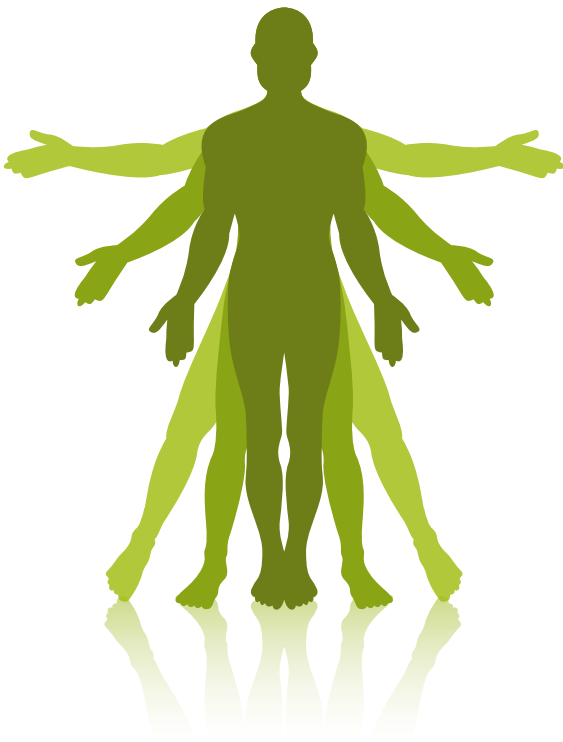


INNOVATING FOR PREVENTION AND HEALTH



TNO innovation
for life

TNO, the Netherlands Organisation for Applied Scientific Research, is one of the leading research and technology organisations in Europe. At TNO more than 3500 TNO professionals put their knowledge and experience to work in developing smart solutions to complex issues. These innovations help to strengthen industrial competitiveness and social wellbeing.

TNO has a long tradition in research and innovation in prevention, healthcare, nutrition, organizational innovation, medical technology and biomedical innovation. In this brochure, based on a symposium organized in June 2013 we outline our vision of innovation for health and care.



HEALTH: A SUCCESS STORY

Our present health care is a major success story: it has allowed us to live healthier, more productive and longer lives than ever before. The continuation of this success story in a future characterised by rapid economic and social change, technological advances, ageing and the growing importance of chronic diseases is a major challenge. These changes require a transition from the welfare state as we know it towards a society where citizens and patients are empowered to take more responsibility for their own health and all parties – business included – are geared towards prevention.

**HIGH QUALITY,
BUT STILL A LOT OF DEBATE**

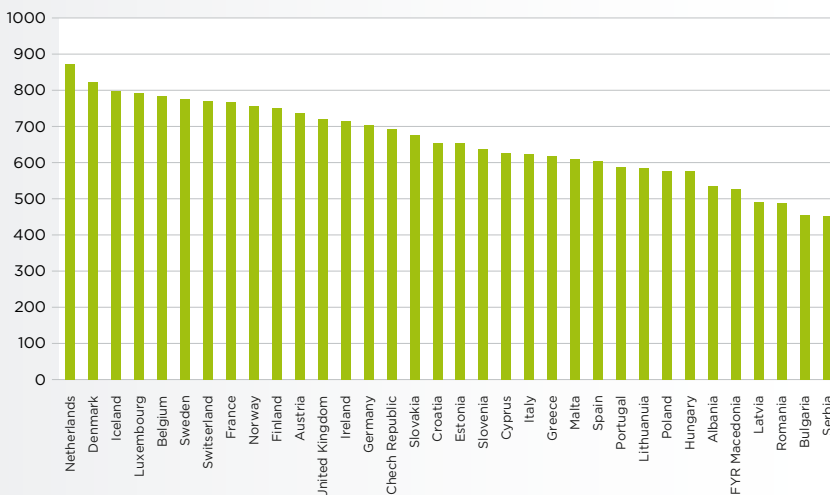
The Dutch healthcare system is among the best in the world: for many years it has ranked high in the Euro Health Consumer Index, and in first place in 2012. The Index contains 42 different indicators from a user perspective. Compared with other countries we spend a good deal of money on healthcare, the tidy sum of 87 billion euros a year. But notwithstanding this high rating, are we getting maximum value for money? And can we keep the cost of care under control?

