend towards consumerism attempts to inject something that's been missing from health benefits — a consumer who cares more about cost and quality. By providing financial incentives and information to patients, the healthcare system can encourage them to assume a greater role in managing their own healthcare and the associated costs, with the intention of enabling patients to make more value-driven healthcare decisions. As patients are asked to contribute more towards their healthcare coverage costs, they are pushing for more information and

higher quality of service. Patients are researching more on the Internet for information on healthcare and healthcare coverage. As Figure 4 shows, the share of online health information seekers has doubled since 2004.

Figure 4:  
**Individuals from EU-27 using the Internet for seeking health-related information – Percentage of individuals aged 16 to 74.**



Source: Eurostat 2010. Note: Health-related information: injury, disease, nutrition, improving health, etc. Within the last three months before the survey.

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### 3. Next steps for hospitals and providers

#### **The steep learning curve must be met with education and expertise**

Hospitals must adapt to the changing healthcare paradigm and take on the aggressive learning curve by educating their healthcare providers on the science and clinical application of genomics and proteomics. Doctors will no longer be able to apply one approach to a set of patients with a disease state that is seemingly similar. These patients may have a dozen different gene-based variations of the disease, each of which could require a variation of the treatment. With formal schooling or training programs, “some physicians might be trained as genomics and

proteomics specialists with holistic knowledge of many different diseases and an understanding of gene interactions, eliminating the need for patients to see a variety of specialists to treat their ailments”.<sup>4</sup> To educate the next generation of physicians and nurses in the complex issues raised by genomic and proteomic science, universities need to update their programs.

In addition to formalised training, conversations with leaders in the field of personalised medicine across the healthcare industry (e.g. government, provider, payer) and academia could offer considerable value. Conversations and working groups between payers and providers, for example, could identify the most efficient reimbursement methods for diagnostic tests. Discussions between physicians and academics/professors could identify the best approach to educating the next

generation of doctors on personalised medicine techniques and create curricula that are actionable by a physician. The European Personalised Medicine Association (EPEMED) is a not-for-profit organisation that puts this very idea into action. EPEMED brings together key leaders across the healthcare industry to discuss personalised medicine, its key challenges, and best practices. It aims to provide a proactive platform for the harmonisation of personalised medicine development and implementation across Europe, focusing on the crucial role of diagnostics, to make personalised medicine a reality.<sup>5</sup> Key players from the healthcare industry, regulators, payers and government have an avenue to foster collaboration, learn from one another and improve patient care through EPEMED.

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#### **Personalised Medicine in Action: Hospital Spotlight**

- The multidisciplinary staff of the Experimental Cancer Therapy Unit at the Herlev Hospital in Copenhagen, Denmark is trained in handling blood samples for pharmacokinetics pharmacodynamics and translational research.
- Genetic diagnostics is done at the University of Eastern Finland, Kuopio, which collaborates closely with the Kuopio University Hospital. Knowledge on monogenic forms of diseases and the potential of modern genetics is part of the course work for medical students.
- The Medical and Health Science Center University of Debrecen in Hungary trains new doctors to practice personalised medicine. There are PhD courses on the field.
- The University Medical Centre Ljubljana, Slovenia, has a Clinical Institute of Medical Genetics, which aims to develop tests and counselling as it relates to personalised medicine.

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<sup>4</sup> PwC, “The new science of personalized medicine: Translating the promise into practice”, 2009.

<sup>5</sup> Association European Personalised Medicine, EPEMED, retrieved 4 May 2010, from <http://www.epemed.org/index.html>.

### Effective technology is the foundation for personalised medicine

The foundation for personalised medicine will be distributed access to health information, not just for health professionals.<sup>6</sup> With the institution of electronic health records (EHRs), genomic, proteomic and personalised medicine data could be shared. Greater sharing of data that is instantaneous could accelerate research efforts dramatically. Results from a PwC survey demonstrated that a majority of respondents felt that within the next five years, “merging of information technology and healthcare” will most likely affect their health system (See Figure 5).

Technology alone, however, will not be sufficient. A great deal of thought will need to be put into what data will be captured, where it will come from, what the appropriate data types and formats will be, and how it should be presented to a physician.<sup>7</sup>

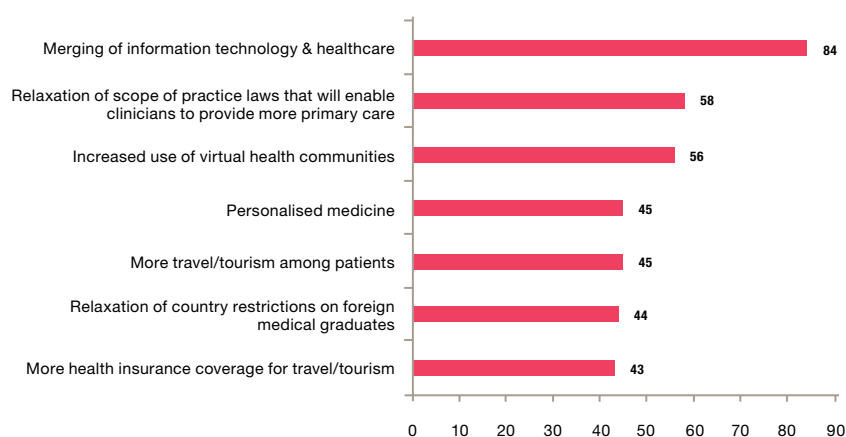
Because medical and academic research centres often work in information silos, connecting EHRs is challenging due to differing data standards. Agreement on common data formats and standards will serve to reduce complexity and allow doctors and hospitals to share data among one another.<sup>8</sup>

Although the agreement on common data and data consistencies is a huge task that requires time, effort and money, there are some promising initiatives from the European perspective such as EUROREC Institute (EuroRec). This is an independent not-for-profit organisation that promotes the use of high-quality Electronic Health Record systems (EHRs) in Europe. EuroRec has also developed some tools to exploit its repository and has elaborated (standard) procedures for the certification of eHealth products.

Due to different needs among specialities, hospitals find it more difficult to integrate EHR systems, although a few countries have more than 50% of their hospitals supported by EHR systems.<sup>9</sup> Most installed EHR systems in European countries are not

interoperable countrywide, due to various restrictions such as technology, lack of standards or legal frameworks. This lack of standardisation also results in challenges for cross-border care in Europe.

Figure 5: In the next five years, which of the following changes, if any, are most likely to affect your health system? (multiple response question)



Source: PwC's Health Research Institute Global Health Leaders Survey

### Personalised Medicine in Action: Hospital Spotlight

- The Experimental Cancer Therapy Unit, Department of Oncology at HEH, has access to MRI, CT and PET-scans and a variety of other interventional diagnostic radiology and clinical physiological assessments.
- Genetics offers the possibility to diagnose monogenic diseases accurately at Kuopio University Hospital.
- New imaging technologies, such as 3 Tesla MRI and PETscan, are available at the University Hospital of Dijon.
- The Medical and Health Science Center University of Debrecen uses telemedicine to remotely monitor cardiology patients with remote ECG (holter).
- The University Medical Centre Ljubljana develops and uses their own analysis software tools for the application of personalised medicine techniques.
- The Hospital Clinic in Barcelona uses remote monitoring devices for cardiac pathologies and chronic diseases.

<sup>6</sup> PwC, “The new science of personalized medicine: Translating the promise into practice”, 2009.

<sup>7</sup> HealthcareLeaders Media in collaboration with PwC, “Breakthroughs: The Impact of Personalized Medicine Today”, 2010.

<sup>8</sup> PwC, “The new science of personalized medicine: Translating the promise into practice”, 2009.

<sup>9</sup> Electronic Health Record Systems-A Main Pillar in European e-Health Developments for Better Delivery of Care. G. Comyn, Head of Unit “ICT for Health”, DG INFSO, European Commission, 2007.



### **Changes in the healthcare paradigm create opportunities to innovate and bend the cost curve**

As the emphasis on wellness grows and payers and consumers seek alternative, less expensive forms of care, hospital admissions will likely decrease. Providers will be challenged to deliver new forms of care in order to maintain consistent revenue. But through the new wave of preventative medicine and wellness, hospitals may be able to create new sources of revenue by launching new services and products focused on wellness and disease prevention, which will in turn create greater demand for molecular tests to determine predispositions and/or therapeutics as well as the corresponding health services required.<sup>10</sup>

Hospitals linked to universities may have brighter prospects, as they are prepared to take the lead in personalised medicine research. Their unique combination of academic research, state-of-the-art technology,

medical education and clinical care makes them well positioned to identify unmet market needs and discover new targeted therapies. Academic medical centres also have access to massive amounts of patient data, which accelerates the discovery process. Moreover, this creates an unprecedented opportunity to redefine the research data continuum by launching an exchange of data that goes full circle — from a researcher's laboratory to a patient's bedside back to the researcher's laboratory again.

The introduction of personalised medicine at the point of care will require a huge change in the way healthcare is organised. How this might be done is illustrated by a system in France for the treatment of cancer. France's National Cancer Institute has set up a network of 28 regional centres, linked with hospitals, where the tumours of cancer patients can be rapidly analysed to establish their suitability for drug

treatment. This has reduced the cost of treatment for key populations.<sup>11</sup>

### **Willingness to collaborate will give providers the competitive edge**

While these changes in the healthcare paradigm have posed challenges to hospitals and providers, they may have also created opportunities for key participants in the healthcare industry overall, particularly for non-traditional healthcare participants. Personalised medicine, specifically, is a highly complex field, and no one organisation or industry has the requisite resources, knowledge and tools needed to implement solutions in this field. This new science not only creates opportunities for hospitals and the industry to innovate, but also to collaborate within or outside their industries to create the best possible solutions.<sup>12</sup>

The following are a few examples of the types of innovation emerging through collaborative relationships:

## **Personalised Medicine in Action: Hospital Spotlight**

- Several departments at the Herlev Hospital/Copenhagen University in Denmark have focused on nutrition and physical activity to improve wellness and treatment of patients.
- The Medical and Health Science Center University of Debrecen in Hungary has a special nutrition centre where patients receive a personal diet, and they are currently building a wellness centre focused on rheumatologic services.

<sup>10</sup> HealthcareLeaders Media in collaboration with PwC, "Breakthroughs: The Impact of Personalized Medicine Today", 2010.

<sup>11</sup> European Perspectives in Personalised Medicine, May 2011. European Commission.

