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# ICT Research
## The policy perspective

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# A healthy approach
## Technology for personalised, preventative healthcare

European Commission
Information Society and Media

This brochure has been produced for the Information Society Policy Link (ISPL) by the *ICT Results* editorial service. ISPL is an important part of the Information Society and Media Directorate-General's goal to draw clear lines between policy, policy-making and European research in the field of information and communications technology (ICT).

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The service's main aim is to:
- raise the visibility of ICT-funded research results
- support projects' access to markets and encourage uptake of innovations
- raise awareness of European ICT programmes and activities

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# My health, our wealth

***In this report produced for the publication series ICT Research: The Policy Perspective, we discover how information and communication technology (ICT) is revolutionising healthcare across Europe. Technology gives patients choice and control, while practitioners make more informed diagnoses and decisions. As research continues, citizens can expect to see their quality of life improve.***

From a global perspective, most Europeans have little to complain about in life. We have food to eat, a roof over our heads, largely free education for our children. And even when unemployment bites or disaster strikes, robust social support systems generally come to our aid.

Yet our quality of life features at the top of all political agendas. Why? Because quality of life depends on far more than a full stomach and somewhere warm and dry to sleep. There is always more to be done so that citizens can be comfortable, safe, independent and happy.

## Health, happiness and hard work

It is clear that health – defined by the WHO as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity" – plays a defining role in our quality of life. Poor health, whether for an individual or for an entire population, sustains a downward spiral into social and economic deprivation.

Health is therefore a central tenet of the European project. Under **Article 152 of the Treaty**, the EU has a mandate to complement the work of national health systems. At an EU level, this work focuses mainly on protecting people from health threats and disease, promoting healthy lifestyles and helping national authorities to cooperate on cross-border health issues.

The EU's overarching health policy framework was renewed in the European Commission's October 2007 Communication **Together for Health: A Strategic Approach for the EU 2008–2013**. It supports the principle that 'health is the greatest wealth'.

## Water everywhere

Flood, storms and industrial accidents are the most feared disasters in Europe.

92% of Europeans think that centralised EU involvement in crisis management is a good idea.

*[Eurobarometer 2009]*

Europeans are generally satisfied and happy with life: on a scale from one to ten, the EU-27 average is 7 for life satisfaction and 7.5 for happiness.

*Source: Eurobarometer 2009*

According to the World Health Organisation (WHO) our quality of life depends on our:

* physical health;
* psychological health;
* level of independence;
* social relations;
* environment;
* spirituality/religion/personal beliefs.

"Health is important for the wellbeing of individuals and society, but a healthy population is also a prerequisite for economic productivity and prosperity," the communication states, linking the aims of the health strategy with those of European efforts to promote better and more growth and jobs.

The strategy identifies one trend more than any other that is driving change in European healthcare: the ageing population. By 2050 the number of people in the EU aged 65+ will grow by 70% and the 80+ age group will almost treble. This demographic shift could cripple national health services unless radical changes are made. Europe must be prepared.

Innovative, dynamic healthcare systems, enabled by, and in combination with, new technologies, offer solutions to these mounting pressures. "New technologies have the potential to revolutionise healthcare and health systems and to contribute to their future sustainability," the strategy states. "E-health, genomics and biotechnologies can improve prevention of illness, delivery of treatment, and support a shift from hospital care to prevention and primary care. E-health can help to provide better citizen-centred care as well as lowering costs and supporting interoperability across national boundaries, facilitating patient mobility and safety."

The strategy effectively places the future of European healthcare into the hands of modern technology. Of course, clever medical devices and expensive hospital equipment will play their part, but our health systems need more: there needs to be a radical change in the very way we 'do' healthcare to make it more efficient, more effective and better geared to the demands of today.

## ICT: the cure?

Europe realised that ICT has this transforming capacity and has welcomed and encouraged e-health initiatives. In 2004, as part of the overarching **eEurope strategy**, it adopted the **E-health Action Plan** (due for revision in 2011). The Plan says that "e-health tools or solutions include products, systems and services that go beyond simply Internet-based applications. They include tools for both health authorities and professionals as well as personalised health systems for patients and citizens".

The Action Plan is now firmly embedded within the **i2010** policy framework for the information society and media. 'Social inclusion, better public services and quality of life' is one of the three pillars of i2010; the actions proposed by the Action Plan touch on all these areas and complement the i2010 flagship initiative for **Ageing Well in the Information Society**.

Across the EU, e-health is making healthcare more accessible, convenient, effective and efficient. For example, citizens can access top specialists or their own family doctor, no matter where they are, thanks to telemedicine. Similarly, personal health systems can continuously monitor patients' health away from a care setting, allowing professionals to keep a distant eye on them; this kind of system is ideal for elderly people and gives them much more independence and a better quality of life in old age.

E-health also makes it easier for patients, professionals and data to cross borders, as different stakeholders, sometimes from different Member States, collaborate together.

The benefits of e-health systems are well documented, but even as a world leader, Europe still has

81% of EU residents said that good health was 'very important' for their quality of life: however, on average, only 21% of people rate their health as 'very good.

*Source: Eurobarometer 2009*



a long way to go. Further cycles of research, evaluation and deployment are necessary to keep driving ICT into every aspect of our healthcare.

The Action Plan identifies some of the obstacles which include:

- the current lack of interoperability between health information systems (especially for cross-border sharing of electronic health records);
- the need for mobility of patients and healthcare professionals;
- the need for enhanced infrastructures and innovative technologies;
- legal and regulatory issues.

## Healthy investments

Health issues touch on almost every other area of EU activity and policy (a phenomenon known as HIAP – Health in All Policy). So it is unsurprising that the EU's investment in initiatives to implement the health strategy are channelled through a wide range of programmes and schemes.

The **Second Programme of Community Action in the Field of Health 2008–2013**, for example, funds projects (not necessarily R&D) that directly address the main objectives of the strategy. The bulk of funding for medical and health R&D is channelled through the **Health Theme** in the Cooperative research arm of the **Seventh Framework Programme (FP7)**. More than €6 billion will be invested in biotechnology, generic tools and medical technologies for human health, projects to improve the translation of research into clinical practice, and the optimisation of healthcare delivery to European citizens.

