

# Personalised Health

Optimisation of health through a person-centered approach

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TNO's innovative approach offers opportunities for science-based lifestyle and nutrition advice.

**TNO** innovation  
for life



# Contents

## Introduction [p.3](#)

[Optimisation of health through a person-centered approach](#)

## 1. Sense, reason & act [p.4](#)

[Three pillars in Personalised Health](#)

## 2. Sense [p.5](#)

[How resilient is your metabolism?](#)

## 3. Reason & act: [p.6](#)

[From measurement to advice.](#)

## 4. The 360° diagnostic tool [p.7](#)

[Broad view on Personalised Health](#)

## 5. Step towards implementation [p.8](#)

[From science to market](#)

[Ancora Health](#)

[MixMasters](#)

[Johnson & Johnson Consumer Health Company](#)

[SLIMMER<sup>+</sup>-study](#)

## References [p.13](#)

# Introduction

## Optimisation of health through a person-centered approach

We are all getting older, but enjoying a long and healthy life is not a given. Our quality of life is declining. Although our lifespan continues to increase, our healthy years have declined. In short, we are mostly living longer but in poor health<sup>1</sup>. More and more people are developing chronic, lifestyle-related conditions, such as type 2 diabetes, obesity and cardiovascular disease<sup>2</sup>. Fortunately, these kinds of diseases can be tackled or even prevented with lifestyle modifications. However, 'one size doesn't fit all' applies to lifestyle advice<sup>3,4</sup>; it is precisely a tailor-made approach that makes the required behaviour change more likely to be maintained and subconsciously integrated into daily life. In this paper we bring science into practice! Read all about the latest solutions and organisations TNO cooperates with.

### Personalised Health Research Programme

In the Personalised Health research programme, TNO has developed knowledge, methodologies and technology for companies and healthcare that can translate personal data into a personalised

intervention that suits users from diverse target groups.

Consider, for example, personalised advice regarding diet and exercise tailored to users' individual biological characteristics including their tastes and other preferences. This can include information for meal recipes, meal boxes, a personalised vitamin combination as well as an app or wearable that can adequately provide people with the right lifestyle advice at the right time.

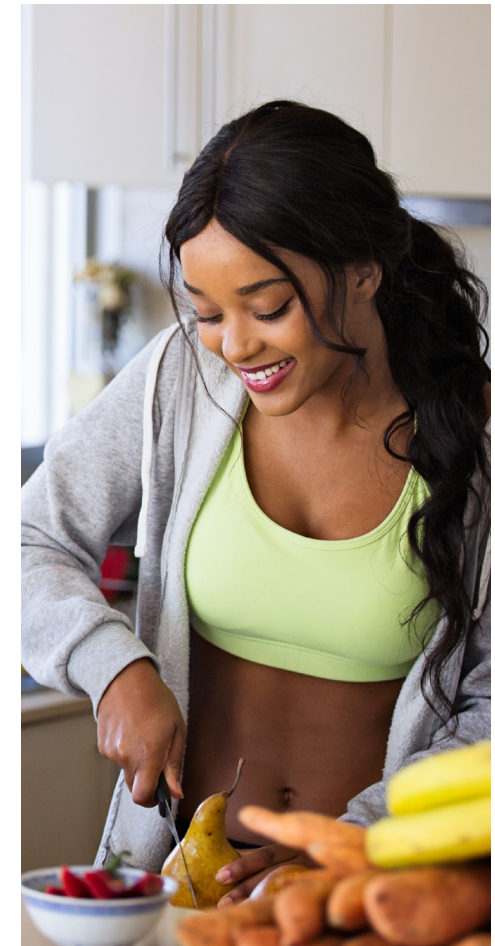
**“Within the Personalised Health research programme, TNO has developed innovative methodologies to provide personalised lifestyle advice to improve health. A systems approach: from measuring health factors to sustainable healthy behaviour change”**

The PhenFlex test developed by TNO is an important method that often underpins these recommendations. The test is based on a standardised 'milkshake' that reads

out a person's metabolic resilience based on differences in blood values.

But it is not just biology that determines a person's health. Psychology, behaviour and social context also play an important role, for example in TNO's '360-degree diagnosis'. This provides a fuller picture of the individual to arrive at the most urgent and appropriate lifestyle intervention.

So a systems approach: from measuring health factors to sustainable healthy behaviour change. TNO is working with various partners to translate this acquired knowledge into various personalised practical applications.



# 1. Sense, reason & act

## Three pillars in Personalised Health

With various partners, TNO is committed to translating this knowledge of personalised health into real-world applications. TNO helps partners and companies using three pillars that are important in such innovations: Sense, Reason & Act (Figure 1).