**ROOM FOR IMPROVEMENT
IN QUALITY**

Healthcare is a complex industry: it employs some 1.2 million people, and it is the place where the high tech of extremely sophisticated equipment meets the low tech of a listening ear and helping patients to dress. It is a very complex sector partly because many different stakeholders are involved, and there are sophisticated constantly changing rules and regulations – especially financial – and above all rapid advances in medical technology. With all this ‘grinding’ it should come as no surprise that the occasional sparks fly off, as we see almost daily in the media, with complaints about insurers, medical errors and substandard treatment or even fraud.

On top of this there is a good deal of research – in the Netherlands and elsewhere – pointing to unnecessary diagnostic procedures and treatments, unnecessary visits to Accident & Emergency and GPs, expensive new equipment left underutilized, and practices and costs which vary between hospitals and regions for no clear medical reason. All in all this less-than-optimum care is costing billions in needless expenditure. Unnecessary diagnostic procedures and treatments may sometimes have serious side effects, thus causing even more expenditure. While patients and users are generally complimentary about the Dutch health service, quality and how to improve it are clearly hot topics, as everyone recognizes the importance of good health and healthcare.

EURO HEALTH CONSUMER INDEX (2012)



**CAN WE KEEP THE COST
OF HEALTHCARE UNDER
CONTROL?**

Since 2000 healthcare spending in the Netherlands has grown rapidly due to the need for cutting waiting lists, new market-oriented funding systems, the availability and funding of expensive new diagnostics and treatments, and a growing demand for healthcare from the population. Although expenditure on medicines and hospital care appears to be leveling off as a result of cost control measures overall spending continues to rise. This is mainly the result of volume growth and to a

much lesser extent the result of price increases. Total healthcare spending (including curative and long-term care) now amounts to over 12% of GDP, placing the Netherlands among the top countries in the European league (see table). If we look at care and cure separately we find that the Dutch spending is particularly high on long-term care. Dutch cure expenditure is in line with the European average, and this sector benefits from a lot of medical innovation and rising labour productivity. Keeping the cost of healthcare under control requires an integrated approach, not only taking into consideration the opportunities for families and local communities to provide more support for long-term care for the elderly, but also looking at unnecessary medical procedures, prevention and cost-saving innovations.

THE INNOVATION PARADOX

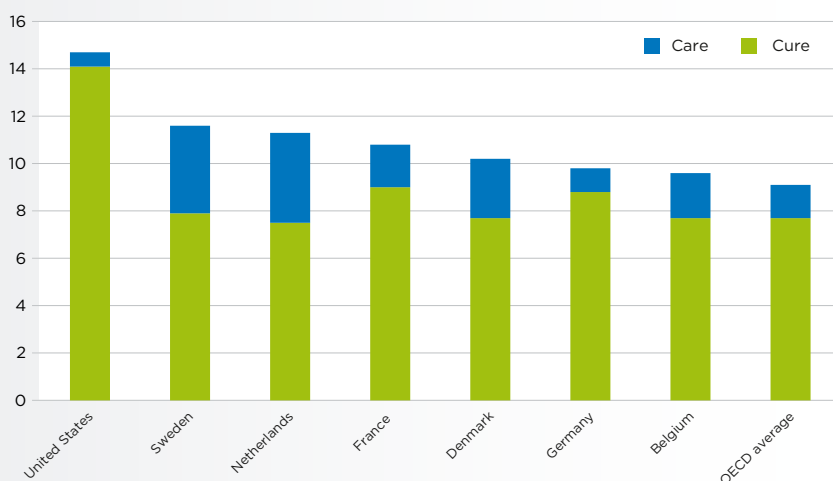
Unlike in many other sectors, where innovation leads to cost reduction, in healthcare, this often results in higher expenditure (the ‘innovation paradox’). There are two reasons for this: firstly innovation often results in better but also more expensive diagnosis and treatment (cf. X-ray versus MRI scan); secondly even cost-cutting innovations often result in wider application and thus in higher expenditure. Since care is largely publicly funded and highly accessible, volume and expenditure continue to rise. This, it goes without saying, is not a reason not to engage in innovation, but it is important to keep a constant eye on the effects of using new technology, whether there is accumulation of old and new procedures, and whether or

not particular treatments should be publicly insured and funded. And we must of course innovate, because health brings major benefits, both economic and social.