<sup>12</sup> PwC, "The new science of personalized medicine: Translating the promise into practice", 2009.



**European universities and medical schools form partnerships with research centres abroad to enhance innovation.**

- The University of Minnesota and Mayo Clinic, under the mantle of the Minnesota Partnership for Biotechnology and Medical Genomics, have formed a strategic research relationship with the Karolinska Institute of Stockholm, Sweden, the top-rated medical research university in Europe. Leaders of each institution signed memoranda of understanding to commit to the formal ongoing collaboration, called the Frontiers of Biomedical Research.<sup>13</sup>

**Pharmaceutical companies have shown their commitment to developing personalised treatments by collaborating with companies in their industry.**

- Procter & Gamble and Inverness Medical Innovations, a diagnostics company, created a \$325 million joint venture to create diagnostics products.<sup>14</sup>
- Merck and AstraZeneca collaborated to combine two experimental cancer drugs, one from each company, to create a cocktail that could provide better results than each alone.<sup>15</sup>

**Non-traditional healthcare companies are working together to increase innovation in technology that will monitor the individual's health.**

- Intel and General Electric formed an alliance to market home-based health. The primary objectives were to enable remote monitoring of patients and lower healthcare costs by reducing the number of necessary hospital visits.<sup>16</sup>

**Multicentre networks of clinical research in Europe.**

- The European Clinical Research Infrastructures Network (ECRIN) is based on the connection of coordinating

centres for national networks of clinical research centres and clinical trials units, and is able to provide support and services to multinational clinical research.

- Biobanking and Biomolecular Resources Research Infrastructure (BBMRI) forms an interface between specimens and data (from patients and European populations) and top-level biological and medical research. During the past three years, BBMRI has grown into a 53-member consortium with over 280 associated organisations (largely biobanks) from over 30 countries, making it the largest research infrastructure project in Europe.
- The European Advanced Translational Research Infrastructure in Medicine

(EATRIS) is based on translation centres created by clinics and biomedical research institutions with translational experience.

We expect to see complex networks of collaboration to emerge, within and across industries and between the public and private sectors, as individual organisations or industries deal with the complex challenges that come with this new focus on personalised medicine.<sup>17</sup> As collaborative partnerships develop, it will be important to consider how these complex alliances can be appropriately managed so that all parties can benefit from the innovations that emerge.

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***Personalised Medicine in Action: Hospital Spotlight***

- The Herlev Hospital/Copenhagen University Hospital is collaborating with other universities in Denmark, the European Union and the United States for research purposes and treatment of patients, as well as with the National Laboratory for Sustainable Energy and many biotech and pharmaceutical companies.
- The Kuopio University Hospital in Finland is collaborating with several institutions for research purposes, including the National Institutes of Health of the US Department of Health and Human Services, the University of Southern California and the University of Ann Arbor in the United States, and the University of Gothenburg in Sweden.
- The University Hospital of Dijon, France, is collaborating with several organisations, including other university hospitals, scientific groups and biotech companies. In particular, the University Hospital of Dijon collaborates with the Cancer Centre Georges François Leclerc, which develops its own research programs, some of which are common within the University Hospital of Dijon, INSERM research centre and the biotech company Oncodesign.
- The Medical Health Science Center University of Debrecen, Hungary, is collaborating with orphan drug companies, such as Genzyme, a laboratory testing research on Fabry disease.
- The University Medical Centre Ljubljana, Slovenia, is collaborating with other universities, companies providing consumables, government and health insurance companies.

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<sup>13</sup> University of Minnesota, Mayo Clinic sign research pact with Karolinska. Available at <http://www.ahc.umn.edu/media/releases/umayokaro/index.htm>.

<sup>14</sup> "P&G partners with Inverness in diagnostics venture" Mass High Tech, 18 May 2007. Available at <http://www.masshightech.com/stories/2007/05/14/daily43-PG-partners-with-Inverness-in-diagnostics-venture.html>.

<sup>15</sup> Ron Winslow, "AstraZeneca, Merck to Test Cancer Drugs in 'Cocktail'", Wall Street Journal, 2 June 2009. Available at <http://online.wsj.com/article/SB124380640803770139.html>.

<sup>16</sup> Gran Gross, "Intel, GE partner on home health tech", NetworkWorld, 2 April 2009. Available at <http://www.networkworld.com/news/2009/040209-intel-ge-partner-on-home.html>.

<sup>17</sup> PwC, "The new science of personalized medicine: Translating the promise into practice", 2009.

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## 4. Conclusions

Although a great deal of progress has been made in genomic and proteomic research and the field of molecular genomics, many challenges remain.

### ***The learning curve poses new challenges for doctors and scientists***

- Recognising which genes or biological mechanisms signify that a patient is predisposed to certain diseases and how this in turn translates into knowledge that can be used for prevention and treatment strategies poses a large learning curve that scientists and doctors will have to overcome.<sup>18</sup>
- Diseases need to be reclassified to reflect new knowledge about human biology. Many clinical entities currently described as single diseases may in fact be more than one disease, requiring different treatment approaches.<sup>19</sup>

### ***Implementation of effective technologies is no easy task***

- Key challenges remain in determining the appropriate type and sophistication of technology needed for doctors to make effective decisions

on which treatment(s) should be used when reading genetic data. This includes making better use of modern imaging technologies as well as the more effective use of decision support tools. While many new potential biomarkers are being discovered, the rate at which these are being qualified and validated is slow.

- Universal standards for managing genomic information in electronic medical records will be necessary to implement this technology and ensure clinical data is collected and interpreted in a standardised manner.<sup>20</sup>

### ***The least evident challenge is often the hardest to overcome***

- Consumer behaviour, an obstacle that may not be apparent, will be key when implementing personalised medicine and creating a culture that can adapt to these changes.<sup>21</sup>
- How we manage our personal health and lifestyle are not only difficult habits to modify but also play a key role in our susceptibility to disease and disease management. Swinging the pendulum from treatment to prevention and from illness to wellness will be essential to implement a consumer-focused culture.
- Patients need to be educated and physicians need to be instructed in the new technologies and methods that allow for a more personalised diagnosis of diseases and treatments.

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<sup>18</sup> PwC, "The new science of personalized medicine: Translating the promise into practice", 2009.

<sup>19</sup> European Perspectives in Personalised Medicine, May 2011. European Commission.

<sup>20</sup> PwC, "The new science of personalized medicine: Translating the promise into practice", 2009.

<sup>21</sup> PwC, "The new science of personalized medicine: Translating the promise into practice", 2009.

These challenges will need to be addressed at European, national, regional and local levels.

With any challenge, however, comes opportunity. The shifting healthcare paradigm provides hospitals and healthcare systems around the world with an opportunity to adapt to the changing needs of the patient, treat the disease sooner and create cost-cutting measures by instituting alternate forms of medicine or treatment. Key recommendations are evident as the health industry considers how to respond to the emerging personalised medicine market and explore sustainable business models.

Recommendations for providers/provider systems are as follows:

- Learn genomics and proteomics to develop effective prevention and treatment plans.
- Provide new health and wellness products and services to the community.
- Work with patients to educate them about the need to proactively manage their own health and commit to wellness programs and the benefits that some programs have derived from putting them into practice.
- Look to other industries to understand how to market directly to patients and deliver excellent customer-centric services.
- Collaborate in research projects to boost personalised medicine research productivity and effectiveness as well as ensure that proper policy recommendations are developed to accelerate and support this emerging market.
- Encourage collaboration between personalised medicine experts and doctors with expertise in the field in the development of new care models.





- Implement interoperable electronic health records to enable the sharing of genomic, proteomic, and other health data related to personalised medicine among research and healthcare organisations.

It is clear that key challenges exist as the pressure to be personalised continues to mount. As evidenced through the above recommendations, hospitals and providers have a clear opportunity to adapt to the new healthcare paradigm and provide services that are targeted to the individual patient. It is important to recognise, however, that different hospitals operate and require different hospital models. Just as doctors will no longer be able to apply the same forms of treatment to a group of patients, not all hospitals will be able to apply the same approach to addressing the challenges brought on by personalised medicine. Fortunately, there are many ways for

hospitals and providers to respond to the changing market. Personalised medicine can be set up and implemented into a hospital model in a variety of ways, as discussed in the interviews with several European hospitals in Part II of this document. As demonstrated through the preceding “Hospital Spotlights”, many European hospitals have already begun to define what personalised medicine means to their hospital and have developed their approach to implementation.



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## *Part II. Hospitals in focus*

### **List of Participating Hospitals**

Herlev Hospital / Copenhagen University Hospital at Herlev, *Denmark*

Kuopio University Hospital, *Finland*

University Hospital of Dijon, *France*

Medical and Health Science Center University of Debrecen, *Hungary*

University Medical Centre Ljubljana (UMCL), *Slovenia*

Hospital Clinic de Barcelona, *Spain*

Copenhagen, Denmark.

## **Herlev Hospital/ Copenhagen University Hospital at Herlev Denmark**



Herlev Hospital (HEH) has for several years focused on research for better personalised medicine and has included new biomarkers in routine clinical practice, e.g. analysis of KRAS mutation status in patients with colorectal cancer before treatment with cetuximab and analysis of HER2 protein expression in patients with breast cancer before

treatment with trastuzumab. Several units at HEH provide technical and logistical support to research in personalised medicine. These units help to improve the effectiveness of the logistics processes and research activities in the field of oncology, hematology, medicine, surgery and gynecology. The units include Departments of

Clinical Biochemistry, Pathology, Radiology and Clinical Physiology. HEH has several PET/CT, CT, MRI and ultrasound scanners used in projects related to personalised medicine, e.g. early evaluation of treatment response to new biologics for cancer patients.

|                            |   |
|----------------------------|---|
| Type of Hospital           | Public/Academic                           |
| Reference Population       | 425,000 (700,000 in certain specialities) |
| N° Beds                    | 624                                       |
| N° Employees               | 4,141                                     |
| N° Physicians              | 768                                       |
| N° Inpatient Admissions    | 131,123                                   |
| N° Day-Hospital Admissions | 426,379                                   |
| N° Surgery Procedures      | 20,400                                    |
| Hospital Annual Revenues   | 3,008 mil DKR                             |

**Interview with Julia S. Johansen,**  
Professor, Senior Consultant, DMSc, Herlev Hospital

**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

Danish patients and healthy subjects are willing to participate in translational studies concerning improved personalised medicine. The infrastructure and logistics are established for translational research at HEH. We mainly need further support for hospital staff, researchers and operational costs for analysis studies in translational research.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

Increase the amount of funding for specific studies related to translational medicine with a main focus on better personalised medicine.