### Sense

is about selecting the right scientifically validated measurements to assess a person's health status from a 360-degree perspective. This can be very diverse, from in-depth phenotyping (PhenFlex test), to continuous measurements with wearables, for example. Depending on the purpose, we select the measurements that are most appropriate.

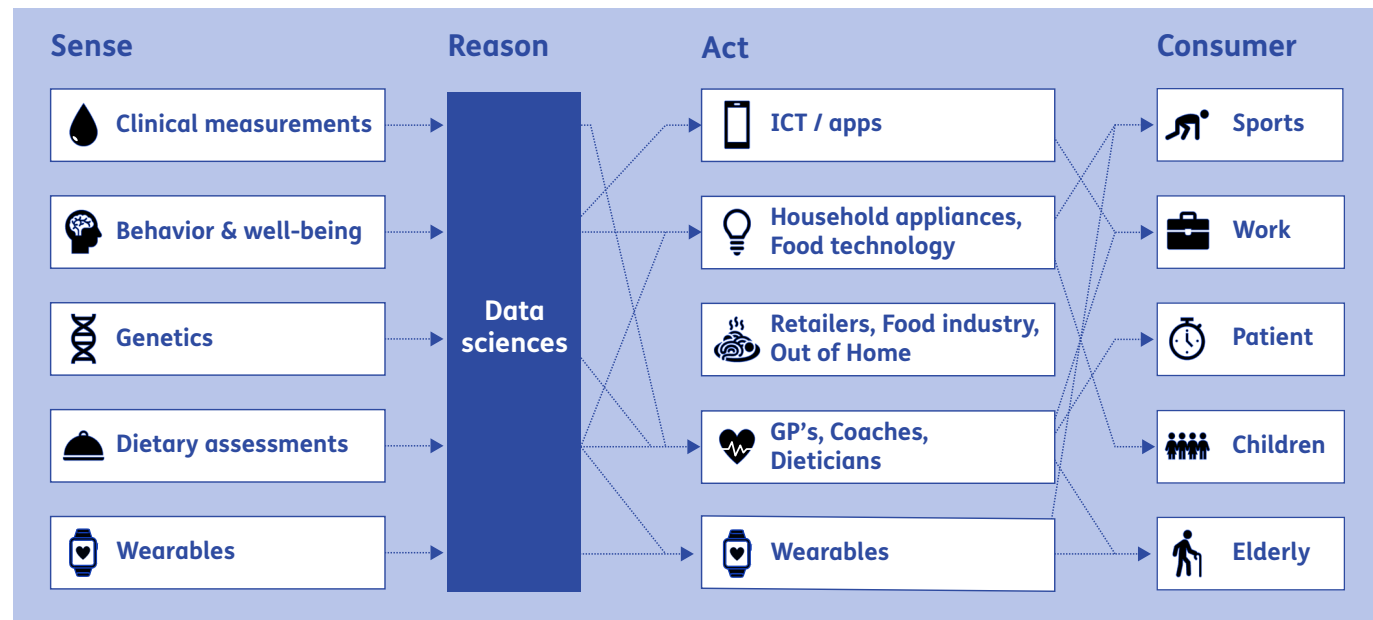
### Reason

is the scientific model that translates personal data from these measurements into health advice. The model is modular, allowing us to create an optimal health advice system with 'plug-and-play'. Depending on the application, artificial intelligence is applied to further refine the health advice.

### Act

is all about the form of the health advice. ACT focuses on the determination of the right lifestyle support, based on someone's personality, behaviour and preferences to support sustainable behaviour change to prevent or reverse lifestyle-related disorders.

The health advice form can be very diverse: an eHealth Coach who can accompany people at home, a personalised meal box, but also a 3D printer that can produce a personalised food product in the right way.



**Figure 1.** The three pillars that are important for innovative products and services in personalised health are Sense, Reason and Act. Personal health advice is built up through these pillars, through measurements, a scientific model that translates personal data into advice and the form of the health advice fitting to the consumer segment where it will be used for.



## 2. Sense:

### How resilient is your metabolism?

TNO has years of research experience in monitoring biomedical and digital health parameters and developing personalised lifestyle interventions. Metabolic status can be measured by applying metabolic challenge tests. These measurements are based on the so-called 'phenotypic flexibility' that everyone naturally possesses and give an indication of the shock absorption capacity of the metabolic regulatory system (see box 'metabolic challenge test').