INNOVATION: THE DRIVING FORCE

The relationship between care and innovation, then, is complex. TNO’s work in this area is based on the notion that innovation is key to our future health and healthcare. Looking ten to fifteen years ahead, we foresee that the major changes will be highly ‘technology-driven’. Text box 1 gives a very brief overview of these technological breakthroughs in which also TNO is involved. Dutch society can benefit greatly from this, in that as many people as possible will be healthy and able to participate in the community. This is an enticing prospect, also given the ageing of the population! The condition, however, is that technological and social changes will need to go hand in hand if we are to avoid the ‘side effects’ overshadowing the benefits. The key message is the need to continue the success of current healthcare in a rapidly changing society, and in a future where technology plays an ever greater role in healthcare. This requires a new vision of healthcare and society where personal responsibility and citizen participation take centre stage.

EXPENDITURES ON CARE AND CURE AS A PERCENTAGE OF GDP (2010)



A NEW VISION OF HEALTH

THE ABILITY TO ADAPT AND SELF-MANAGE

In 1948 the WHO defined health as ‘a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’. At that time this definition, which stresses complete well-being, was new and radical in that it defined health in positive terms (rather than as the absence of disease). This definition is more and more difficult to apply as more and more people are suffering from

chronic disorders as a result of ageing, improved medical facilities and lifestyle disorders. According to this definition, many people could be ill for a large part of their lives! A new definition of health (Huber et al., 2011) therefore emphasizes people’s ability to adapt and cope in spite of limitations: the ability to adapt and self-manage.

TEXT BOX 1: TECHNOLOGICAL BREAKTHROUGHS AND SUPERCONVERGENCE

ICT AND E-HEALTH

ICT, e-Health, big data and m-Health offer enormous opportunities for care innovation that are at present under-utilized (remote care, video contact and telemonitoring). More and more solutions are becoming available on mobile platforms (m-Health). Social



media can help to involve people more heavily in the organization of care, as well as providing opportunities for care users to organize care among themselves. Social media show the transformative power of technology, which has changed the professional-patient relationship and relationships between patients and brought about greater transparency (see patient forums such as PatientsLikeMe). Serious games: surgeon training, fitness (‘exergames’), healthy eating, etc. In the long run the biggest revolution is likely to be brought about by ‘big data’, obtaining useful information from the increasingly large databases of all kinds that are becoming available and being linked up, not only in hospitals but also on the internet. This is where we are seeing superconvergence: personal information, e.g. from biomarkers, is sent by wireless via the internet and analysed in relation to the data pool.

MEDICAL TECHNOLOGY

This is hardware such as MRI scanners, pacemakers, surgical robots, artificial kidneys and ventilation equipment at IC units. Important developments are that devices are becoming more complex, combining more and more functions and communicating with one another (via the ‘Internet of Things’). Another trend is towards more portable or implantable technology. Breakthroughs can be expected particularly in the area where different technologies meet, e.g. Key Enabling Technologies (KETS): nanotechnology, microelectronics and nanoelectronics, photonics, industrial biotechnology and advanced materials.