The specific area of e-health falls within the scope of the **ICT Theme** of **FP7**. The ICT theme focuses on seven 'challenges'; Challenge 5 covers health and personalised care and responds to all three objectives of the EU Health Strategy. Building on two decades of collaborative European research, projects funded under FP7 promise solutions to some of the most pressing healthcare issues.

Emphasising the growing impact of the ageing population, FP7 research is complemented by the **Ambient Assisted Living** (AAL) Joint Programme, a €700 million programme of research between 20 EU Member States, three Associated States and supported by the Commission. AAL projects aim to develop solutions, generally incorporating ICT, to help elderly people remain safe, active, healthy and independent. A total of 23 projects were funded under the first call for proposals; and these began running during 2009.

The research undertaken by projects funded through FP7 and AAL take a medium- to long-term view. Most of the technologies and solutions developed in these projects are unlikely to reach the market in less than three years, and more likely take at least five years. But the Commission acknowledges that Europe needs e-health to become mainstream now; waiting another decade for digitalisation will be too late.

As part of the **Competitiveness and Innovation Programme** (CIP), the **ICT Policy Support Programme** (ICT PSP) has been set up to spearhead pre-commercial collaboration to deploy new technologies in real-world settings, evaluate their uptake and generate market relevant data to support commercialisation.

## EU Health Strategy

The EU's Health Strategy identifies three main objectives:

- fostering health in an ageing Europe;
- protecting citizens from health threats;
- supporting dynamic health systems and new technologies.

E-health deployments have been covered in most of the annual ICT PSP calls since the programme was launched in 2007. The 2009 annual call, for example, covered ICT for health, ageing and inclusion, in support of the i2010 flagship initiative on ageing well, the **eInclusion** initiatives and the E-health Action Plan.

A total of eight ICT PSP health-related projects have been funded so far, building on the 40 e-health projects funded by the predecessor eTEN programme.

## E-health for all

The Commission also recognises the economic importance of the e-health sector. The sector includes a number of large world-class firms, plus an estimated 5,000 SMEs. As a whole, the health sector in the EU spends almost 9% of gross domestic product and is expected to reach around 16% by 2020. It is essential that European businesses tap into this market opportunity with innovative e-health solutions that will generate a return on investment to the taxpayer.

The e-health sector is one of six sectors to be covered by a **Lead Market Initiative** (LMI). LMIs deal with regulation, public procurement, standardisation and supporting activities to lower the barriers within a sector and bring new products or services onto the market. The e-health LMI's actions include policy measures to reduce market fragmentation, improve interoperability and to support health authorities embracing change through the implementation of e-health systems.

"We made the right investments over 20 years to become the world leader in e-health," noted Neelie Kroes, Commissioner for the Digital Agenda in March 2010. "The investments worked because we took them early and we took them together.

"Now it is time to step up another gear. Our finances demand it. Our citizens expect it. The technology is ripe. We are all rightly proud of our health systems in Europe. We have every reason to be proud to be working towards e-health for all."




## Meeting the challenges

Quality of life for European citizens is at the top of the political agenda. Health is intimately associated with wealth – financial, social and cultural. But in the wake of economic pressures and faced with an ageing population, health services across Europe must quickly be transformed, so that citizens can still access world-class, affordable healthcare.

Europe must therefore drive a dramatic shift towards more personalised, preventative medicine through the application of innovative ICT. Only a massive research undertaking can develop the solutions we so desperately need.

### Health is personal

With more elderly people in the population, the prevalence of chronic and serious medical conditions is on the rise. But how can health services meet the steady rise in demand? Putting patients in control, Europe is pioneering personal health systems, such as remote monitoring units, so that patients can help themselves.

### At the bio-ICT interface

The worlds of biology and electronics are beginning to merge. Materials scientists, engineers, biologists and medical experts are finding new ways to shrink laboratories down to the size of a microchip. Soon doctors will be able to test samples on their premises; faster diagnoses could help to save many lives and unnecessary costs.

### Stitch it together

Thanks to the web and electronic patient records, health professionals have so much information at their fingertips. But it is all too easy to miss essential data due to information overload. Researchers are developing new tools to link up databases, make it easier for doctors to collaborate and share information, and guide professionals through the data to make difficult decisions. Clever data analysis can also pick out patterns that humans might miss, making predictive medicine a possibility.

### Virtual patients

Europe is leading a global research effort to develop computer models of human physiology, from single cell interactions to whole organs. In the future, the ability to simulate how a patient 'ticks' could speed up pharmaceutical development cycles, help doctors to prescribe optimal doses and avoid dangerous drug mixes. Modelling could also help to predict how an individual (or an entire population) may respond to an illness or treatment.

### More information:

**EU Health Portal: http://ec.europa.eu/health-eu/index_en.htm**

**Together for Health: A Strategic Approach for the EU 2008–2013: http://ec.europa.eu/health/ph_overview/strategy/health_strategy_en.htm**

**E-health Action Plan: http://ec.europa.eu/information_society/activities/health/policy/index_en.htm**

**Treaty of Lisbon: http://www.europarl.europa.eu/charter/default_en.htm**

**i2010: http://ec.europa.eu/information_society/eeurope/i2010/index_en.htm**

**Ageing Well in the Information Society: http://ec.europa.eu/information_society/activities/einclusion/policy/ageing/launch/index_en.htm**

**FP7: http://cordis.europa.eu/fp7**

**Second Programme of Community Action in the Field of Health 2008–2013: http://ec.europa.eu/health/ph_programme/pgm2008_2013_en.htm**

**ICT PSP: http://ec.europa.eu/information_society/activities/ict_psp/index_en.htm**

**eTEN: http://ec.europa.eu/information_society/activities/eten/index_en.htm**

**The Ambient Assisted Living (AAL) Joint Programme: http://www.aal-europe.eu**

**Lead Market Initiative: http://ec.europa.eu/enterprise/policies/innovation/policy/lead-market-initiative**


## Patient, heal thyself

***It is hard to be happy when you suffer from poor health. Whether it is a debilitating disease or just niggly problems, everyday life can be a chore – sometimes unbearable. But European researchers are building new gadgetry to help us maintain a good quality of life: fewer trips to the doctors, better diagnoses and optimised, effective treatments.***

Until fairly recently, if you were ill – a nasty bout of flu or some chronic complaint – you simply went to a doctor. But today, and thanks to the power of ICT, patients have other options. It may be possible to book an appointment online or even by text. You might decide to go on the web and 'wise up' on your symptoms and self-help on a website.