**What are the top five value propositions that personalised medicine may provide?**

| Value Proposition         | Feasibility/ Ease of Implementation <sup>1</sup> | Time Horizon |
|---------------------------|--|--------------|
| Better clinical response  | 1  | 10 years     |
| Better survival           | 1  | 15 years     |
| Reduce treatment failures | 1  | 10 years     |
| Reduce side effects       | 1  | 10 years     |
| Decrease cost             | 1  | 10 years     |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

Lack of research funding for better personalised medicine.

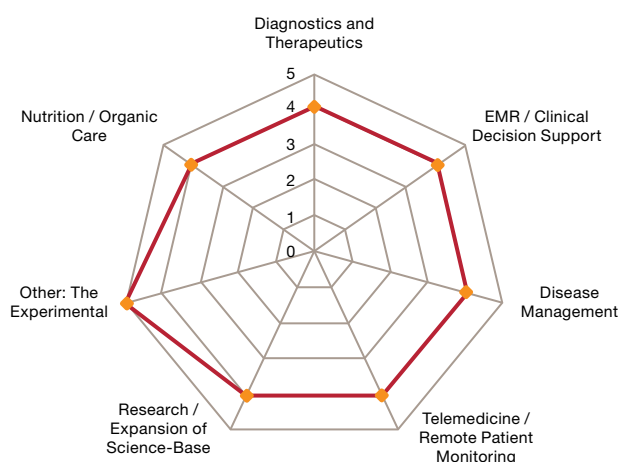
**Description of personalised medicine approach in your hospital:**

| Core Activity                                 |  |
|---|--|
| <b>Diagnostics and Therapeutics</b>           | Many departments at HEH have a high focus on better diagnostics and therapeutics, e.g. cancer patients are discussed at multidisciplinary team conferences (surgeons, oncologist, pathologists and radiologists).  |
| Personalised Medical Care                     |  |
| <b>EMR/Clinical Decision Support</b>          | Conducted between departments and at multidisciplinary team conferences.   |
| <b>Disease Management</b>                     | Disease management is used in several departments, such as oncology, haematology, intensive care, surgery and medicine, paediatrics, and gynaecology. Personalised medical care is used in disease management.   |
| <b>Telemedicine/Remote Patient Monitoring</b> | Multidisciplinary teleconferences with other hospitals.  |
| <b>Research/Expansion of Science-Base</b>     | <p>HEH participates in many research projects related to better personalised medicine that is funded by public and private agencies.</p> <p>The <b>Copenhagen General Population Study</b> is located at the Department of Clinical Biochemistry. This is a blood biobank and research study which will follow about 100,000 volunteers, aged 20 years to 100 years, from the Copenhagen area in Denmark. Today more than 60,000 volunteers are included. Initial enrolment is taking place at HEH, and the participants are followed yearly in the Danish Health registries thereafter.</p> <p>The secretarial office of the <b>Danish CancerBiobank</b> is located at the Molecular Unit, Department of Pathology, HEH. The objective of this biobank nationally is to collect blood and tissues optimal for translational research from patients with primary cancer in order to, for example, improve personalised medicine. The project started in January 2010, which included biological material from 5,281 patients in its first year. There is a connection with the Danish nationwide clinical databases and other national registries.</p> |
| <b>Others</b>                                 | <p>The <b>Experimental Cancer Therapy Unit</b>, Department of Oncology at HEH has been involved in clinical trials for more than 25 years. The department has broad experience with cytostatic drugs, biological and anti-hormonal agents, dendritic cells, and intrahepatic chemotherapy. The <b>Experimental Cancer Therapy Unit</b> was founded in 2004. Its core competency focuses on the planning, preparation and conduct of phase I clinical trials in cancer patients as well as early phase II trials.</p> <ul style="list-style-type: none"> <li>• The unit offers complete project and clinical trial management systems.</li> <li>• The unit operates with ICH GCP and standards of the pharmaceutical industry, including standard operating procedures (SOP's) covering all aspect of clinical trials.</li> <li>• The unit complies with all current legal requirements and the EU Directive on Clinical Trials (Directive 2001/20/EC &amp; Directive 2005/28/EF).</li> <li>• The unit has experience in design and administration of databases and the development of computerised trial management software.</li> </ul>               |

|  |   |
|--|---|
| Others                                     | <ul style="list-style-type: none"> <li>• The unit has experience in incorporation of health economics and quality-of-life measures.</li> <li>• The unit has a network of leading scientists and oncologists and collaborates with other phase I units in Denmark and Europe.</li> </ul> <p>A dedicated team, including research nurses, oncologists, and statisticians staffs the unit. The staff members have a comprehensive experience in developing, planning, implementing and running a clinical trial, as well as conducting data management and statistical analysis. The staff members are trained in handling blood samples for pharmacokinetics, pharmacodynamics and translational research. Additionally, tissue sampling may be added to the unit through the collaboration with the Department of Diagnostic Radiology and various surgical departments. Furthermore, the unit has access to MRI, CT and PET-scans, and a variety of other interventional diagnostic radiology and clinical physiological assessments.</p>   |
| <b>Nutrition &amp; Wellness</b>            |   |
| Nutrition/Organic Care                     | Several departments have focused on nutrition and physical activity to improve wellness and treatment of patients.  |
| Complementary & Alternative Medicine       | N/A   |
| Others                                     | N/A   |
| <b>Other Related Products and Services</b> |   |
| Stem Cells                                 | N/A   |
| Others                                     | <p>The <b>Clinical Research Unit</b>, Department of Oncology, HEH has been involved in clinical trials for more than 25 years. The department has broad experience with cytostatic drugs, biological and anti-hormonal agents, dendritic cells, and intrahepatic chemotherapy.</p> <p><b>Clinical Research Unit</b> was founded in 1992. The main objective of the unit is to conduct high-quality research to achieve patient benefits. Its core competencies focus on the planning, preparation and performance of phase I–III clinical trials in cancer patients.</p> <ul style="list-style-type: none"> <li>• The unit offers complete project and clinical trial management systems.</li> <li>• The unit operates with ICH GCP and standards of the pharmaceutical industry, including standard operating procedures covering all aspect of clinical trials.</li> <li>• The unit complies with all current legal requirements and the EU Directive on Clinical Trials (Directive 2001/20/EC &amp; Directive 2005/28/EF).</li> <li>• The unit has experience in the design and administration of databases and the development of computerised trial management software.</li> <li>• The unit has experience in incorporation of health economics and quality-of-life measures.</li> <li>• The unit has expertise and computing facilities required to coordinate multicentre clinical trials.</li> <li>• The unit organises educational activities, including training courses and workshops.</li> <li>• The unit has a network of leading scientists and oncologists, including collaboration with other phase I units in Denmark and Europe.</li> </ul> <p>The unit collaborates closely with the <b>Experimental Cancer Therapy Unit</b>, a dedicated unit for experimental cancer therapy and phase I trials. Furthermore, the unit has easy access to a basic science laboratory and all facilities of a large centre.</p> <p>A dedicated team, including research nurses, oncologists and statisticians staff the unit. The staff members have comprehensive experience in developing, planning, implementing and running a clinical trial, as well as conducting data management and statistical analysis. The staff members are trained to handle blood samples for pharmacokinetics, pharmacodynamics and translational research. Additionally, tissue sampling may be added to the unit through the collaboration with the Department of Diagnostic Radiology and various surgical departments. Lastly, the unit has access to MRI, CT and PET-scans, and a variety of other interventional diagnostic radiology and clinical physiological assessments.</p> |



**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

HEH is collaborating with several institutions for research purposes and treatment of patients. These institutions include:

- Other University Hospital in Denmark
- Other universities in Denmark, the European Union, and the United States
- The Danish Technical University
- RISØ, National Laboratory for Sustainable Energy
- Many biotech and pharmaceutical companies

**Have you built a research centre that encompasses personalised medicine?**

The Clinical Research Unit, Department of Oncology, has a close collaboration with the **Experimental Cancer Therapy Unit**, a dedicated unit for experimental cancer therapy and phase I trials. Furthermore, the unit has easy access to a basic science laboratory and all facilities of a large centre.

The units have access to MRI, CT and PET-scans, and a variety of other interventional diagnostic radiology and clinical physiological assessments.

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

Several tests for personalised medicine are used in daily clinical practice (e.g. KRAS mutations, HER2 expression, molecular profiling in haematological disease).

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

- Clinical chemistry: e.g. SNPs, genes, mRNA, microRNA, protein biomarkers
- Pathology: e.g. SNPs, genes, mRNA, microRNA, protein biomarkers
- Radiology: CT, MRI, ultrasound
- Clinical Physiology: PET/CT

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Herlev Hospital has for several years focused on research for better personalised medicine and has rapidly incorporated new biomarkers in routine clinical practice, e.g. analysis of KRAS and BRAF mutation status in patients with colorectal cancer and melanoma before treatment with biologics and analysis of HER2 protein and FISH expression in patients with breast cancer before treatment with trastuzumab.

HEH participates in many research projects related to better personalised medicine funded by the Hospital, and also by, e.g. the Danish government, the Danish Cancer Society, the Danish Heart Association, the Danish Rheumatism Association, Biotech Companies like Novo Nordisk, Roche, Merck/Serono, Novartis and private foundations.

The “Copenhagen General Population Study” is located at the Department of Clinical Biochemistry, HEH. This is a blood biobank and research study which will follow 100,000 volunteers, aged 20 years to 100 years, from the Copenhagen area in Denmark. Today more than 60,000 volunteers are included. Initial enrolment is taking place at HEH, and the participants are followed yearly in the Danish Health registries thereafter. Some of the expenses (e.g. salaries to technicians and doctors, biomarker analysis) for this unique biobank are paid by HEH.

The secretarial office of the “Danish CancerBiobank” is located at the Molecular Unit, Department of Pathology, HEH. The objective of this biobank is to nationally collect blood and tissues optimal for translational research from patients with primary cancer in order to, for example, improve personalised medicine. The project started in January 2010, and during the first year, biological material from 5,281 patients was included. There is a connection with the Danish nationwide clinical databases and other national registries. Some of the expenses (e.g. salaries to technicians and doctors) for this unique biobank are paid by HEH.