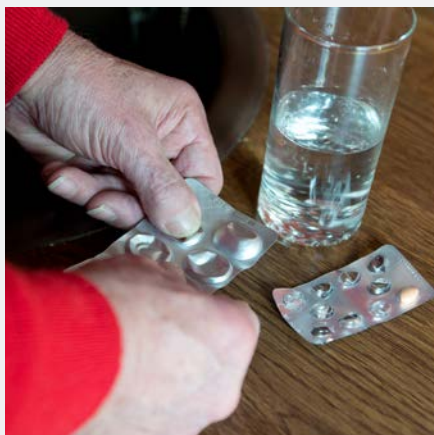
This makes health not just an end in itself but above all a means of participating in society and the labour market. This change is also related to the fact that the traditional welfare state is coming under pressure as a result of trends such as individualization, globalization, ageing and the debt crisis. New business models and partnerships between the public and private sectors and civil society are

needed to shape this 'participation society'. A participation society encourages as many people as possible to take responsibility for their own health and take part in the community. New multi-faceted technological advances, which we encapsulate under the heading of 'P4 Health and Care', could reinforce this.

TEXT BOX 1 CONTINUED

PHARMACEUTICALS

In spite of increased investment, the rate of innovative breakthroughs is declining and new drugs are often merely variations on old ones. Recent fundamental breakthroughs in genomics and biotechnology that have changed our fundamental understanding of disease processes. Biotechnology companies have taken over the leading role of 'big pharma'



and are developing completely new classes of drugs that have a far more complex molecular composition and need to be administered differently. This knowledge is making far more individualized therapy possible, i.e. 'personalized medicine'. This is a breakthrough in that we know that current drugs do not work, or work differently, in a quarter to half of patients and can cause side effects. Individualized therapy is also made possible by the combination of biomarkers and medical laboratory technology (an example of superconvergence). This will result in fewer side effects and less unnecessary expenditure on treatments that do not work. There are growing indications that what we regard as a single disease is actually a variety of conditions with different causes.

NUTRITION

Breakthroughs can be expected in understanding of the effects of chronic slight underconsumption of micronutrients on the incidence of chronic and lifestyle diseases and of the correct macronutrients for optimum health (both the correct proportions and their distribution throughout the day), e.g. to achieve stable body weight. Information is becoming available on the mechanisms that regulate food intake and the connection between excessive body weight and chronic medical conditions. The technology that shows us how the use of the genetic code can be changed by diet ('nutrigenomics') will continue to develop under the influence



P4 HEALTH AND CARE

The standard model of medicine has its origins in the 19th century and is essentially reductionist and organ-centred. It assumes a single cause and a battle ground metaphor, with an attacker (the bacterium, the cancer cell) and a defender (the immune system). It is also based on the metaphor of man as a machine. A part breaks down: there is not much you can do about it yourself, but with a bit of luck and a

good doctor it can be fixed. While this concept has been subject to change, it is still firmly embedded in our culture and the doctor-patient relationship.

The new model, on the other hand, is based on health as a complex psycho-bio-social balance. Being 'off balance' can be manifested in various kinds of symptoms, and being 'in

HOUSING AND CARE

of epigenetics (the influence of the environment on genes). Knowledge of epigenetics will enable us to use diet to preserve long-term health more effectively. Food technology is developing towards a situation where the 'easy choice' for consumers is also the 'healthy choice'. Nutrition and health will increasingly become inseparable. The main emphasis is currently still on physical aspects, but mental well-being will become more and more important.

Innovative housing solutions are essential if we regard self-sufficiency and participation as important, particularly for the elderly. There is a major role here for new combinations of housing and care, made possible partly by new technology and social innovation: technology in the form of such things as sensors, robotics and