In the future, trips to the doctor's may be the exception, rather than the rule, even for people with serious conditions such as cardiovascular disease or diabetes. New wireless monitoring devices – perhaps worn in clothing to measure your vital signs or dotted around your house to monitor your movement and activity – could keep track of your health. Powerful data analysis could spot danger signs and alert your doctor long before your ever realised you might be in trouble. And in an emergency, automated systems could call for an ambulance or phone a family member and ask them to visit.

The direct benefits of personal, remote health monitoring are obvious: healthier individuals, faster interventions, more prevention and fewer hospitalisations. Economically, this means that the workforce is more productive while elderly people have greater independence and need fewer expensive interventions.

### Health is personal

The move towards more patient-centric care has been one of the most significant shifts in the medical world in the last half century. The advent of the internet and the pervasiveness of ICT have greatly accelerated this change in dynamics. As personalised medicine and monitoring systems begin to enter the market, Europe continues to invest in R&D so that patients get more control and choice.

"E-health is today's tool for substantial productivity gains, while providing tomorrow's instrument for restructured, citizen-centred health systems and, at the same time, respecting the diversity of Europe's multi-cultural, multi-lingual health care traditions," states the E-health Action Plan. The Action Plan embraces patient power and ushers in patient-centric, decentralised and efficient healthcare systems.

The European R&D effort to support the patient-centric healthcare can be traced back beyond the Fourth Framework Programme (FP4). However, the concept of 'personalised health systems' (PHS) became explicit in FP6; indeed 'Personal health systems', with an emphasis on wearable, wireless systems, were a strand of FP6 e-health activity and 11 projects were funded.

FP7 continues this work, looking at wearable and portable devices for remote monitoring of patients with chronic illnesses and conditions.

Chronic disease management accounts for 7 out of every 10 euros spent on healthcare

Healthcare is becoming increasingly patient-centred and individualised, with the patient becoming an active subject rather than a mere object of healthcare.

Together for Health: A Strategic Approach for the EU 2008–2013

Diagnostic systems are also added to the mix, in particular point-of-care devices that can speed up the time for diagnosis. This area of research also aims to develop systems that will help doctors assess the most appropriate treatments for a condition, perhaps based on a patient's genetic code or past medical history, so that they can be prescribed an optimal, customised treatment regime.

The 2009-2010 ICT Work Programme earmarks more than €60 million for such PHS projects. The projects will combine a variety of technologies including biomedical sensors; micro- and nanosystems; mobile and wireless communications; user interfaces; and intelligent signal processing and knowledge management.

The ICT PSP is supporting the ground-breaking research of the Framework Programmes, taking fledgling PHS solutions and deploying them in different, real-life settings. Several pilots have been launched around the idea of a patient-centred health service.

The pilots aim to demonstrate the sustainable benefits and commercial viability of PHS, showing how they help patients to manage their care, but also how they support healthcare professionals to improve their decision-making. PHS is not about taking power away from the professionals, but making the most of all the information available to find the best answers for every individual.

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## Projects in focus

### COCHISE
### BIOTEX
### PROETEX
### COGKNOW
### SENSACTION-AAL
### Medical Care Continuity
### DREAMING

Cancer is a major killer and an intractable problem confronting medical science, but now European researchers have developed a biosensor that will help doctors to use the patient's own immune system to combat the disease.

The **COCHISE** project has developed a way to select a patient's "active cells", which are successfully fighting the cancer cells, amplify them in a test tube, and then re-inject them into the body. It is like building a clone army and sending them in to reinforce the existing troops.

The COCHIS biosensor uses a combination of microscopic fluid channels and electronics to first isolate immune system cells and cancer cells, then identify the active cells by analysing how the cells interact. Active cells are then separated from the rest.

"The procedure we identified for measuring cell activity is at the core of the technology," says Massimo Bocchi, a researcher with the project. "When an event of interest is measured... [say] a cell of the immune system kills a target tumour cell, the cell of interest can be retrieved from the platform, transferred to a standard plate and cultured. This complete workflow allows doctors to study the behaviour of cells because we are able to isolate them on the basis of their functional activity. This is a key innovative concept in this field."

While COCHISE may one day create personalised therapeutics, several projects have also brought monitoring to a personal level too. A cluster of EU research projects (SFIT Group) have worked on a range of smart fabrics, interactive textiles and flexible wearable systems.

Jean Luprano coordinates the **BIOTEX** project. "One of the most obvious applications for smart fabrics is in the medical field," he says. "There has been a good deal of progress with physiological measurements, body temperature or electro-cardiograms. But no-one has yet developed biochemical sensing techniques that can take measurements from fluids like sweat and blood."

One of the main achievements of BIOTEX has been the development of a suite of sensors capable of measuring sodium, potassium and chloride in sweat samples. Another probe measures the conductivity of sweat and a miniaturised pH sensor uses colour changes to indicate the pH of sweat. An immunosensor, which could be integrated into wound dressings or bandages, can detect the presence of specific proteins in fluid samples. The sensors work on tiny volumes of liquid, so the project also developed clever ways to channel minuscule droplets of liquid from the skin, through the textile and to the sensor unit.

The **PROETEX** project, also part of the SFIT cluster, has integrated the BIOTEX technology with other micro- and nanosystems for specific applications (e.g. for fire fighting and rescue teams).

But Luprano warns that with new technology must come new ways of thinking. "It's new and healthcare providers are not used to it. We are not used to the information that continuous, remote monitoring can provide. BIOTEX makes this remote monitoring possible."

Patient-centric healthcare tries to keep patients independent and able to self-treat as much as possible. Soon, even people with mild dementia may be able to look after themselves, and free up their carers, thanks to a new system developed by **COGKNOW**.

One of the first and most debilitating symptoms of dementia is short-term memory loss, which means care is required for people who are otherwise quite capable of looking after themselves. COGKNOW created two very user-friendly devices: a flat-screen monitor for the home and a mobile smart phone with a much simplified user interface.