TNO's knowledge of metabolic resilience is often used as a starting point to develop personalised advice. However, that does not mean that personalised advice will come about from this challenge test approach alone. Personalised lifestyle recommendations combine different types of both objective as well as subjective measurements. These can be clinical measurements (such as blood measurements of various biomarkers, functional tests) but also genetic information and data from wearables (such as a smartwatch and/or continuous glucose monitors) combined with validated questionnaires around personality and

wellbeing, lifestyle behaviour, as well as the inclusion of taste preferences and personal goals.



## 3. Reason & act:

### From measurement to advice

The chosen set of measurements must then be translated into advice. Depending on the target group and what the possible requirements are for the final personalised service and/or product, the various types of measurement are assessed on aspects such as duration, validity, feasibility for a user, costs, and subjectivity and/or objectivity of a measurement. For the final selection of the set of measurements, scientific validity is important, as well as the linkage to a specific substantiated lifestyle intervention.

To go from measurement to advice, TNO's intelligent modular advice system is used, a knowledge base that contains various decision trees, algorithms, data science models and artificial intelligence that can be flexibly integrated with a 'plug and play' principle for specific user purposes. We advise our customers on how to use this 'intelligent' advice system for their application.

#### Metabolic challenge test

With a standardised nutritional challenge test (for example, a mixed meal test such as the PhenFlex milkshake, a muffin or the glucose tolerance test), metabolic regulation is temporarily disrupted.

It then uses a time series of biomarkers to determine how quickly physiology returns to normal and thus how flexible the system is. Based on this information, early health derailment can be identified sooner and with higher sensitivity. Moreover, in people with metabolic diseases, such as type 2 diabetes, such a test can be used to pinpoint the biological cause of the disease (this is called diabetyping). This provides insight into the functioning of various metabolic processes and enables the deployment of specific lifestyle interventions that have been scientifically established as being capable of improving these dysregulated mechanisms. In this way, the lifestyle intervention can be tailored to personal physiological characteristics.

In the context of maintaining and/or improving health using this approach developed by TNO, a nutritional real-life study was conducted among employees in the United States. This showed that a personalised nutrition programme promotes employees' lifestyle habits and health<sup>5</sup>. Another TNO example is a study conducted in Dutch primary health care practices (the Hillegom study), in which tailor-made lifestyle treatment was offered for the first time to a group of people with early onset type 2 diabetes. This proved clearly to be more effective than usual care<sup>3</sup>.