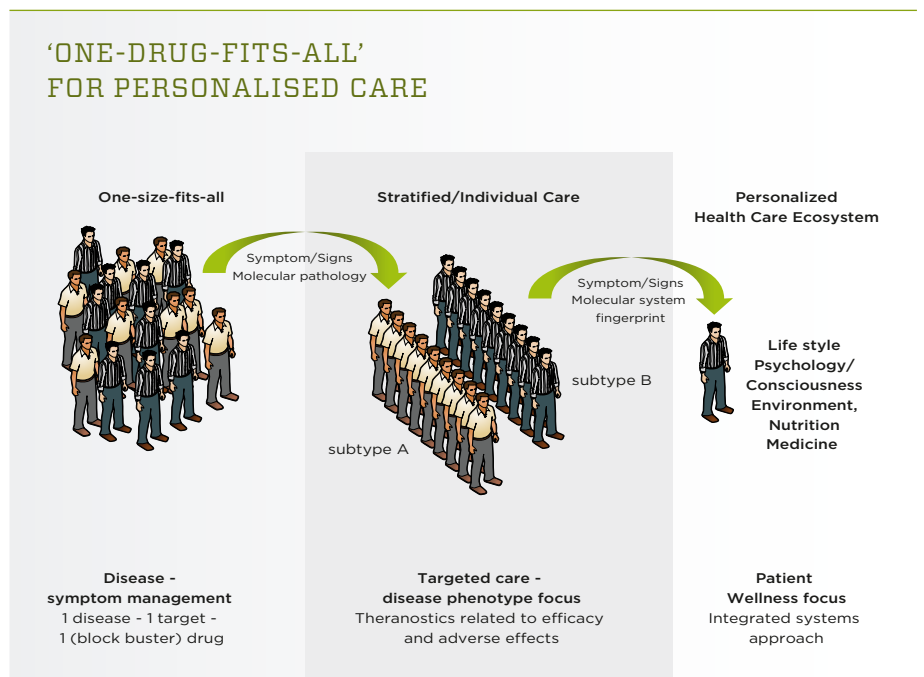
communication solutions, and social innovations such as new business models that make tailor-made services for the elderly available, as well as new forms of self-organization. Lastly, the organization of public space can make a major contribution to independence for the elderly.



balance again’ – albeit a new balance in many cases – can be achieved in various ways. The better we can define this balance in an individual, the more targeted the prevention-based ‘life action plan’ and the therapy (personalized care) can be. Thanks to technological advances this is no longer theory but can be applied in practice. Topol (2012) refers to the ‘superconvergence’ of technologies, the integration of the mobile internet, sensors, social media, genomics, information systems and so on.

An example based on the evolution of medicines illustrates the meaning of personalized care. Drugs are developed for the average of large groups of people. If a drug had good effects on average and few side effects on average it was a good one. Neither the effect nor the side effects can be effectively predicted in individual cases, however. If a much more personal diagnosis enables us to make a much more specific choice and set a much more specific dose, and combine it with healthy behaviour, there is a spectacular rise in the health benefit (see figure: one-drug-fits-all’).

We interpret personalized care broadly as P4 Health and Care, based on the four Ps: preventive, personal, predictive and participatory. The essence of the P4 concept is that people can take control of their health to the best of their ability and by acting in this way make a contribution to society. Prevention and healthy behaviour are paramount here, and this entails a major cultural change. Breakthroughs in information science and medical technology support this change, as they enable highly personal, detailed socio-psychobiological personal profiles to be developed. This allows for tailoring preventive rules for behaviour and treatments to individual patients, with better results and fewer harmful side effects. These profiles also have predictive value for future health. The vital component is active participation on the part of individuals, not only because in the end they are responsible for their own goals, choices and lifestyles, but also because they are responsible for the availability and sharing of the enormous amount of data that makes personalized diagnosis and prognosis



SOURCE: van der Greef et al. 2010

possible. Thus individuals have an active role to play in prevention and therapy, and professionals will have to accustom themselves to this shared decision-making. The P4 model promises to produce more efficient prevention and care than is currently the case, but also requires major investment and co-ordinated innovation management of the many stakeholders involved.

The prospect of P4 Health and Care is an inspirational vision of the future, if we can combine the technological elements with social change. Only then will this future care contribute to citizen participation and the population’s health actually improve, while keeping the cost of prevention and care manageable. But how are we to achieve these benefits, and how are we going to deal with potential drawbacks such as increasing medicalization due to more and more information and early diagnosis? How are we going to deal with ignorance about health (‘health illiteracy’) and the fact that people find it difficult to change their behaviour in spite of their knowledge? What value should we attach to self-sufficiency and participation? Lastly, how are we going to pay for all this? Major investments will be needed, and the benefits are as yet uncertain and will only be achieved in the long term. There are a lot of questions, then. Let us now look at the role that TNO envisages for itself in achieving this new vision of health and care.