All the user has to deal with are simple, self-explanatory icons on the touch screen. The in-home system can be set up to start issuing reminders from wake-up time in the morning until bed time. These can be recorded in a friend or relative's voice, and give instructions for all sorts of activities such as picking up the morning newspaper, brushing teeth, preparing or warming pre-prepared meals, laundry and dish washing and myriad other daily activities. Videos can show how to operate, for example, the stove, microwave oven or washing machine.

Many elderly people worry if the door is open or unlocked, and the COGKNOW system monitors this so they don't keep on checking that during the day. On-screen icons in the form of photos help them to picture-dial friends and relatives, simply by touching a particular photo.

Most functions are also included on the mobile device, which comes with an important extra GPS-based feature. Dementia sufferers can get disoriented when out, and the device can guide them home whenever necessary.

The system was field-tested on user groups in three countries, and the majority of users and carers perceived significant improvement in their lives and their ability to get through the day.

A variety of sensing devices are already on the market, thanks to the work of the **SENSACTION-AAL** project. Unlike many health monitoring systems that require multiple sensors as well as separate components for data storage and transmission, the DynaPort Hybrid device and MoveMonitor application, both developed by the SENSACTION-AAL researchers, carry out movement sensing, data collection and data transmission in a single compact package. Worn on the user's waist in a special elastic belt, the devices monitor and record a person's physical movement and body posture, assist them with rehabilitation exercises, and can be configured to automatically alert emergency services in the event of a fall. The devices are now sold in more than 20 countries.

Several other projects are also supporting the wider deployment and commercialisation of PHS solutions. The **Medical Care Continuity** (MCC) and **DREAMING** projects, funded through eTEN and ICT PSP respectively, aim to assess the benefits of remote monitoring systems. Sensors around the home (including cameras) or worn by a patient are linked to a call centre or healthcare professionals. If unusual circumstances are detected, the control centre is alerted; with the aid of a decision-support system, professionals can initiate the most appropriate response. On the basis of successful trials, it will be possible to elaborate business plans for different countries, and extend these systems to help a broader range of patients.

## More information

**COCHISE http://cochise.arces.unibo.it**

**BIOTEX http://www.biotex-eu.com**

**PROETEX http://www.proetex.org**

**COGKNOW http://www.cogknow.eu**

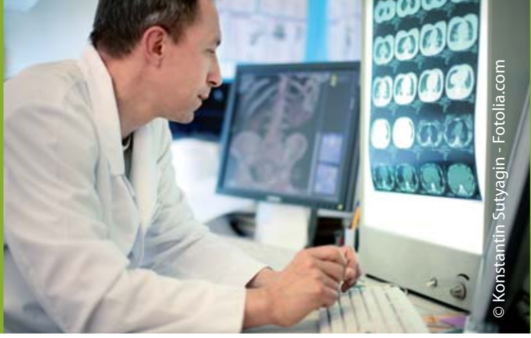
**SENSACTION-AAL http://www.sensaction-aal.eu**

**Medical Care Continuity http://www.eten-mcc.org**

**DREAMING http://www.dreaming-project.org**

**ICT and 'e-health' stories on ICT Results: http://cordis.europa.eu/ictresults (enter search terms 'health', 'e-health')**

**http://cordis.europa.eu/fp7/ict**





## New frontiers in nanoworlds

***Chemists like to talk about organic and inorganic substances – materials that make up living things, and materials that don't. Until recently, silicon chips were firmly in the inorganic camp. But with the advent of nanotechnology, scientists are finding clever ways to merge seamlessly the worlds of biology and electronics.***

When you simply look at the words, it is easy to see how the combination of 'ICT' and 'biology' leads to 'bioinformatics', the analysis of biological information. But ICT and biology can be merged and mixed in so many different ways, not just through software. Scientists are now finding new and relatively cheap was to entwine biological substances into the very core of electronics components, especially the silicon chip.

Thanks to the development of nanotechnology and significant advances in the production of microscopic electro-mechanical devices (MEMS), scientists now have a variety of techniques to link organic and inorganic substances together. They can bind DNA or proteins to silicon or plastics in extremely tiny amounts or in precise arrangements. In doing so they have created a new sort of 'chip' – the lab-on-chip.

The results are impressive and just beginning to appear on the market. Within the next five or so years you will probably encounter a lab-on-chip device, most likely in your doctor's office.

You go to the doctor, she takes a blood sample, puts a drop into a machine and within minutes you get your result. No agonising about whether you have a terrible disease, waiting around for weeks for a lab to run the tests and send them back.

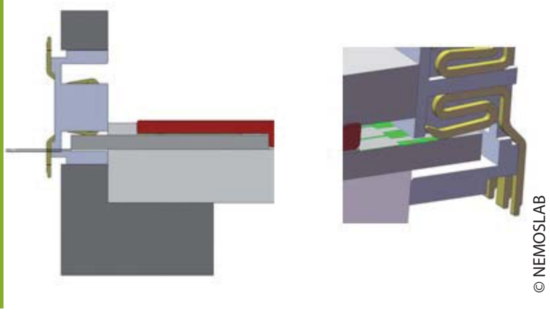
### At the bio-ICT interface

The role of ICT in health is at the boundary of medicine, biology and electronics. But this boundary gets even more blurred when you start to explore the kit: EU researchers are finding new ways to combine living and non-living systems and developing exciting new devices that could revolutionise healthcare.

Europe's emphasis on personalised health – and its funding for R&D into personal health systems under FP7 – recognises that the lab-on-chip concept will have an important part to play. After all, if you can get results back in a minute, that's a pretty good personal service!

Research into the components for devices using lab-on-chip technology has made great headway in the past 10 years, but it is now time to put everything together and produce effective point-of-care diagnostic systems. Call 1 of ICT FP7 in 2007 sought to drive forward developments in this area, asking for "targeted solutions that integrate all necessary technologies and components (e.g. sensors and networks, interfaces, intelligent algorithms, services over converged platforms)." The vision is for smart devices that can carry out multiple tests on a sample to extract and analyse as much information as possible about an individual. "They will be able to identify predisposition to diseases, enable early diagnosis of a disease or their recurrence, and also provide detailed information to aid treatment, such as dosage advice or indicate when an individual should not be treated by a particular drug."

