Midterm review NUTRIM 2021-2023

Metabolic Health | Liver and Digestive Health | Healthy Ageing

Preface

The NUTRIM Institute of Nutrition and Translational Research in Metabolism is one of the research institutes of the Faculty of Health Medicine and Life Sciences (FHML) of Maastricht University. As from July 2024 the previous term School was replaced by Research Institute in line with the faculty regulation, the term Research institute (and Research Institute Council (RIC)) is used in the current midterm review.

The midterm review is based on a self-assessment using the light version template of FHML and building on the action plan upon the recommendations of the independent external review over the period 2014-2020. Related strategy meetings resulted in refining our key research areas. Accordingly, per August 2024, the 3 divisions have been redefined as 3 research areas. In the current report the term division is used for evaluations over the period 2020-2023. The term 'research areas' is introduced for the future strategy.

Content

1. Reaction on and follow-up of the recommendations of the External Review Committee

In November 2021, NUTRIM was reviewed over the period 2014-2020 in line with the Dutch Strategy Evaluation protocol. The external review committee (ERC) **highly appreciated the positioning of NUTRIM, its research quality, output, infrastructure and link with the academic hospital Maastricht**. Further, they **stressed the unrivalled potential of NUTRIM to span the fields of nutrition and medicine and to step up in a leadership role in this and the prevention field**. The follow up of the recommendations of the ERC as described in the NUTRIM Action Plan (AP; see also Addendum 3) is given below.

Follow up of recommendations on research expertise and strategy

In line with the ERC advice (AP 1), an **international strategic advisory board has been installed** covering a broad range of NUTRIM expertise (Prof. GJ Navis, Prof. P. Calder, Prof. Y Boirie, Prof. N. van Meeteren, and Prof. E. Kampman). The first annual meeting is scheduled for December 2024. A **first stakeholder meeting (AP 2)** is planned in Q2 2025 and will be scheduled every 3 years. The latter ascertains input from **relevant patient organizations and other stakeholders to include their perspective** and topics of relevance in the strategy of NUTRIM, as recommended by the ERC. NUTRIM is taking a proactive strategy (*e.g*. via the Research Institute council (RIC), annual Planning & Control (PC) meetings with department heads and via Development boards) to stimulate stakeholder involvement when setting up studies and knowledge dissemination via various media (see also Figure S4). Various NUTRIM researchers are in close contact with relevant patient organizations and fulfill positions in *e.g.* advisory boards, guideline committees and are active in patient information sessions (see also Table S3 for representative examples).

In strategic meetings with the Management Team (MT) and the RIC, NUTRIM has **evaluated its research expertise and strategy,** leading to slight adjustments **to further strengthen the profiling of key expertise, connecting themes, and the focus of division 3 (AP general recommendation)**. Largely in parallel with the prior divisions, three key research areas have been defined with five overarching research themes in line with NUTRIM's expertise and strengths (see also Figure 1; **AP 4/5)**. Whereas researchers are preferentially embedded in one research area (led by 2 Principle Investigators (PIs)), NUTRIM **stimulates collaborations and exchange of expertise between research areas** by organizing **thematic meetings** and **infrastructural collaborative initiatives** (*i.e*. Complex Big data analysis, NUTRIM analytics, Joined Imaging Meetings) **(AP 4/5).** As examples, a cross-department "Cancer Metabolism expert group" is formed and a cross-department Big Data Analysis Team developed a 2-day hands on course on complex data analyses tailored to the needs of NUTRIM researcher as identified in this inventory. Further, several **new projects spanning different research areas and departments** have started/been submitted, including cross-institute and inter-faculty collaborations. This also benefits research on the **inter-organ crosstalk** (**AP 6**), which is a strong asset of NUTRIM, as is **the field of gut physiology (AP 6)** where NUTRIM PIs have leading roles (inter)nationally (see also Table S3). Gut physiology, including the microbiome, is embedded in an increasing number of NUTRIM studies in the different research areas (see also Addendum 2 case study 2).