P4 HEALTH AND CARE

PREDICTIVE	PERSONALIZED
Integrative Health diagnosis including genomics and molecular biomarkers will alert possible undesired future events.	Each individual will have a contextual diagnosis tailored to their own unique molecular and psychological profile.
PREVENTIVE	PARTICIPATORY
Integrative optimal Health advice will enable patients to make the choices that fit their unique situation best.	The passive patient will be transformed into the engaged consumer who takes ownership of his or her own health. Healthcare will become enjoyable, actionable and effective

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TNO'S AMBITIONS

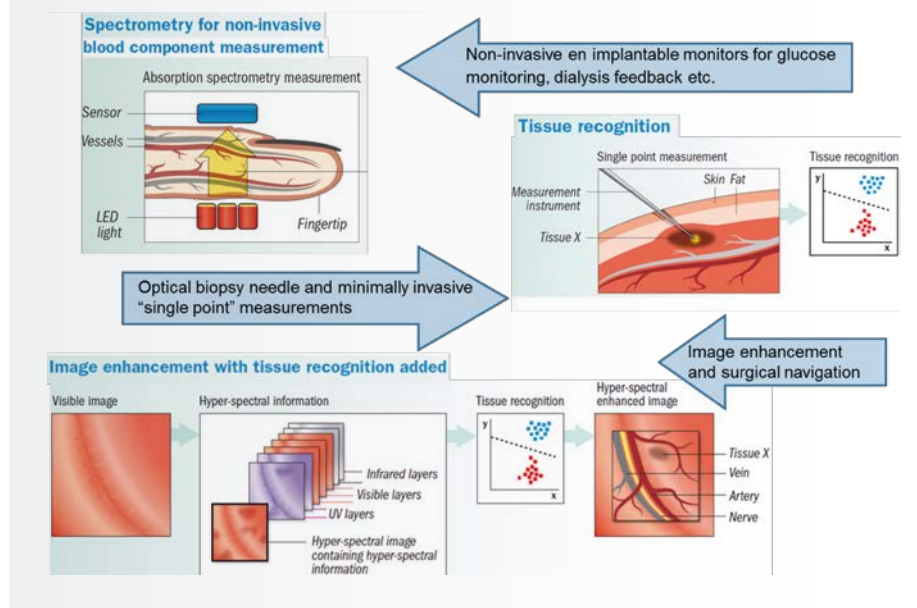
TNO's mission is to contribute with its knowledge and skills to a healthy, vital society, to sustainable prevention and care in the Netherlands, and to improving economic opportunities in the Netherlands (and Europe). Our aim is to be a knowledge and innovation partner for organizations and individuals in the Life Sciences & Health sector: to be a bridge between policy-makers, researchers, industry and practitioners with the goal of speeding up innovations – applying them broadly and in a manner that adds value.

For TNO the P4 model is a vision which helps us to plot our course. The path towards this goal, however, is one of experimentation and trial and error: experiments in the form of innovative Shared Research Programmes and what we refer to as 'Living Labs'.

SHARED RESEARCH PROGRAMMES

An example of a TNO shared research programme is the Van 't Hoff Shared Research Programme, which aims to develop new medical technology using light (spectral techniques) in innovative ways. This technology enables different types of tissue to be identified and analysed. A shared research model of this kind combines the strengths of charitable medical funds, leading research institutions, hospitals with leading specialists and innovative public and private companies with the aim of achieving new technological breakthroughs together in collaboration with local or regional authorities. The participating companies can then