Several units at HEH provide technical and logistic support to research in personalised medicine and help to improve the

effectiveness of logistics processes and research activities in the field of oncology, haematology, internal medicine, surgery and gynaecology. The units include Departments of Clinical Biochemistry, Pathology, Radiology and Clinical Physiology. HEH has several PET/CT, CT, MRI and ultrasound scanners used in projects related to personalised medicine, e.g. early evaluation of treatment response to new biologics for cancer patients. Technicians at the Department of Clinical Biochemistry take many project-related blood samples from healthy subjects and patients included in different projects, without cost, at the same time as routine blood samples are collected. This is also a benefit for the patients (they will not have to give blood twice) with various types of diseases included in different clinical studies (including biomarkers studies of treatment response to, for example, biological treatment of patients with cancer and inflammatory diseases).

**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges                |
|----------------------------|---------------------------|
| Architecture and Equipment | Too little space          |
| Services Offered           | -                         |
| Clinical Activity          | -                         |
| Organisational Structure   | -                         |
| IT                         | Bad/slow in many areas    |
| Financial                  | Limited financial support |
| Research & Development     | -                         |
| Academic/Teaching activity | -                         |

**How does personalised medicine impact on quality measures in your hospital?**

- Better survival
- Fewer side effects
- Shorter hospitalization
- Cost
- Patients are more satisfied

**Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?**

Several units at HEH provide technical and logistical support to research in personalised medicine. These units help to improve the effectiveness of the logistics processes and research activities in the field of oncology, haematology, medicine, surgery and gynaecology. The units include the Departments of Clinical Biochemistry, Pathology, Radiology and Clinical Physiology. HEH has several PET/CT, CT, MRI and ultrasound scanners used in projects related to personalised medicine. Early evaluation of treatment response to new biologics for cancer patients is one example.



**With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?**

New technologies of initiatives for personalised medicine are typically adopted as soon as they are introduced.

**Did personalised medicine impact the roles and responsibilities of your healthcare providers?**

Yes, very much. In recent years, the cost of new medicine, i.e. biologics like adalimumab and infliximab (for patients with rheumatoid arthritis); trastuzumab (for patients with breast cancer); rituximab (for patients with lymphoma) and bevacizumab, cetuximab and panitumumab (for patients with colorectal cancer) have increased dramatically during the last five to ten years. Unfortunately, less than 30% of the patients will benefit from the treatment since it is very expensive and has severe side effects. The healthcare providers know very

well that better personalised medicine is needed — to benefit the patients and make healthcare more cost effective. Better biomarkers (i.e. more sensitive, specific and accurate) could be of value for better personalised medicine, and there is a growing focus on identification of better biomarkers.

***Is your hospital training new doctors to practice personalised medicine? Please describe the process.***

Yes. Many new doctors and PhD students are trained in personalised medicine. In Denmark, for example, several doctors obtain their PhD after medical school.

***What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?***

Good grant support for research and collaboration between different departments and specialties is important. Networking between hospitals, universities, biotech companies and the pharmaceutical industry is also very important.

***Please describe one case study related to personalised medicine in your hospital:***

At the Department of Oncology, HEH runs several projects related to personalised medicine. One of the projects, Discovery of new microRNA biomarkers for treatment response and prognosis in patients with metastatic colorectal cancer treated with bevacizumab, is described at a high level below.

It is not known why only some patients with colorectal cancer (CRC) respond to treatment with bevacizumab (Avastin®), an antibody targeting vascular endothelial growth factor (VEGF). This treatment is very expensive and has several severe side effects. Early selection of patients with metastatic CRC for optimal treatment with biologics is very difficult, and no biomarkers today can identify the patients who will benefit from treatment with bevacizumab. Biomarker discovery in patients with metastatic CRC must therefore be accelerated. This is a critical step in translational medicine for personalising treatment. A Biomarker is “a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes or pharmacological responses to a therapeutic intervention”.

The study aims to improve the selection of patients with metastatic CRC to optimal treatment. We will test the hypothesis: A panel of specific microRNAs in CRC cancer tissue, plasma and blood cells is useful for prediction of treatment response and prognosis in CRC patients treated with bevacizumab.

The aims of this translational cancer research project of patients with metastatic CRC are to:

- Identify microRNA expression profiles in CRC tissue, EDTA plasma and blood cells (including circulating tumour cells) that can predict treatment response to bevacizumab in combination with chemotherapy, and evaluate if these profiles are different from patients treated with chemotherapy only or patients treated with cetuximab.
- Identify microRNA expression profiles in CRC tissue, EDTA plasma and blood cells (including circulating tumour cells) that are associated with poor prognosis in patients treated with bevacizumab, and evaluate if these profiles are different from patients treated with chemotherapy only or patients treated with cetuximab
- Determine if changes in miRNA expression profiles in EDTA plasma and blood cells two months after start of bevacizumab are associated with treatment response and prognosis.
- Determine if miRNA expression profiles in EDTA plasma and blood cells at time of disease progression in patients treated with bevacizumab are associated with prognosis.
- Compare the microRNA expression profiles in CRC tissue, EDTA plasma and blood cells.

The project will provide new important information regarding patients with metastatic CRC and optimising improved survival rates of patients with CRC and personalised treatment of these patients. It will also save the healthcare system from expensive treatment for CRC patients who will not respond to bevacizumab treatment. The project is new, has a high development potential at a high professional level and is very innovative. The project includes a retrospective study (I) and a prospective study (II):

- Study I: In the retrospective study we will evaluate the microRNA expression profile in 500 patients with metastatic CRC already treated with bevacizumab. This include a Discovery study and a Validation study.
- Study II: In two prospective studies with a total of 600 patients with metastatic CRC treated with bevacizumab in combination with chemotherapy will be evaluated. This study will determine if specific microRNA expression profiles in the primary tumour, EDTA plasma and blood cells before and during treatment provide new information of treatment response and prognosis.



Kuopio, Finland

## **Kuopio University Hospital,** *Finland*



Kuopio University Hospital focuses the application of personalised medicine on the accurate diagnosis of diseases based on genetics and treatment tailored to the genetic characteristics of patients.

Genetic diagnostics is done at the University of Eastern Finland, Kuopio, which collaborates closely with the Kuopio University Hospital.

|                                   |                 |
|-----------------------------------|-----------------|
| <b>Type of Hospital</b>           | Public/Academic |
| <b>Reference Population</b>       | 260,000         |
| <b>N° Beds</b>                    | 800             |
| <b>N° Employees</b>               | 4,200           |
| <b>N° Physicians</b>              | 520             |
| <b>N° Inpatient Admissions</b>    | 48,000          |
| <b>N° Day-Hospital Admissions</b> | 7,500           |
| <b>N° Surgery Procedures</b>      | 21,000          |
| <b>Hospital Annual Revenues</b>   | 330,000 EUR     |

Interview with **Jorma Penttinen**,  
Medical Director, Kuopio University Hospital

**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

Increase the efficacy and decrease the side effects of the treatment.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

The healthcare system is optimal for personalised medicine in Finland due to good collaboration between primary care and hospital care. In the new law of healthcare, primary and secondary healthcare are closely connected, and in many times are even within the same organisation. Tailoring of the treatment in Diabetes Type 1 is a good example of how the collaboration between the two levels of care furthers the advancement of personalised medicine.

Also, care pathways have been made according to Current Care recommendation (Current Care = Käypä hoito is a grounding member of GIN (Guidelines International Network)).

**Description of personalised medicine approach in your hospital:**

| Core Activity                                   |  |
|---|--|
| <b>Diagnostics and Therapeutics</b>             | Diagnosis of monogenic forms of diabetes (MODY, neonatal diabetes, mitochondrial diabetes), dyslipidemia (familial hypercholesterolemia, etc.), calcium metabolism disorders (hyperparathyroidism), thyroid diseases (thyroid hormone resistance), and several other monogenic diseases. |
| Personalised Medical Care                       |  |
| <b>EMR/Clinical Decision Support</b>            | Genetics offers the possibility to diagnose monogenic diseases accurately, such as MODY, dyslipidemia, calcium metabolism disorders, thyroid diseases, etc.  |
| <b>Disease Management</b>                       | Accurate diagnosis of monogenic diseases helps to plan for the treatment of MODY, dyslipidemia, calcium metabolism disorders, thyroid diseases, etc.   |
| <b>Telemedicine/Remote Patient Monitoring</b>   | Not yet applied.   |
| <b>Research/Expansion of Science-Base</b>       | Genetic diagnosis of monogenic diseases is a very important part of research activity.   |
| <b>Others</b>                                   | N/A  |
| Nutrition & Wellness                            |  |
| <b>Nutrition/Organic Care</b>                   | N/A  |
| <b>Complementary &amp; Alternative Medicine</b> | N/A  |
| <b>Others</b>                                   | N/A  |
| Other Related Products and Services             |  |
| <b>Stem Cells</b>                               | N/A  |
| <b>Others</b>                                   | N/A  |

**What are the top five value propositions that personalised medicine may provide?**

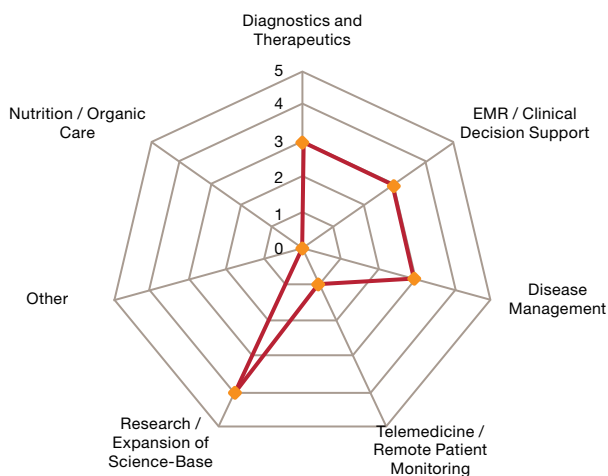
| Value Proposition  | Feasibility/ Ease of implementation <sup>1</sup> | Time Horizon |
|--|--|--------------|
| Accurate diagnosis of several monogenic diseases                             | 4  | 12 months    |
| Tailored treatment of several monogenic diseases                             | 2  | >40 months   |
| Identification of individuals having side effects relating to drug treatment | 2  | >40 months   |
| Lower costs for diagnostics of monogenic diseases                            | 3  | >40 months   |
| Lower costs for treatment of monogenic diseases                              | 3  | >40 months   |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

Lack of knowledge among the doctors about the possibilities of modern diagnostics using information from genetics.