Now inextricably linked into the very fabric of human biology, the development of ICT-based smart diagnostic systems is ensuring that every patient gets fast, optimised treatments for their ills.




## Projects in focus

### NEMOSLAB
### SEMOFS
### POCEMON

A portable 'lab on a chip' that can identify target molecules in blood samples has been created by European researchers. It is being used to measure fertility hormones and detect the genes associated with certain types of cancer.

"The question was whether we could combine silicon or other semiconductor technologies with bioassay techniques and the diagnostic technologies," explains **NEMOSLAB** project coordinator Dr Konstantinos Misiakos. "Some of the technologies were innovative or state-of-the-art at the time the project started, some others were more or less conventional."

NEMOSLAB uses an optical technique to recognise the presence of selected biological molecules. Light passes down a silicon nitride waveguide – a flat rectangular pipe about eight micrometres wide and 0.15 micrometres thick – to a detector which turns it into an electrical signal.

The waveguide is coated with a probe molecule that can recognise target molecules by binding to them. This could be an antibody, which will bind with a specific protein, or a strand of DNA that will bind with a complementary strand in the sample fluid.

A microfluidics system within the chip passes the sample – normally blood serum – over the waveguide. When a target molecule in the sample binds to the surface of the waveguide the optical properties are changed and the amount of light arriving at the detector also changes. The step in the signal is distinctive.

Each NEMOSLAB chip contains nine waveguides which are exposed to the sample at the same time and can be primed to detect different molecules. The entire chip is fabricated as a single unit.

"We can't claim the physics is new," says Misiakos, "but the realisation of the physics into an integrated and small format through the mature silicon technology is new. Our advantage is that we have all the optical components integrated on the silicon chip."

One of the partners, an infertility treatment centre in Dortmund, is interested in using the device to monitor hormone levels in the blood of women seeking to conceive a baby through in-vitro fertilisation. The NEMOSLAB device can test for nine different hormones at the same time. At present, women have to travel to the clinic every day for the tests but with NEMOSLAB they could do the tests themselves at home.

The project has also developed a set of probes for detecting the BRCA1 gene which is associated with breast and ovarian cancer. Several different mutations of the gene can be sensed at the same time. This opens up the possibility of screening for a predisposition to these conditions.

Low-cost, disposable cartridges that would let doctors perform diagnostic tests at the point-of-care could speed up diagnosis and treatment while lowering costs. Researchers in the European **SEMOFS** team knew that, to reach their goal of disposable cartridges capable of performing complex medical diagnostic tests quickly and at low cost, they would have to push existing technology to the limit.

"We are targeting state-of-the-art sensitivities or better," says Jerôme Gavillet, the dissemination coordinator of SEMOFS, "in a system that could be available anywhere for less than €50."

The team's goal is a polymer-based device the size of a credit card that would incorporate sophisticated technologies to control the movement of biological fluids, detect the presence of specific proteins, for example early signs of cancer, and analyse the results.

"For each patient, a physician would open the package, put some blood or serum on the card, let it work, and then connect it to a card reader," says Gavillet.

The EU-funded SEMOFS has made the greatest progress in two areas – microfluidics and plasmonics. Microfluidics involves materials and techniques for controlling the movement of minute quantities of fluids. The SEMOFS card moves blood, serum and other fluids through channels slightly wider than a human hair. The researchers developed ways to make the surfaces of the channels extra water-loving or water resistant. They used nanotechnology to structure the interior surfaces of the device's channels to 'force' fluids through channels without the need for any kind of pump.

Plasmonics uses the properties of the 'gas' or plasma of free electrons moving inside or along the surface of a conductor. The researchers found that, by carefully engineering a stack of conductive and insulating layers, topped by a layer primed to bond with the target protein, they could push the device's sensitivity beyond current limits.

"The final objective is to reach one picogram per square millimetre," says Gavillet, "i.e. to reach state-of-the-art sensitivity even on a low-cost disposable chip."

The FP7 **POCEMON** project continues to push the frontiers of lab-on-chip technologies. This project is combining new hardware and software in the form of so-called "pocket-sized labs" (i.e. labs that can be fitted onto a microchip) linked remotely to a central computer with appropriate diagnostic software. Simple blood or saliva samples will be analysed by mobile devices. During the subsequent diagnostic process, the doctor will be assisted by a knowledge management system that can link the results from the microchip with extensive data from relevant databases (e.g. medical literature, electronic patient records, etc.).

## More information

**NEMOSLAB http://www.imel.demokritos.gr/projects/nemoslab**

**SEMOFS http://www.semofs.com**

**POCEMON http://www.pocemon.eu**

**ICT and 'e-health' stories on ICT Results: http://cordis.europa.eu/ictresults (enter search terms 'health', 'e-health')**

**http://cordis.europa.eu/fp7/ict**

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## All joined up

***What was life like for doctors in the days of Hippocrates, when medical diagnoses were based on little more than a patient's described symptoms? In contrast, today doctors suffer from the reverse: information overdose. But European research is finding ways to search, select and process data intelligently. As professionals get more support to make the most of available information, patients will find that treatments improve too.***

It is all very well having amazing diagnostic systems, smart monitoring and advanced, automated devices. But health professionals often suffer from information overload. There is too much data out there – they either can't find what they need, or can't use what is available in a coherent and comprehensive way. They need help to manage their knowledge.

Governments and public health authorities also need support. They want information about the health of populations. How do they use data from millions of individuals to extract meaningful information to guide them on health risk management?

In so many areas of everyday life, from business to national security, knowledge management and decision-support systems are helping people deal with the unprecedented wealth of information that is so readily available. Information – or more specifically knowledge – is the keystone of modern society. In the health sector, where information is not just important, but can sometimes affect life or death decisions, it is important to be sure that the information available is sufficient and accurate. ICT helps healthcare to be more 'joined up'.

### Stitch it together

It is hard to imagine life without the internet – we've all come to rely on it. So have doctors who now have such a wealth of online guidance and information at their finger tips. European researchers are having to develop new ways to help health workers manage all this information and use it effectively.