VAN 'T HOFF SHARED RESEARCH PROGRAMME



TEXT BOX 2: BETTER IN, BETTER OUT

Patients undergoing surgery are much better off when they are physically fit. They recover faster and suffer fewer complications. This observation prompted the development of the 'Better In, Better Out' concept, pioneered by TNO, jointly with hospitals, the Royal Dutch Society for Physiotherapy, the Ministry of Health, the Netherlands Organisation for Health Research and Development (ZonMW) and others. Better In, Better Out aims to improve the peri-operative physical condition of frail elderly patients. Instead of passively awaiting the operation, Better In, Better Out encourages these patients to actively participate in their treatment. Patients are screened using specific prediction models for surgery related risks. Every patient then receives personal advice and in cases of physical frailty training or a nutritional program to improve their condition before undergoing surgery. In the Netherlands about 100,000 frail elderly patients are operated each year, and within this group expected health benefits are highest. A conservative estimate suggests that 100 to 160 million Euros may be saved in health care expenditure if all of these patients were to participate. TNO is actively involved in implementing further the Better In, Better Out concept nationally and internationally.

translate these breakthroughs into safe, affordable products or services that offer tailor-made functionality for which there is a real need. In addition to the Van 't Hoff Programme, TNO is involved to varying degrees in a number of similar initiatives in the Netherlands.

LIVING LABS

Living Labs are partnerships in which policy-makers, researchers and practitioners come together. Developers/knowledge suppliers, care providers, manufacturers and industry, patient and consumer organizations collaborate on a long-term basis to develop the P4 concept and put it into

practice. The success of the path to P4 Health and Care will stand or fall with the positive involvement of care professionals and citizens/patients.

This is easier in a regional Living Lab where citizens, the authorities, professionals and developers have the opportunity to get to know one another; even more so if there is a clearly defined population whose prevention and care needs can be identified. We also need to be on our guard for over-optimistic expectations if we are to avoid disappointments. It will be a complex transition process, requiring more time than the average project or a government term of office. Social and cultural changes will be

needed in an area that people regard as the core of our high standard of living. Also, our unhealthy lifestyle has developed over decades. Conversely, the initial success stories must be properly highlighted as the first steps towards future P4 Health and Care. TNO is already involved in a number of living labs of this kind. Two examples are the Better In, Better Out initiative (Text Box 2), while an example of a regional Living Lab is presented in Text box 3. In addition TNO is working on specific technological solutions to improve health as show in text Box 4.

TEXT BOX 3: LIVING LAB INTEGRATED CARE AND CASE MANAGEMENT IN AMSTERDAM

The borough of Amsterdam North is a suburban area with high unemployment, low SES and health problems. The Living Lab Amsterdam North aims to improve the health situation of the local population, quality of life as well as participation in society and labour market. The Living Lab does so through the integrated provision of services (care, cure and community) aimed at health, work and social activation. This case of social innovation requires the effective collaboration of many: providers of healthcare and social services, a medical insurance company, the local government and TNO. This change – both in system as in professional attitude – equires a major transition from a focus on sickness and care towards healthy behavior and participation. To monitor progress in this complex transition some 20 performance indicators are monitored focusing on the local population, health care providers, local government, civil society and insurance.

TEXT BOX 4: REDUCING SALT LEVELS IN BREAD

Bread is major source of salt consumption in the Netherlands. And salt is an essential ingredient in the taste of bread. TNO has related new insights on the functioning of salt receptors on the human tongue – i.e. that contrast in taste is important – to innovative baking processes. TNO found a way to ensure that bread with less salt does not loose the taste that consumers appreciate. By alternating layers of dough with higher and lower salt levels, the bread appears to taste saltier than it actually is. This results in a 28% salt reduction without the consumer noticing.

› THE ROLE OF TNO

TNO invests in innovations which contribute to a participation society that enables individuals to take responsibility for their own health and social participation, actually improving health and participation while keeping the cost of prevention and care manageable. The Living Labs and Shared Research Programmes show how we deal with the complex reality of technological and social innovation, moving towards the prevention and care of the future with our partners. We work together with partners who are building this future with equal enthusiasm. We are stepping up our collaboration with prevention and care providers and professionals, patient and consumer organizations, manufacturers and developers, local authorities and insurers. We do this in consultation with government (primarily the Ministries of Health, Welfare & Sport, Social Affairs & Employment and Economic Affairs) as regards investing our knowledge.

If you are interested in exploring these issues further we shall be happy to exchange ideas with you on health and care in the future.

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TNO

STRATEGY
CHANGE