**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

Kuopio Hospital collaborates with several institutions for research purposes. These institutions include:

- NIH, US
- University of Southern California, Los Angeles, United States
- University of Ann Arbor, United States
- University of Gothenburg, Sweden

**Have you built a research centre that encompasses personalised medicine?**

A research centre that encompasses personalised medicine has not officially been built yet in diabetes, but there are comprehensive centres in Finland with the aim to produce research and tailored treatment plans for individuals with cancer.

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

Genetic diagnostics of monogenic diseases is a part of the clinical practice in our hospital. In many cases the treatment depends on the accurate diagnosis of this condition.

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

Genetic diagnostics of monogenic diseases, or treatment tailored to genetic diagnosis in several diseases. The potential growth for this service is expanding continuously.

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Activity of key personnel who develop diagnostics based on genetics.



**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges  |
|----------------------------|---|
| Architecture and Equipment | None  |
| Services Offered           | Number of diagnostic tests based on genetics should be expanded.  |
| Clinical Activity          | Knowledge of the potential significance of diagnostic tests based on genetics among clinicians is still limited.            |
| Organisational Structure   | None  |
| IT                         | None  |
| Financial                  | None  |
| Research & Development     | Research on monogenic diseases is a good stimulus to develop new genetic tests for monogenic diseases.                      |
| Academic/Teaching Activity | Teaching on monogenic forms of diseases and the potential of genetic testing has been added in courses of medical students. |

**How does personalised medicine impact on quality measures in your hospital?**

Quality indicators have not been developed yet.

**How does personalised medicine impact into your current/potential revenues? And into your costs?**

There is no impact to our revenues.

In the long-run, genetic testing will substantially lower the costs of diagnostics of monogenic diseases because the testing is done only once.

**Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?**

Genetic diagnostics are conducted at the University of Eastern Finland, Kuopio, which collaborates closely with the Kuopio University Hospital.

**With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?**

Application of genetic diagnostics for monogenic diseases has already reduced the diagnostics and treatment costs of monogenic diseases. It is likely that the costs will be further reduced in the future.

**Did personalised medicine impact the roles and responsibilities of your healthcare providers?**

Yes, doctors treating diseases must obtain additional knowledge on the potential of modern genetics. This will better facilitate the diagnosis of disease and identification of individuals who will benefit more from certain treatment options.

**Is your hospital training new doctors to practice personalised medicine? Please describe the process.**

Not yet, but knowledge on the potential of modern genetics is a part of the course work for medical students.

**What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?**

All hospitals in our country should apply diagnostics based on genetics for monogenic diseases.

**Please describe one case study related to personalised medicine in your hospital:**

Congenital hyperinsulinemia of infancy is a serious illness manifesting with low glucose level and hyperinsulinemia. We have found two mutations in the Finnish population for this rare condition in the ABCC8 gene. Depending on the mutation, a newborn or a young patient will have different treatments (i.e. drug treatment or pancreatectomy). In other words, we can tailor the treatment based on genetic diagnosis.

Dijon, France

## University Hospital of Dijon, France



The University Hospital of Dijon sees personalised medicine as an approach aimed at optimising medical procedures –both diagnostic and therapeutic– to each individual specifically, as opposed to applying “average” procedures.

At the University Hospital of Dijon, multiple platforms, laboratories, and collaborations, together with complementary expertise in epidemiology, clinical research, and basic research, converge to develop personalised medicine.

|                            |                                       |
|----------------------------|---------------------------------------|
| Type of Hospital           | Public/Academic                       |
| Reference Population       | 1,700,000 (region of Burgundy)        |
| N° Beds                    | 1,763                                 |
| N° Employees               | 6,812                                 |
| N° Physicians              | 1,711 (including 616 students)        |
| N° Inpatient Admissions    | 72,425                                |
| N° Day-Hospital Admissions | 28,895                                |
| N° Surgery Procedures      | 20,329 (patients admitted in surgery) |
| Hospital Annual Revenues   | 446,653,860 EUR                       |

Interview with **Alain Bonnin**,  
Professor of medical parasitology and mycology;  
Director Parasitology Mycology Laboratory;  
Director Biological Resource Centre Ferdinand Cabanne,  
University Hospital of Dijon



**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

In the hospital setting, the major trends will probably be treatment optimisation based on

- Newly characterised markers with diagnosis, prognosis, or therapeutic interest.
- Ability to determine individual variations in the pharmacokinetics of drugs, to optimise the balance between efficacy and/side effects.

In addition, the characterisation of markers that are predictive of increased risks may have a huge impact on the whole health system, from ambulatory medicine to hospital medicine.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

Firstly, by implementing large scale clinical and epidemiological studies to: (i) determine the range of variation for markers of clinical interest in human populations, (ii) evaluate the predictive values of the markers characterised, and (iii) determine the medico-economic benefit of these markers.

Secondly, by developing finance analytical platforms in terms of: (i) equipment and buildings, if necessary, and (2) re-agents and consumables.

Overall, the health system should institute education and training that targets the newly developed techniques.

**What are the top five value propositions that personalised medicine may provide?**

| Value Proposition   | Feasibility/Ease of implementation <sup>1</sup> | Time Horizon |
|---|---|--------------|
| Improved treatment efficacy for individual patients                     | 4   | 5 years      |
| Reduced treatment side effects for individual patients                  | 5   | 5 years      |
| Early diagnosis   | 5   | 5 years      |
| Modified life styles on the basis of individual risk factors identified | 1   | 10 years     |
| Global health improvement of the population at the country scale        | 1   | 20 years     |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

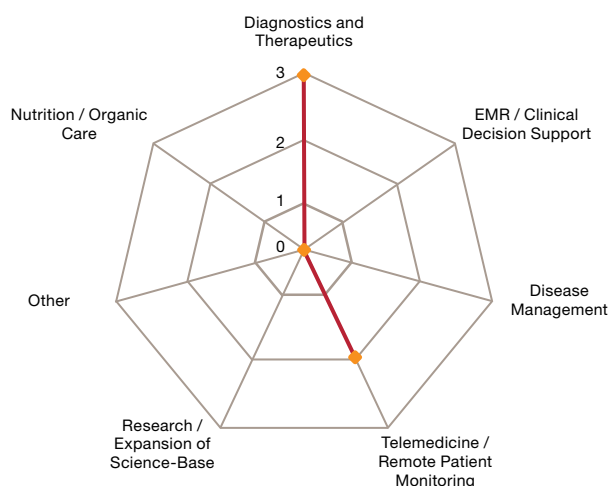
- The need for clinical and epidemiological studies that demonstrate the benefit of the new approaches is a pre-requisite.
- Short-term increase in the cost generated by the determination of new markers.
- Ethical issues.

**Description of personalised medicine approach in your hospital:**

| Core Activity                                 |   |
|---|---|
| <b>Diagnostics and Therapeutics</b>           | Several platforms have been developed on the Dijon health campus, some in collaboration with the Cancer Centre Georges François Leclerc <ul style="list-style-type: none"> <li>• Cancer molecular genetic platform to develop new genetic markers for cancer</li> <li>• Molecular genetic platform with DNA sequencing and biochip analysis</li> <li>• Clinical proteomic platform (CLIPP) to develop peptide/protein markers</li> <li>• Biological Resource Centre Ferdinand Cabanne for both clinical research aimed at developing new markers, and the long- term storage of samples for clinical diagnosis</li> </ul> New imaging technologies, such as 3 Teslas MRI; PETscan, etc. |
| Personalised Medical Care                     |   |
| <b>EMR/Clinical Decision Support</b>          | N/A   |
| <b>Disease Management</b>                     | N/A   |
| <b>Telemedicine/Remote Patient Monitoring</b> | Programs are currently being developed in pathology and neurology.  |
| <b>Research/Expansion of Science-Base</b>     | N/A   |
| <b>Others</b>                                 | N/A   |

|  |     |
|--|-----|
| <b>Core Activity</b>                       |     |
| <b>Nutrition &amp; Wellness</b>            |     |
| Nutrition/Organic Care                     | N/A |
| Complementary & Alternative Medicine       | N/A |
| Others                                     | N/A |
| <b>Other Related Products and Services</b> |     |
| Stem Cells                                 | N/A |
| Others                                     | N/A |

**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

University Hospital of Dijon is collaborating with several organisations. These organisations include:

- **University of Bourgogne and PRES Bourgogne Franche Comté:** The University Hospital is a founding member of the “Scientific Cooperation Foundation” of the PRES Bourgogne Franche Comté. The university conducts common research programs.
- **GIS Pharmimage:** The University Hospital is a founding member of the GIS Pharmimage (“Scientific Interest Grouping”), a public sector/private sector partnership aimed at developing new imaging and therapeutic methods based on molecular probes.
- **INSERM:** INSERM Research Centre U866 in Dijon is a scientific partner with close collaborations to develop biomarkers.

- **Cancer Centre Georges François Leclerc:** A university cancer hospital that develops its own research programs, some of which are common within the University Hospital of Dijon, INSERM and ONCODESIGN. The cancer centre is also a founding partner of the PRES Bourgogne Franche Comté.
- **Oncodesign:** Oncodesign is a biotech company in the field of preclinical evaluation of anti-cancer drugs. Oncodesign is a founding partner of the GIS Pharmimage.

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

Personalised medicine is slowly emerging in clinical practice in the field of cancer.

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

- **Cancer Molecular Genetic Platform:** Clinical evaluation and typing of specific cancer markers. This service has a high potential growth.
- **Proteomic Platform CLIPP:** Clinical evaluation of proteomic markers, mainly in the field of cancer. So far, this service is at the research stage. This service has a high potential for growth.
- **Biological Resource Centre:** Long-term storage of patients samples for basic and clinical research and for individual characterisation of markers when clinical interest is demonstrated. This service has a high potential for growth.
- **Molecular Genetic Platform:** DNA sequencing; microsatellite typing. This service has a moderate potential for growth.

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Close partnerships between the hospital environment (including the cancer centre) and the University of Bourgogne and PRES Bourgogne Franche Comté.