## 4. The 360° diagnostic tool

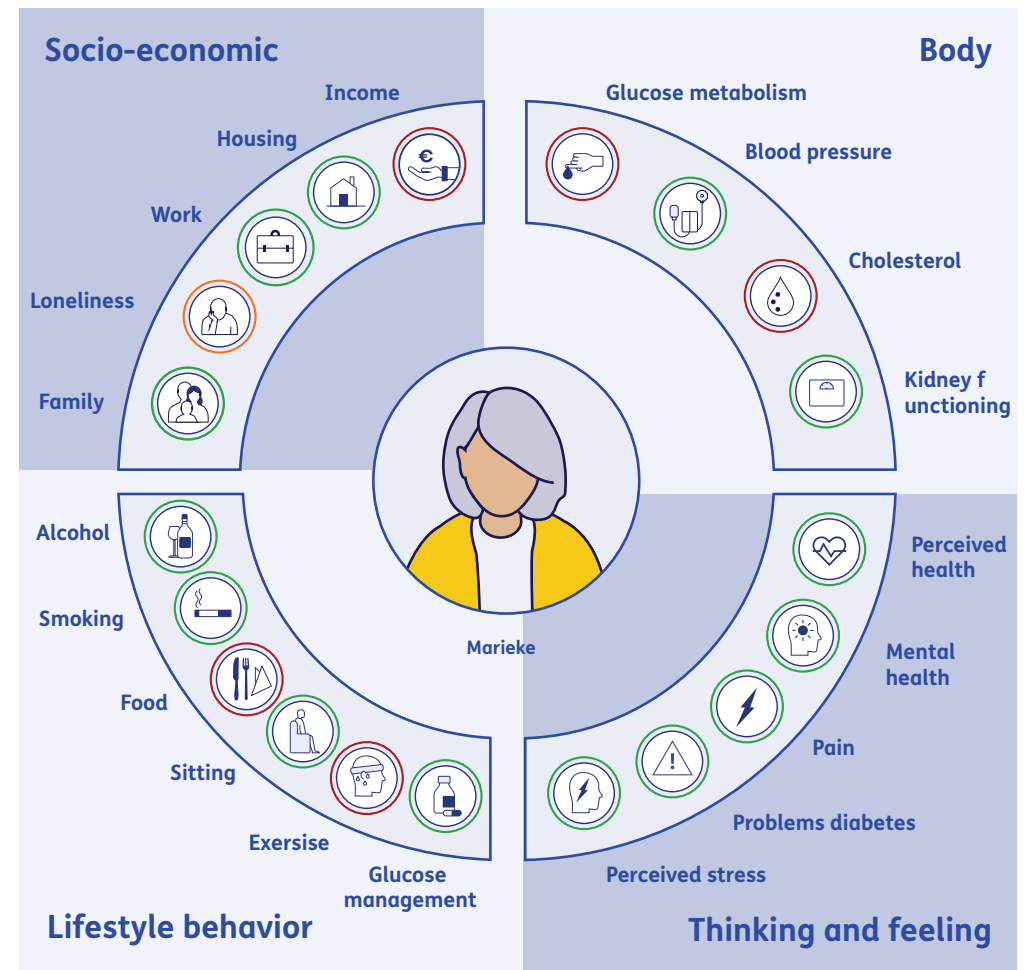
### Broad view on Personalised Health

An example of a systems Personalised Health approach is the 360-degree (360°) diagnostic tool, developed to gain a broad perspective on the health status of people with type 2 diabetes and provide them with a personalised lifestyle advice<sup>6</sup>. The aim is to use this as the basis for improving cooperation among healthcare professionals and with users, for example, people with type 2 diabetes, as well as to promote self-management, empowerment and informed decision-making.

The 360° diagnosis includes clinical measurements of physical health – clinical chemistry, blood pressure, anthropometric measurements and diabetyping based on the extended oral glucose tolerance test – and questionnaires on lifestyle behaviour, mental health and socio-economic & environmental factors. The personal biomedical and psychosocial data are via algorithms processed into a personal profile wheel in which via traffic light colours it is being visualised which aspects of health need more or less attention (Figure 2).

Based on this, a personalised lifestyle advice is formulated by the user in

consultation with a lifestyle coach, practice supporter or dietician. Lifestyle behaviour and several aspects of health is monitored through a blended care approach and the 360° diagnosis can be repeated at a later time. An initial feasibility study shows that the 360° diagnostic tool contributes to improved health and that participants and healthcare professionals are positive about it.<sup>7</sup>



**Figure 2.** The '360° diagnostic tool' developed by TNO for healthcare professionals for motivational interviewing with their client or patient. Each quadrant represents the main health aspects discussed.

## 5. Step towards implementation

### From science to market

TNO has developed Personalised Health knowledge and technology prototypes with and for companies, knowledge institutes and healthcare professionals, and advises on how to use and convert these scientific knowledge and tools into concrete products and services. These include personalised nutritional advice, implementation of behaviour change technology to encourage healthy choices and testing the efficacy of developed personalised products and/or services on health.

Four organisations explain how they accelerated from science to market together with TNO:

- Ancora Health
- MixMasters
- Johnson & Johnson Consumer Health Company
- SLIMMER<sup>+</sup>-study





# Ancora Health

“Together with TNO, we are looking at how to get away from ‘one size fits all’ solutions and how we can apply this to type 2 diabetes. Although the symptoms are the same, type 2 diabetes can have different causes. TNO’s knowledge of diabetyping is of enormous value and can accelerate a personalised approach to diabetes care.”



## Ancora Health

Ancora Health was inspired by the Hillegom study and is putting this approach – a diabetes lifestyle programme within healthcare – into practice.

Ancora Health helps people to improve their health with an innovative offer of preventive health and care programmes. “We would like to empower people to make their best lifestyle choices to prevent chronic disease, and if chronic disease is already present, then to reverse the metabolic disease. We particularly focus on cardiometabolic disorders,” says Sridhar Kumaraswamy, CEO of Ancora Health.

Ancora Health plans to conduct a large study in which diabetyping is the starting point for personalised lifestyle interventions to put type 2 diabetes into remission. “Ultimately, the aim is to use diabetyping to create a personalised plan for diabetic patients. We are thinking of a blended approach where an app combined with personal coaching inhibit the progression of diabetes. With this innovative vision and approach on lifestyle interventions, we have the future in our hands,” says Kumaraswamy.

# MixMasters

“Using TNO’s intelligent advice system, the results of the phenotype test can be converted into a profile of the optimal macro- and micro-nutrients for a person.”



## MixMasters

MixMasters has been working on personalised nutrition since 2019. “We develop, manufacture and package Powdered food products and sports supplements.