The issue of interoperability is especially important in this respect. If patient data cannot be transferred between institutions, then caregivers will be limited in the information they have available; they may not be able to make informed decisions about a patient's care. The Recommendation on Cross-border Interoperability of Electronic Health Record Systems argues that connecting people, systems and services is vital for the provision of good healthcare in Europe. It states that interoperability must be addressed at four levels: political, organisational, technical and semantic.

Data mining and modelling also have the power to spot trends and make predictions about the health of individuals or a population. The move from a focus on treatment to prevention is one of the big paradigm shifts that the application of ICT in health is finally making possible. E-health can improve safety for individuals and, by identifying risks, disease clusters and potential epidemics, inform public health authorities when they need to swing into action. But all these applications rely on access to information from a variety of different sources.

Nearly 30 projects received funding through FP6 for the development of decision-support technologies and systems. These included the development

of knowledge-based, smart diagnostic systems, further refinements to electronic records and the intelligent, semantic analysis of patient records and other sources for relevant information.

FP7 takes a slightly different perspective, placing more emphasis on the management of risk, for example assessing drug interactions or monitoring compliance to treatment programmes. In 2008 the Commission allocated €30 million for projects that would develop systems to monitor and analyse adverse events, for example unwanted drug effects. In 2009, the Commission set aside a similar amount to co-fund projects focusing on safer surgery, improving interactions between clinical care and clinical research activities (e.g. streamlining patient selection for clinical trials) and the early detection of public health events.

The ICT PSP is complementing FP7 research; it ensures that new technologies will enter a market that is ripe for the commercialisation of joined up e-health systems. The 2010 ICT PSP Work Programme pays particular attention to the need to scale up e-health services and. It is also supporting EU initiatives on e-health governance.

## epSOS

When electronic patient record systems (EPR) were first developed, they focused on patient summaries and emergency data sets, the medication record and the integration of the EPR with ePrescribing solutions.

While every EU Member State is committed to deploying EPR systems in principle, some regions and countries are more advanced than others in terms of their capacity to implement proposed solutions. To enhance the possibility of these services being provided across national or regional borders, interoperability among systems and services must be achieved between the different national and/or regional systems.

The ICT PSP epSOS project aims to build and evaluate a service infrastructure demonstrating cross-border interoperability between EPR systems in Europe. The overarching goal of epSOS is to develop a practical e-health framework and an ICT infrastructure that will enable secure access to patient health information, particularly patient summaries and ePrescriptions, between different European healthcare systems.

When it was established, 12 countries agreed to participate in epSOS trials. However, recognising the importance of this work, the 2010 ICT PSP Work Programme allocates an addition €7 million to the project so that it can be extended to encompass more Member States. "An important part of the work should be on pan-European agreements for interoperability," the Work Programme states, "with the aim to improve safety of e-health services across Europe, to defragment markets and to offer better quality and cheaper eHealth solutions. It is also expected that interoperability will be addressed in a more global way by working with international organisations and considering major world markets such as that of USA."


## Projects in focus

### HAMAM
### Health-e-Child
### TEN4Health
### NetC@rds
### HEALTH OPTIMUM
### Multi-Knowledge

The **HAMAM** project is using a kind of knowledge management to improve diagnoses of breast cancer in women. Every year about 350,000 new cases of breast cancer are diagnosed in Europe, accounting for one in four of all cases of cancer in women.

As the causes of breast cancer are not well understood, the priority is to detect it early so that effective treatment can be given. Common diagnostic techniques include x-ray mammography, ultrasound and biopsy. Newer tools include x-ray tomosynthesis, magnetic resonance imaging, positron emission mammography and automated 3D ultrasound. All these techniques reveal different information about any suspicious lump and together they can help the clinician make a more informed and accurate diagnosis.

But what is the best way to use all these sources of information? That's where HAMAM comes in. The project is developing a tool that will integrate test results in one clinical workstation. The doctor will be able to compare different images side by side while viewing the patient's history and other information. HAMAM also aims to help clinicians with an element of computer-assisted diagnosis. The workstation will be connected to an extensive database of images and other clinical data. It will be able to suggest further investigations to guide the doctor in coming to a diagnosis.

Also in the field of cancer, a new software tool called AITION can integrate all the medical data from a tumour patient and then analyse it to calculate the probable factors that are stimulating tumour development, combining up to 30 correlated variables.

AITION's conclusions are displayed as a 'knowledge model', a graphical network of medical factors with links that represent the correlations between them. Strongly interdependent concepts are directly connected, loosely dependent concepts are not connected at all. The patient's doctors can play around with the knowledge model. They can improve the model by adding information they know to be true about the patient. They can use the model to test the likely effects of different types of medication, surgery or treatments on the tumour's growth and the patient's health.

"We have shown the knowledge models to doctors treating brain tumours, juvenile idiopathic arthritis, [as well as] to cardiologists and they have found it quite intuitive," says Harry Dimitropoulos, one of the researchers from the **Health-e-Child** project which developed the software. "Because of the graphical way it presents the data they have found it easy to click on the links. Some training is required if they want to look in depth at how conclusions were reached, or to modify the statistics or the graph."

The researchers' next step will be to link AITION to ontologies of medical data (exhaustive databases of facts and concepts on a particular topic) to provide even more context for AITION's probability calculations and predictions.

Even the most powerful computers cannot predict every time you might fall ill. And so sometimes the worst happens: disaster strikes when we are on holiday. Fortunately, help is at hand with better technology and cross-border administration that make the 'sun, sea and sickness' formula sound less dreadful.

Two eTEN projects developing IT-based services for cross-border healthcare provision, **TEN4Health** and **NetC@rds for eEHIC ID**, have agreed on common European messaging standards that link hospitals and other healthcare providers with health insurance organisations, and with national healthcare IT infrastructure.

The common web services agreed by the EU-funded projects are specified in WSDL, a web-services description language; messaging is communicated through XML, a software mark-up language for documents containing structured information, like healthcare records.

The agreement is considered a major step towards full interoperability of web services throughout the European healthcare sector. It could pave the way for a European standard supporting the necessary communication and data exchange processes for cross-border healthcare in Europe.