**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges  |
|----------------------------|---|
| Architecture and Equipment | A new medical biology building with clinical laboratories was built in 2008. A clinical research laboratory building is currently under way. It will house part of the proteomic platform. In our experience, this is a major challenge given the delay between the expression of a new need and the time a building is available (about ten years). The cost of maintaining new buildings is also a challenge that needs to be taken into account. Equipment costs are also a challenge, but in our experience, it may be easier to overcome than architectural needs. |
| Services Offered           | N/A   |
| Clinical Activity          | N/A   |
| Organisational Structure   | N/A   |
| IT                         | N/A   |
| Financial                  | In our experience, funding is rather easy at the pre-clinical stage, and is effective to help structure a new analytical activity. Real difficulties arise at the time the new activity is included in daily medical practice, since no permanent and specific funding is generally available at that stage. Therefore, new activities often have to be supported by the general budget of the hospital.  |
| Research & Development     | The line between research/development of a new marker/daily typing of this marker as part of a new medical strategy is difficult to determine. This can cause difficulties with respect to funding (which budget – research or clinical – is funding what?).  |
| Academic/Teaching activity | N/A   |

**How does personalised medicine impact on quality measures in your hospital?**

The accreditation process will apply to the different platforms involved in personalised medicine.

The Biological Resources Centre is certified according to norm NF S 96 900; the certification process has had a strong cultural impact on the community with respect to the importance of quality assurance.

**How does personalised medicine impact into your current/potential revenues? And into your costs?**

Personalised medicine is currently a source of increased costs. Potential revenues for university hospitals could result from performing specialised analysis for primary or secondary healthcare institutions. However, we are much too early in the development process for this to become a reality.





**Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?**

Several platforms have been developed on the Dijon health campus, some of which are in collaboration with the Cancer Centre Georges François Leclerc (see the Core Activity above). A new medical biology building with all clinical laboratories has been built in 2008 and a clinical research laboratory building is currently under way. It will house part of the proteomic platform.

**With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?**

We are at the very beginning of the process.

**Did personalised medicine impact the roles and responsibilities of your healthcare providers?**

No, the responsibilities of our healthcare providers have not changed.

**Is your hospital training new doctors to practice personalised medicine? Please describe the process.**

Not specifically.

**What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?**

- Plan for long-term investment in the development of technological platforms (proteomic, genetics, Biological Resource Centre, new imaging technologies).
- Develop a strong research and development culture in the institution, since this is a field at the very interface of basic research, clinical research, epidemiological research and daily clinical practice.
- Develop a culture of collaboration between the medical world (e.g., academic hospital, school of medicine) and other scientific fields (e.g. chemistry, physics, etc.) since future developments will rely on close interfaces (e.g. potential health applications of nanosciences and nanotechnologies).
- Clarify the financial relationships between research and patient care in your institution to avoid financial conflicts between different sources of funding. A key question is to admit the idea that short-term research costs are investments for the future through improving the global health level of the society.

**Please describe one case study related to personalised medicine in your hospital:**

• **Breast cancer**

Arnould L, Arveux P, Couturier J, Gelly-Marty M, Loustalot C, Ettore F, Sagan C, Antoine M, Penault-Llorca F, Vasseur B, Fumoleau P, Coudert BP. Pathologic complete response to trastuzumab-based neoadjuvant therapy is related to the level of HER-2 amplification. *Clin Cancer Res.*; 13(21):6404-9. 2007.

<http://www.ncbi.nlm.nih.gov/pubmed/17975153>

• **Malignant haemopathies**

Giron F, Schaeffer C, Cleyrat C, Mounier M, Lafont I, Santos FD, Vidal A, Maynadié M, Hermouet S. Frequent reduction or absence of detection of the JAK2 –mutated clone in JAK2V617F– positive patients within the first years of hydroxyurea therapy. *Haematologica.* 93(11) 1723 – 7 2008.

<http://www.ncbi.nlm.nih.gov/pubmed/18728027>

• **Colorectal cancer**

Barault L, Veyrie N, Jooste V, Lecorre D, Chapusot C, Ferraz JM, Lièvre A, Cortet M, Bouvier AM, Rat P, Roignot P, Faivre J, Laurent-Puig P, Piard F. Mutations in the RAS-MAPK, PI(3)K (phosphatidylinositol-3-OH kinase) signalling the network correlates with poor survival in a population-based series of colon cancers. *Int J Cancer.* May 2008 15;122(10):2255-9.

<http://www.ncbi.nlm.nih.gov/pubmed/18224685>

Debrecen, Hungary

## **Medical and Health Science Center University of Debrecen, Hungary**



Personalised medicine is to provide a holistic and personalised approach to each patient. Though molecular biologic approaches are a corner stone of the definition, personalised medicine has to be more than just the application of genomic and molecular data to better target health care delivery. Neither a molecule nor a mutation is a person.

The Medical and Health Science Center University of Debrecen is regularly working with molecular tools in oncological (e.g. breast cancer, GIST tumour) and haematological therapy (e.g. hypereosinophil leukaemia, MDR).

|                                   |   |
|-----------------------------------|---|
| <b>Type of Hospital</b>           | Public/Academic   |
| <b>Reference Population</b>       | 2,500,000 (region)/ 10 million (nationwide) in special services |
| <b>N° Beds</b>                    | 1,594 (active) and 96 (chronic)                                 |
| <b>N° Employees</b>               | 3,647   |
| <b>N° Physicians</b>              | 866   |
| <b>N° Inpatient Admissions</b>    | 90,857  |
| <b>N° Day-Hospital Admissions</b> | 506,368   |
| <b>N° Surgery Procedures</b>      | 31,371  |
| <b>Hospital Annual Revenues</b>   | 46,533,407,000 HUF  |

Interview with **György Pfliegler**,  
Head of Division of Rare Diseases Institute of Medicine,  
Medical and Health Science Center University of Debrecen

**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

These have to be multisided, e.g. lectures, interactive meetings, conferences, publications in the field that are both highly scientific and “popular” (for GPs, non-expert medical staff, etc.), local guidelines, etc. New results and cost effectiveness must be emphasised both for politicians and the public.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

- A new medical Society for Personalised Medicine was founded one year ago.
- There is a National Board for Rare Diseases. The Board was set up three years ago and a National Plan for Rare Diseases on the basis of Europlan was elaborated. The strategy runs until year 2013.
- The Semmelweis Plan (for renewing healthcare in Hungary) is the government’s strategy and it covers the treatment and care of rare disease.

**What are the top five value propositions that personalised medicine may provide?**

| Value Proposition   | Feasibility/Ease of Implementation <sup>1</sup> | Time Horizon |
|---|---|--------------|
| Improve non-invasive and early diagnostic tests (e.g. in transplant rejection, disease progression)                             | 5   | 20-24 months |
| To better evaluate risk-benefit ratio and e-medicine, web-based medicine, laboratory directories, feasibility for special tests | 5   | continuous   |
|   | 5   | 10 months    |
| More therapy-effective and cost-effective treatment will better persuade lawmakers, experts for reimbursement                   | 4   | 36 months    |
| Improve patient's comfort by promoting the feeling it is really him/her for whom the whole story has been written               | 5   | continuous   |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

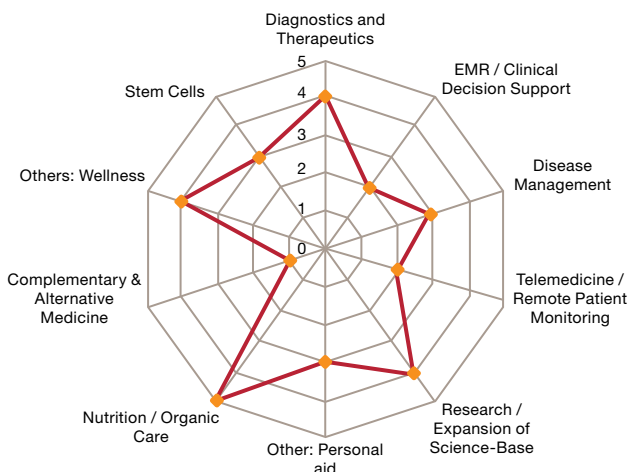
- Uncertainty of third parties for reimbursement.
- Lack of knowledge.
- Understanding the importance of personalised medicine by hospital personnel.

**Description of personalised medicine approach in your hospital:**

| Core Activity                                 |   |
|---|---|
| <b>Diagnostics and Therapeutics</b>           | In a number of molecular diagnostic, genetic tools (e.g. bcr/abl, multidrug resistance, vitamin K-antagonist resistance/hypersensitivity (VKORC). These tools continue to increase as well.   |
| Personalised Medical Care                     |   |
| <b>EMR/Clinical Decision Support</b>          | Not in an organised form; however, it does work. Whether or not it works depends greatly on the physician’s personality .   |
| <b>Disease Management</b>                     | Expert’s meetings, counselling, decisions (e.g. “oncoteam”, clinical discussions, etc.).  |
| <b>Telemedicine/Remote Patient Monitoring</b> | Cardiology remote ECG (holter) monitoring.  |
| <b>Research/Expansion of Science-Base</b>     | Laboratory Medicine at Debrecen University is dealing with a very wide scale of laboratory examinations, including molecular genetics. Besides this, there is a Centre for Clinical Genetics which has an outpatient service. Many examinations are carried out locally but they also have a wide international collaboration. At the university there is a Centre for Inherited Immunodeficient Patients. There are also scientific activities focused on rare diseases, personalised medicine (pharmaceutical), rare inherited bleeding disorders, neurosurgery (gamma-knife, inherited craniofacial malformations), etc. |
| <b>Others</b>                                 | Personal aid.   |

| Nutrition & Wellness                 |  |
|--------------------------------------|--|
| Nutrition/Organic Care               | Special nutrition centre exist. Patients receive a personal diet, if necessary.  |
| Complementary & Alternative Medicine | In the public, alternative medicine already has too much power with little responsibility. And although “alternative” or “natural” products are not cheap, they are easily accessible without any repercussions if they fail or are harmful. A wellness centre/physiotherapy is under construction within the University Hospital. Its focus is on rheumatologic services. |
| Others                               | In the neighbourhood, many wellness facilities exist.  |
| Other Related Products and Services  |  |
| Stem Cells                           | Autologous available; allogenic in development.  |
| Others                               | Special laboratories (e.g. sleep apnea), special surgical techniques (e.g. the gamma-knife is the only one in Hungary).  |

**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

The Centre collaborates with several institutions:

- **Pécs University:** Rare Disease project, laboratory tests, tissue banking (in progress).
- **Semmelweis University, Budapest:** Rare Disease project, laboratory tests, tissue banking (in progress).
- **Szentgyörgyi University, Szeged:** Rare Disease project, laboratory tests, tissue banking (in progress).
- **Numerous personal/department connections with academic institutes abroad:** Various research projects and special diagnostics.
- **Orphan drug companies (e.g., Genzyme):** Laboratory testing (e.g. Fabry disease).