We are looking at how we can make healthy food accessible in innovative ways,” says Tom Geleijnse, CEO of MixMasters. “The big question we wanted to answer is how to do an extensive personalised test and still remain user-friendly. We researched personalised food product and supplement development based on DNA profiles. The problem is that the user has to do a saliva test, which needs to be sent to a laboratory and which has a relatively long analysis time and high cost.

We came to TNO asking whether it was possible to develop a DNA self-test where the result would be known within an hour, like a pregnancy or COVID-19 self-test. That proved unfeasible within our conditions at the moment, and in consultancy of TNO, we quickly switched to a phenotype test. A phenotype test – consisting of a questionnaire (to evaluate the user’s fibre intake and type and degree of exercise) combined with anthropometric measurements such as weight and waist circumference – was developed and an idea for a new concept was born; FoodiYou.

“Using TNO’s intelligent advice system, the results of the phenotype test can be converted into a profile of the optimal macro- and micro-nutrients for a person. The idea is to offer a complete package of fresh meals based on a person’s profile and goals. We are now looking at how to bring this concept to the market,” Geleijnse explains.



# Johnson & Johnson Consumer Health Company

## Johnson & Johnson Consumer Health Company

Gabriele Ronnett, who helps lead Medical Sciences & Systems Health at Johnson & Johnson Consumer Health Company, has been in contact with TNO for many years. “When I was still working in another position at J&J, I came into contact with TNO and was amazed at the collaborative resource that I had found. I found TNO’s Personalised Health research visionary. I was surprised by how mature the research already was.

It’s great to see how TNO is addressing the question of how we can bring personalised health advice to people. This combination makes TNO an ideal party to work with. TNO can use its methodology to help assess personal health status and link this to valid interventions to optimize health. In several projects we have collaborated on nutritional strategies to modulate inflammatory dynamics in metabolic disorders<sup>8</sup>. Ideally, you want to give people real-time feedback on how their metabolism is functioning.

If we understand what goes wrong in diabetes and other chronic lifestyle-related diseases and which biomarkers are relevant to recognize at an early stage that someone is moving towards illness, then we can come to a solution. We can determine how to use nutrients, diet, and lifestyle modifications to prevent disease on a personal level. We will continue to work on that together,” emphasizes Ronnett.

“I found TNO’s Personalised Health research visionary. It’s great to see how TNO is addressing the question of how we can bring personalised health advice to people.”



# SLIMMER<sup>+</sup>-study

“Using the 360° diagnostic tool, we had all kinds of data already available before intake. This provided a basis for going through all aspects of health with the patient in a structured way, providing insight into how someone is doing and, as a result, it allows you to better coach and guide that person.”



## SLIMMER<sup>+</sup>-study

SLIMMER is a combined lifestyle intervention (CLI) for overweight adults that are at increased health risk. Within the SLIMMER<sup>+</sup> study, this existing intervention was personalised, implemented and tested, based on TNO's Personalised Health knowledge and technology. It is expected that with this personalisation, the CLI will increase the essential sustainable long-term behaviour change. Wytse Brongers (physiotherapist at Leidsche Rijn Julius Health Centres) and colleagues run the SLIMMER-CLI and participated in TNO's research into a personalised version of it.

They used the TNO's intelligent advice system, the PhenFlex challenge test, the TNO user portal and a few of TNO's selected and own developed measurement tools and tested these in a real-life setting on people at risk of type 2 diabetes. “Using the 360° diagnostic tool, we had all kinds of data already available before intake. This provided a basis for going through all aspects of health with the patient in a structured way, providing insight into how someone is doing and, as a result, it allows you to better coach and guide that person.

The use of a Fitbit and TNO's 'How Am I' app, to let users set personal health and lifestyle goals, were also a valuable addition. All these tools help to provide the health care professional a more complete picture of the person in front of you. The personalised variant of the SLIMMER-CLI is a nice addition to the current programme,” Brongers explains.



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## Context

This publication is in line with the Dutch Innovation Centre for Lifestyle Medicine, an initiative of TNO and LUMC that aims to make self-management of health and lifestyle interventions an important pillar of healthcare. The Dutch Innovation Centre for Lifestyle Medicine is an open, national platform that connects, coordinates and increases impact under the name Lifestyle4Health.

Lifestyle4Health and this publication are the result of the Early Research Program Personalised Health, a multi-year TNO research program that focused on research into the prevention and treatment of lifestyle-related diseases by means of a person-tailored approach.

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## Can we help your organisation?

Do you develop product concepts in the Personalised Health domain? Are you looking for evidence-based knowledge and technology related to personal health advice? We would be happy to help your organisation. Contact us if you would like to get started with our evidencebased knowledge and technology to offer personalised advice to your clients or patients.