Another eTEN project has worked to demonstrate that telemedical services can cut costs and improve treatment across the continent. Participants in **HEALTH OPTIMUM** have shown how it is possible to get expert medical advice without having to be rushed off to a specialist clinic.

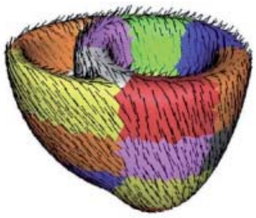
"We set out to prove the sustainability of telemedical services from an organisational and economic point of view," says HEALTH OPTIMUM project coordinator Claudio Dario. "In our two years of market validation, we found that telemedicine not only gave advantages from an economic point of view, but was very useful for the needs of patients."

"The concept of telemedicine is that you can bring the high-level specialisation of a few centres to patients all over the region," says Dario. First, an IT infrastructure was put in place to support remote but full-service neurosurgical consultation using a hub-and-spoke model.

Reorganisation of medical record keeping proved to be a crucial step. An adequate and inclusive system had to be designed to move records, such as computed axial tomography (CAT) images and lab results, smoothly and securely between a specialised centre and the peripheral clinics. With the infrastructure in place, patients no longer need to be ferried from the accident site to a surgical centre, but can simply be brought to the nearest of 60 emergency rooms in the region, says Dario.

"Our analysis showed that up to 80% of transportations have been avoided by this system, achieving a high level of savings," says Dario. "In addition, by speeding up expert assessment, telemedicine saves lives."

Combining different data sources and communication channels makes remote medicine a possibility. But ICT also offers great scope for actually generating new knowledge. The **Multi-Knowledge** project





has developed an IT platform that can combine clinical, laboratory and metabolic information with high throughput genomic data about the same individual on a large scale.

By combining information in this way, doctors and researchers will be able to analyse the correlation between the gene expression profile in the blood of an individual and their risk of developing cardio-vascular disease.

"We find pre-clinical conditions to be associated to certain genomic signatures in this population," he says. "This means that disease processes that start early might already manifest themselves in the genomic data."

For example, doctors could use the information to identify blood gene expression signatures that link smoking and cardiovascular disease (CVD) in some patients, and cholesterol and CVD in others.

If achieved, this level of understanding would provide a powerful tool in preventative medical care. Simple lifestyle changes could reduce an individual patient's risk of developing a CVD to almost zero.

## More information

**HAMAM http://www.hamam-project.eu**

**Health-e-Child http://www.health-e-child.org**

**TEN4Health http://www.ten4health.eu**

**NetC@rds http://netcards-project.com**

**HEALTH OPTIMUM http://www.healthoptimum.info**

**Multi-Knowledge http://www.multiknowledge.org**

**ICT and 'e-health' stories on ICT Results: http://cordis.europa.eu/ictresults (enter search terms 'health', 'e-health')**

**http://cordis.europa.eu/fp7/ict**


## Silicon guinea pigs?

***Most people avoid getting involved in clinical trials; despite strict ethical and clinical guidelines they still don't fancy taking the risk. The difficulty in recruiting for trials and the extra cautious protocols add significant expense to the time-consuming process of testing new medicines. Europe is spearheading an international research effort to develop computer models that simulate human physiology, from single cell interactions to whole body systems and effects.* In silico *testing is ready to revolutionise medical R&D and healthcare delivery.***

While much of the health research being funded through FP7 builds on themes developed in earlier Framework Programmes, the EU has also identified some extremely new and exciting fields of research. In particular, Challenge 5 of the ICT Theme of FP7 highlights the growing need for tools and models that will allow medical professionals to simulate what goes on in our bodies – when we are ill or healthy. Simulation is a powerful technique, and promises to enhance health research, diagnostics and treatment decisions.

The idea of a 'virtual physiological human' (VPH) stems from the work of the STEP EuroPhysiome Coordinated Action. It is a quite remarkable concept. Imagine what research teams could do with a functional human at their disposal, on whom they could do whatever experiments they wanted. Ethics and the law rightly exclude any risky or dangerous trials on humans, but with a virtual human it would be easy to assess the effects of a drug overdose, adverse interactions between two or more therapeutics or the effect of taking a medication for 20 years.

### Virtual patients

One of the biggest problems when it comes to developing new medicines or improving medical interventions is actually testing the products and protocols. Strict ethical guidelines and protocols for patient safety makes clinical trials time consuming and expensive. But the power of computing makes it possible to run extremely complex and insightful simulations. Virtual testing is now within reach.

The development of models and simulation tools for normal and pathological human physiology fulfils many of the aims of the EU Health Strategy. Simulations feed directly into more personalised medicine (you can tweak a generic model to simulate the specific effects of a therapeutic, say, in an individual patient), prevention (by observing how changes in model parameters alter the course of a simulation, then address those parameters in real life) and patient safety.

The VPH will also transform the very way that health knowledge is even generated. We will have to rely far less on animal experimentation and the large-scale, double-blind clinical trials that are so hard to run today. Simulation will provide a wealth of information, fill in many of the knowledge gaps and streamline planned trials.

The modelling scale spans from the whole body down to specific cells and the proteins they synthesise.

Results will include personalised disease prediction, early diagnosis, better surgery planning and training, and a better understanding of the link between genes, disease and treatment. The predictive models will significantly improve the diagnosis,

treatment and monitoring of the patients. Combined outputs could also help governments to manage the health of the population and identify health risks at this macro scale.

A total of €72 million was allocated to VPH projects in the first call of the FP7 ICT Theme. The bulk of this funding went to projects developing new computational models and/or data processing techniques. The areas of application included simulations for surgical training, planning and intervention; predictive and early diagnostic systems based on the integration of patient history and biomedical imaging; and physiological models designed to assess the efficacy and safety of specific drugs.