**Have you built a research centre that encompasses personalised medicine?**

Yes, as well as others within the frame of the Biochemical and Molecular Biological Institute Proteomic Centre and Clinical Genomic Centre (e.g. Molecular Medicine Research Centre, Clinical Research Centre).

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

With the oncological (e.g. breast cancer, GIST tumour) and haematological therapies (e.g. hypereosinophil leukaemia, MDR), available molecular tools are regularly used in decision making. The same applies for antiplatelet/anticoagulant therapy.

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

- **Medsol:** Electronic health record shows continuous growth.
- **National Blood Bank:** Improving haemovigilance, blood-records kept and available for decades. This project is in progress.
- **Laboratory Medicine:** Personalised laboratory (molecular biological) tests. We are continuously introducing new methods.

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Improving knowledge, implementation, reports, discussions, and meetings could enable personalised medicine in the hospital environment.



**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges   |
|----------------------------|--|
| Architecture and Equipment | New, modern buildings, high-tech equipment (e.g. Life Science Building, and Laboratory Medicine building)  |
| Services Offered           | Determination of personnel medicine-related tests, consultation  |
| Clinical Activity          | Real-life personal contact   |
| Organisational Structure   | Diagnostic test indications, prices and access has just been finished by the Hungarian Society of Laboratory Diagnostics. It is available via the web for all physicians.        |
| IT                         | A more sophisticated and robust IT is needed; with special focus on clinical outcomes data. The key question remains regarding the balance between security, privacy and access. |
| Financial                  | Applications, national health insurance, third parties   |
| Research & Development     | Projects, integration  |
| Academic/Teaching activity | To build personalised medicine in graduate and post-graduate education   |

**How does personalised medicine impact on quality measures in your hospital?**

- Disease-free survival; survival data of special disease
- Cost-effectiveness; reimbursement
- Rapid and exact diagnosis

**How does personalised medicine impact into your current/potential revenues? And into your costs?**

A regular reimbursement is not following the increase in costs. On the other hand, decrease in therapy (due to increase in diagnosis) is not directly connected to each other. Costs usually exceed revenues.

**Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?**

Molecular genetic testing, flow cytometric analysis, and histology with special staining, etc.

**With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?**

We are on the first steps.

**Did personalised medicine impact the roles and responsibilities of your healthcare providers?**

It is too early to answer this question with yes or no. This is a long road.

**Is your hospital training new doctors to practice personalised medicine? Please describe the process.**

Yes, for example, in graduate medicine they “hear about it”. In addition, the scientific work for these students is in the field. There are PhD courses and PhD students focused in the field of personalised medicine.

**What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?**

- Become familiar with new results
- Work on implementation
- Remain critical
- Keep “salus aegroti suprema lex esto” the most important guideline

**Please describe one case study related to personalised medicine in your hospital:**

A patient with eosinophilia and artificial heart valve was replaced for the third time due to valve-thrombosis. Thrombosis occurred, despite adequate anticoagulant therapy, likely due to very strong prothrombotic activity. In the background, eosinophilic leukaemia could be proven (FIP1L1-PDGFR mutation).



## **University Medical Centre Ljubljana (UMCL), Slovenia**



Modern personalised medicine is a relatively new field in medicine and therefore has a broad developmental potential. In the strict sense, it is the use of genetic information from patients to predict the disease prognosis, decide on preventive measures, or the most appropriate therapy for that individual patient.

Currently, it is at its beginning, being used predominantly in the field of clinical genetics, pharmacogenetics and cancer management. In the latter, for example, targeted therapy is used and designed to target aberrant molecular pathways in a subset of patients with a given cancer type.

Translational techniques – genomics are being employed in the hospital environment and used intensively for research. We have our own microarray facility, using expression and DNA variation microarrays. Additionally, we use several sequencers, PRC machines, and other related smaller equipment.

|                                   |   |
|-----------------------------------|---|
| <b>Type of Hospital</b>           | Public/Academic                                     |
| <b>Reference Population</b>       | 700,000/2 million (nationwide) for certain diseases |
| <b>N° Beds</b>                    | 2,145   |
| <b>N° Employees</b>               | 7,441   |
| <b>N° Physicians</b>              | 1,204   |
| <b>N° Inpatient Admissions</b>    | 102,000   |
| <b>N° Day-Hospital Admissions</b> | Non available.                                      |
| <b>N° Surgery Procedures</b>      | 81,000  |
| <b>Hospital Annual Revenues</b>   | 443.5 M EUR   |

**Interview with Borut Peterlin,  
Head of Clinical Institute of Medical Genetics, University  
Medical Centre Ljubljana**

**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

Personalised medicine implementation is currently the most prominent in the field of clinical genetics; pharmacogenetics; and cancer prognosis, treatment and therapy. Trends towards its use in other fields are growing exponentially.

The field of different translational techniques termed “-omics” (genomics, proteomics, metabolomics) is under constant development. Advances in the field of genomics and genetics created an enormous amount of information. Researchers are trying to connect and integrate these results with the genome and medical history of patients.

We believe that these methods will enable new approaches to diagnosis, drug development and individualised therapy. These methods are currently being implemented in hospital environments and will provide the necessary technological support.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

Panels comprising various stakeholders should be organised. Stakeholders should include medical doctors, the pharma

industry, insurance companies, ethics experts, etc. Ground rules and an implementation plan should be prepared. The plan should be discussed among all European countries before future action is taken.

**What are the top five value propositions that personalised medicine may provide?**

| Value Proposition   | Feasibility/Ease of Implementation <sup>1</sup> | Time Horizon |
|---|---|--------------|
| Deciding on effective pharmacological treatment in cancer   | 1   | -            |
| Deciding on effective pharmacological treatment in “modern” diseases, such as cardiovascular diseases, metabolic syndrome, diabetes | 1   | -            |
| Efficient neurodegenerative disease progression prognosis   | 1   | -            |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

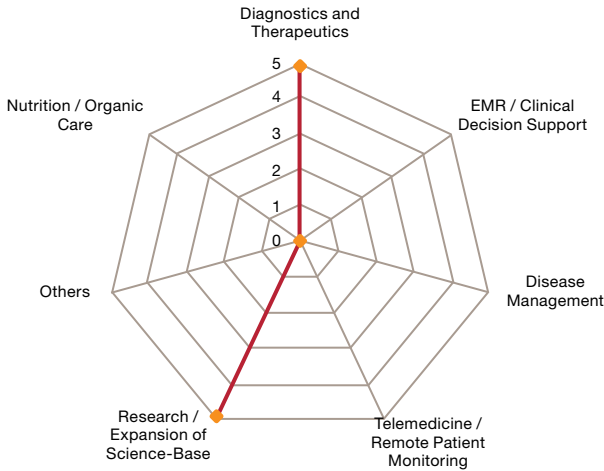
**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

Barriers include a lack of definite scientific proof and know-how for many of the potential applications at this time.

**Description of personalised medicine approach in your hospital:**

| Core Activity                          |   |
|--|---|
| Diagnostics and Therapeutics           | Therapy of certain cancers (e.g. BCR-ABL1 mutation suggests therapy for chronic myeloic leukemia, SLC19A1 polymorphisms influence decision on metotrexate therapy in acute lymphoblast leukemia). |
| Personalised Medical Care              |   |
| EMR/Clinical Decision Support          | N/A   |
| Disease Management                     | N/A   |
| Telemedicine/Remote Patient Monitoring | Not applicable yet.   |
| Research/Expansion of Science-Base     | Translational techniques (e.g. different “-omics”- genomics, proteomics, metabolomics) are being employed in the hospital environment and used intensively for research.                          |
| Others                                 | N/A   |
| Nutrition & Wellness                   |   |
| Nutrition/Organic Care                 | N/A   |
| Complementary & Alternative Medicine   | N/A   |
| Others                                 | N/A   |
| Other Related Products and Services    |   |
| Stem Cells                             | N/A   |
| Others                                 | N/A   |

**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

The Centre is collaborating with several institutions. These institutions include:

- **University of Ljubljana, Medical faculty:** Collaboration in research activities.
- **Companies providing consumables:** Collaboration in everyday routine procedures and research activities.
- **Government:** Collaboration in health system organisation and development.
- **Health insurance companies:** Collaboration in health system organisation and development.

**Have you built a research centre that encompasses personalised medicine?**

No, we have a Clinical Institute of Medical Genetics, which aims to develop specific, dedicated tests and counselling as it relates to personalised medicine.

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

Decision on therapy in certain cancers (e.g. leukemias) and decision on preventive measures in certain cancers (e.g. breast cancer).

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

Oncology, which includes leukemias and breast cancer, is more developed in the hospital as it relates to personalised medicine.

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Not applicable.

**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges  |
|----------------------------|---|
| Architecture and Equipment | Expensive equipment   |
| Services Offered           | Up-to-date knowledge  |
| Clinical Activity          | Additional education, services and people needed  |
| Organisational Structure   | A small department with human resources specifically allocated to personalised medicine would be useful |
| IT                         | Better IT support and equipment   |
| Financial                  | Additional financial support  |
| Research & Development     | Staying up-to-date  |
| Academic/Teaching Activity | Constant education  |





***How does personalised medicine impact on quality measures in your hospital?***

Not applicable.

***How does personalised medicine impact into your current/ potential revenues? And into your costs?***

Not applicable.

***Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?***

Translational techniques – genomics are being employed in the hospital environment and used intensively for research. We have our own microarray facility, using expression and DNA variation microarrays. Additionally, we use several sequencers, PRC machines and other related smaller equipment.

Additionally, with regards to common analysis software tools, we develop and use our own.

***With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?***

Not applicable.

***Did personalised medicine impact the roles and responsibilities of your healthcare providers?***

Not yet. We believe this will change in the future.

***Is your hospital training new doctors to practice personalised medicine? Please describe the process.***

Not yet. We believe this will change in the future.

***What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?***

Not applicable.

***Please describe one case study related to personalised medicine in your hospital:***

Leukemia patients with 17p deletions are treated with alemtuzumab.

Barcelona, Spain

## **Hospital Clinic de Barcelona, Spain**



The Hospital Clinic of Barcelona understands personalised medicine as the provision of care adapted to the patient's profile.

Genetic screening is used for treatment in familial colorectal cancer, melanoma at the Hospital Clinic. They also use remote monitoring for cardiac devices and chronic diseases.

|                                   |  |
|-----------------------------------|--|
| <b>Type of Hospital</b>           | Public/Academic  |
| <b>Reference Population</b>       | 550,000 as primary care/1,500,000 as tertiary care       |
| <b>N° Beds</b>                    | 850  |
| <b>N° Employees</b>               | 5,395  |
| <b>N° Physicians</b>              | 1,142 (including 400 resident physicians or in training) |
| <b>N° Inpatient Admissions</b>    | 46,601   |
| <b>N° Day-Hospital Admissions</b> | 95,247   |
| <b>N° Surgery Procedures</b>      | 22,844   |
| <b>Hospital Annual Revenues</b>   | 464 M EUR  |

**Interview with Raimon Belenes,  
Chief Executive Officer, Hospital Clinic de Barcelona**

**What do you believe to be the key trends related to the implementation of personalised medicine within the hospital environment?**

Scientific evidence demonstrates how different patient profiles can be treated differently and in a more efficient way.

**How should the health system in your country lay the groundwork for the next steps in personalised medicine?**

Recognise the value of classifying patients that have difference conditions using genetic tests and including them as diagnostics tests.

**What are the top five value propositions that personalised medicine may provide?**

| Value Proposition           | Feasibility/Ease of Implementation <sup>1</sup> | Time Horizon |
|-----------------------------|---|--------------|
| Cancer treatment            | 2   | 0-48 months  |
| Cardiovascular risk profile | 3   | 24-36 months |
| Diabetes, nutrigenomics     | 3   | 36-48 months |
| Psiquiatric disorders       | 1   | 48-60 months |
| Neurodegenerative           | 1   | 36-48 months |

<sup>1</sup> Each proposal is rated within a scale 1: high complexity and 5: low complexity

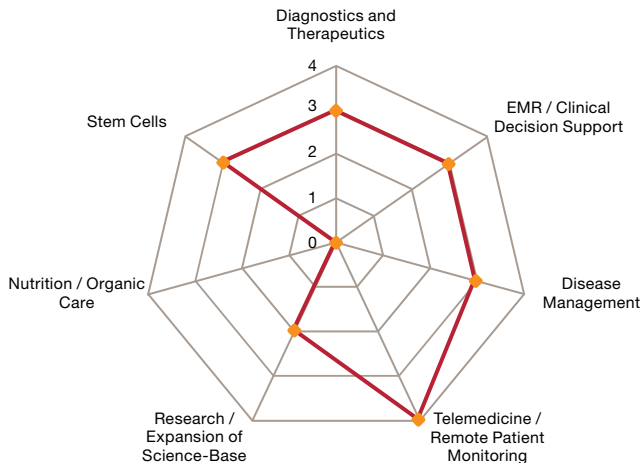
**Description of personalised medicine approach in your hospital:**

|   |  |
|---|--|
| <b>Core Activity</b>                            |  |
| <b>Diagnostics and Therapeutics</b>             | New targets for cancer treatment, familial forms of disease, chip development.           |
| <b>Personalised Medical Care</b>                |  |
| <b>EMR/Clinical Decision Support</b>            | New targets for cancer treatment, familial forms of disease, chip development.           |
| <b>Disease Management</b>                       | New targets for cancer treatment, familial forms of disease, chip development.           |
| <b>Telemedicine/Remote Patient Monitoring</b>   | Implemented program for remote patient control, including devices and chronic illnesses. |
| <b>Research/Expansion of Science-Base</b>       | Development of new therapeutic targets, polymorphism-related disease, etc.               |
| <b>Others</b>                                   | N/A  |
| <b>Nutrition &amp; Wellness</b>                 |  |
| <b>Nutrition/Organic Care</b>                   | N/A  |
| <b>Complementary &amp; Alternative Medicine</b> | N/A  |
| <b>Others</b>                                   | N/A  |
| <b>Other Related Products and Services</b>      |  |
| <b>Stem Cells</b>                               | Several programs in cardiology, cancer, neurological diseases.                           |
| <b>Others</b>                                   | N/A  |

**What are the main barriers for the implementation of personalised medicine within the hospital environment?**

- Lack of strong scientific evidence in some fields
- Costs

**Where does your hospital stand on the implementation level of each activity?**



(0: Not applicable; 5: High development).

**Do you have relationships or affiliations with other sector organisations as it relates to personalised medicine (such as universities, IT companies, government, biotech, etc.)? How do these relationships work?**

Not applicable.

**Have you built a research centre that encompasses personalised medicine?**

We have a research centre for basic science that includes different projects supporting personalised medicine, cancer research, genetic research, etc.

**Current status report on the integration of personalised medicine into actual clinical practice within your hospital:**

In some areas, genetic screening is used for treatment in familial colorectal cancer and melanoma.

**Which service lines, including clinical services as well as non-clinical services, related to personalised medicine are more developed in your hospital?**

- **Cancer:** Familial forms, screening
- **Stem cells:** Neurological, inflammatory diseases, cardiovascular, oftalmologic
- **Remote monitoring:** Devices, chronic disease
- **Nutrigenomics:** Personalised diets
- **Cardiac:** Cardiovascular and neurological risk assessment

**Policies and programs play an important role as an accelerator and regulator. What are the key personalised medicine enablers in your hospital environment?**

Our own researchers and physicians are the key enablers in our hospital environment.

**What are the operational challenges you have experienced in your hospital as it relates to integrating personalised medicine?**

| Dimension                  | Challenges  |
|----------------------------|---|
| Architecture and Equipment | Enable space for research and funding for equipment                               |
| Services Offered           | Obtain enough scientific evidence   |
| Clinical Activity          | Have adequate research programs and funding for clinical assistance               |
| Organisational Structure   | Insert new evidence and needs into the classical assistance                       |
| IT                         | Obtain adequate tools to integrate information, specifically in remote monitoring |
| Financial                  | Obtain recognition by the payers  |
| Research & Development     | Obtain funding for the projects   |
| Academic/Teaching Activity | Include personalised medicine into regular academic activity                      |



***How does personalised medicine impact on quality measures in your hospital?***

- **Mortality:** Too complex because it depends on the pathology
- **Readmission:** Currently in the evaluation phase for chronic diseases
- **Complications:** Has not been evaluated thus far
- **Mean hospital stay:** Not enough data yet

***How does personalised medicine impact into your current/potential revenues? And into your costs?***

The impact on revenues is not relevant at present, although they are potentially important in some areas. Regarding costs, they are basically financed by research funds thus far.

***Can you describe the basic infrastructure (technologies and tools) for the application of personalised medicine that exists in your hospital today?***

Different areas have special programs, such as colorectal cancer, melanoma, and others, such as remote monitoring for cardiac devices or for chronic disease.

***With any new technology or new initiative, there is an adoption curve before the initial investment pays off. Where do you stand with personalised medicine on that curve?***

Obtaining scientific evidence and if positive, implementing at a small scale.

***Did personalised medicine impact the roles and responsibilities of your healthcare providers?***

Not yet, but it might be important in the future, especially for chronic disease control.

***Is your hospital training new doctors to practice personalised medicine? Please describe the process.***

Not specifically, but it is included in the context of adequate patient management

***What is your advice for other hospitals that are looking to the future of personalised medicine and wondering what to do?***

Implement it when scientific evidence is strong enough to use it universally in patients.

***Please describe one case study related to personalised medicine in your hospital:***

Melanoma, colorectal cancer, device control.





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## *The impact of personalised medicine tomorrow*

This report describes the approach towards personalised medicine in six European hospitals in Denmark, Finland, France, Hungary, Slovenia and Spain.

The personalised medicine landscape extends over many aspects, from its core activity focused on molecular diagnostics and targeted therapeutics, to the personalised medical care market (including EMR, disease management, telemedicine and remote patient monitoring) as well as to the nutrition and wellness markets (including nutrition and organic care, complementary and alternative medicine).

Most of the hospitals featured in this report are in the process of consolidating their activities on the therapeutics and diagnostics market. They all have multidisciplinary teams in their hospitals working on better

treatment for patients, particularly in genetics, oncology, cardiology, neurology, radiology and the treatment of diabetes.

However, the potential of personalised medicine reaches beyond this core market to encompass personal health record management, disease management, nutrition and wellness. Whereas the development of new diagnostics and therapies of certain diseases come to terms with the practice of the European hospitals, the technology issues and wellness activities are still one step back on the personalised medicine approach.

On the one hand, adopting electronic health records will increase the collection of health data and, if the information is shared among research organisations, there will be a great potential for achieving better health outcomes. On the other hand, the long-term view of good health must focus on wellness-based efforts. Educating patients on healthy lifestyle habits plays a key role in our susceptibility to manage disease.

Implementing personalised medicine will require a high level of collaboration among the many stakeholders in the life science and medical sector: research organisations,

medicines and diagnostics manufacturers, regulators, the health technology industry, doctors, other health professionals and patients. The healthcare community must collaborate to foster innovation in the area of molecular biology of human health and diseases.

Leading practices related to personalised medicine will continue to emerge as hospitals solidify their definition of personalised medicine and their approach for implementation to create a culture of customised healthcare.

<http://www.pwc.com/global-health>  
[www.hope.be](http://www.hope.be)

### About PwC's Global Healthcare Network

PwC's Global Healthcare practice draws from its global capabilities across and beyond the health industries to solve the complex problems health organisations face, lead cultural and clinical transformation, and create a new, sustainable model for care delivery that is quality driven, patient centered and technology enabled.

Our global network of more than 5,000 health industry experts provide assurance, tax and advisory services that are grounded in an unmatched understanding of the entire healthcare system and the dynamics that drive it. We use our unparalleled network of resources to provide strategies that help clients succeed in a competitive and changing market. Within our network, we have a range of expertise across the health continuum, including leading minds in medicine, science, information technology, operations, administration, and health policy.

We help clients manage today's key issues, such as revolution in care as enabled by technology, regulatory reform, impact of new science, innovation and wellness strategies, and new capital project and infrastructure as well as public-private partnerships.

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### About HOPE

HOPE, the European Hospital and Healthcare Federation, is an international non-profit organisation created in 1966. HOPE represents national public and private hospital associations and hospital owners, either federations of local and regional authorities or national health services. Today, HOPE is made up of 32 organisations from 26 Member States of the European Union, plus Switzerland. HOPE's mission is to promote improvements in the health of citizens throughout Europe, high standard of hospital care and efficiency with humanity in the organisation and operation of hospital and healthcare services.

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