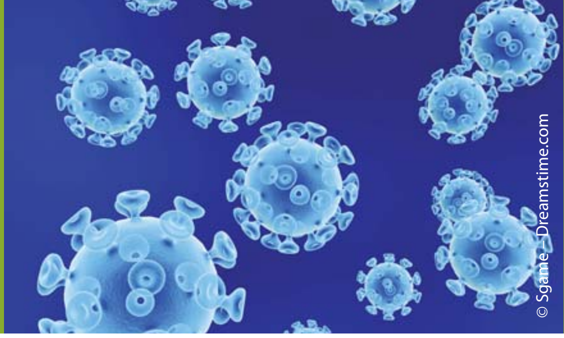
The 2010 FP7 ICT Work Programme continues to press for research in this area, recognising its potential. Projects working on specific models and simulation tools will be complemented by other actions to drive the development and deployment of the VPH forward. For example, it highlights the need for projects to develop ICT tools, services and specialised infrastructure for the biomedical researchers involved in VPH research. It also calls for an evaluation and assessment of VPH projects and studies to investigate shared tools and infrastructure, clinical achievements so far, and the market potential or penetration of the technique.

Europe is not alone on this project because it is a global initiative. But VPH research provides an excellent opportunity for Europe to take a global lead. In 2010 the Commission earmarked €5 million for projects to increase international cooperation in the field, for example in the development of global standards and interoperability. As a leader in e-health, Europe is well placed to act as the hub for VPH research; citizens stand to be among the first to benefit from the personalised and predictive platforms that this research will soon have to offer.

## Putting it all together

The FP7 METABO project shows how different areas of research can all be combined to create a powerful new paradigm for the management of the most debilitating, widespread and costly diseases. The project is building an entire end-to-end platform that should greatly improve the quality of life for diabetics. The project touches on every aspect of modern healthcare: personalisation, prediction and prevention.

Wearable monitors and wireless devices continuously record data on the vital signs, physical activity, food intake and other clinical factors for a patient. All this data is linked to other relevant information contained in databases and the patient's electronic health record or EHR. This data can then be fed into metabolic models and used to run simulations that could predict disease progression or pathologies and hence provide healthcare professions with robust advice on management approaches. Treatment regimes, for instance changes to diet, alterations to warning alarm thresholds, etc., could be discussed with patients via their mobile phones or other management devices.




## Projects in focus

### EuResist
### ViroLab

A cure for the virus that causes AIDS may still be beyond our grasp, but European researchers have developed a predictive software system for HIV that could help extend the lives of victims of the killer disease.

By focusing on the genotype of the virus – information which is inexpensive and easily available – and combining this with clinical information about the patient, researchers behind the EU-funded **EuResist** project developed new mathematical prediction models.

EuResist's key achievement was to combine data from HIV databases in Italy, Sweden and Germany, giving "probably the largest database of its kind in the world", according to Francesca Incardona, the project's coordinator.

Combining the world's largest databases and newly created software has given the project the ability to predict how the HIV virus will react in a certain person given a certain combination of drugs. And this performance is better than the current state-of-the-art predictive systems available to medical researchers, says Incardona, who is based at Italian company Informa.

All of the information is now located in a database of AIDS resistance-related information with more than 18,000 patients, 64,000 therapies, and 240,000 viral mode measurements. Compared to the existing systems, which calculate only according to single drugs, the EuResist model can account for combinations of therapies, bringing the results closer to everyday situations.

Researchers from the three academic partners – Italy's University of Siena, Sweden's Karolinska Institute, and Germany's Max Planck Institute – together with Informa have created the EuResist Network GEIE, a European not-for-profit organisation, to continue the good work of the project.

The aim of the network is to maintain the database and make both it and the predictive programs available to medical researchers and doctors all over the world. At the centre of this network is a web interface, which Incardona says will be free on the web for the global medical community.

The core components of the **ViroLab** Virtual Laboratory are also to be made available online and for free. ViroLab uses the latest advances in machine learning, data mining, grid computing, modelling and simulation to turn the content of millions of scientific journal articles, disparate databases and patients' own medical histories into knowledge that can effectively be used to treat disease.

Developed by a multidisciplinary team of European researchers working in the EU-funded ViroLab project, the virtual laboratory is already being used in seven hospitals to provide personalised treatment to HIV patients and is eliciting widespread interest as a potent decision-support tool for doctors.

"ViroLab finds new pathways for treatment by integrating different kinds of data, from genetic information and molecular interactions within the body, measured in nanoseconds, up to sociological interactions on the epidemiological level spanning years of disease progression," explains Peter Sloot, a computational scientist at the University of Amsterdam and the coordinator of ViroLab.

The system continuously crawls grid-connected databases of virological, immunological, clinical, genetic and experimental data, extracts information from scientific journal articles (such as the results of drug resistance experiments) and draws on other sources of information. This data is then processed to give it machine-readable semantic meaning and analysed to produce models of the likely effects of different drugs on a given patient. Each medication is ranked according to its predicted effectiveness in light of the patient's personal medical history.

Crucially, the system incorporates the concept of provenance, ensuring that every step a doctor takes in creating a workflow to find the right drug for a patient and every step the system takes to provide a recommendation is recorded.

Because of the distributed nature of the virtual laboratory, cases can be compared to those of other patients living a few streets or thousands of kilometres away. And the system can even generate models simulating the likely spread and progression of different mutations of viruses based not only on medical data but also on sociological information.

"Say a government has 500 million euros to spend on HIV research and wants to know whether they should focus on funding the development of new drugs or on preventive measures such as encouraging people to change their sexual behaviour. We can give them an answer as to what would be more effective," Sloot says.

The ViroLab Virtual Laboratory could be equally effectively used to create personalised drug rankings to aid in the treatment of people suffering from other diseases. It is something Sloot and other members of the ViroLab consortium are exploring in **DynaNets**, a follow-on EU-funded project that will look at drug dynamics in groups of people infected with the H1N1 flu virus and co-infections, in addition to drug-resistant HIV.

## More information

**EuResist http://www.euresist.org/**

**ViroLab http://www.virolab.org/**

**ICT and 'e-health' stories on ICT Results: http://cordis.europa.eu/ictresults/ (enter search terms 'health', 'e-health')**

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## What's inside?

Content for this publication was provided by the *ICT Results* editorial service, working to showcase breakthrough ICT research in Europe. It is part of a series of domain surveys drawn together from articles featuring EU-funded ICT research.

# ICT Results

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**Information Society and Media: Linking European Policies**

## Further information:

**FP7 ICT Work Programme**
http://cordis.europa.eu/fp7/ict/

**Information Society Policy Link initiative:**
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