Apart from collaborations between individual PIs, the **NUTRIM translational research can further benefit from intensifying collaborations with other research institutes including MERLN** (on regenerative medicine and use of biomedical model systems), **M4I** (on molecular imaging) **and other faculties including FSE** (on Advanced Computing Science, AI, and Systems Biology) **(AP 6)**. This warrants a pro-active strategy for which exploratory meetings will be organized (Q1/2 2025).

As part of the strategic discussions, previous **division 3 (Respiratory and age-related health) has been renamed** as "Healthy ageing", including aging per se, chronic diseases exemplifying ''accelerated ageing" (*e.g.* lung/kidney) and impact of environmental factors and host susceptibility **(AP 7**). This is accompanied **with an update of the research area description and strategy** (see also Addendum 4).

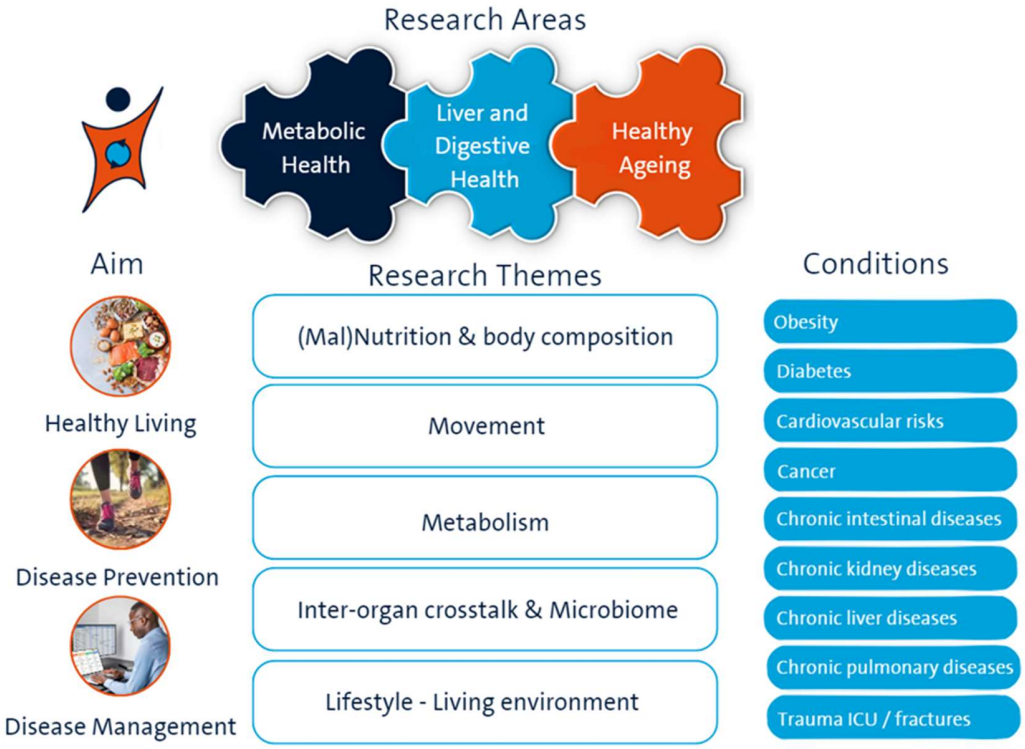


Figure 1: NUTRIM Institute of Nutrition and Translational research in Metabolism aims to contribute to personalized approaches for healthy living, disease prevention and disease management in three main research areas: Metabolic health, Liver and digestive health, and Healthy ageing.
Key themes include '(mal)nutrition & body composition ', 'movement', 'metabolism', the 'inter-organ cross talk including the microbiome', and the impact of 'lifestyle and living environment'. These are addressed in all three research areas, stressing the shared expertise and inter-connection. Research is performed in the context of various prevalent non-communicable conditions, unraveling lifestyle- and disease-specific derangements, and taking into account inter-individual differences.

NUTRIM has a strong link with the academic hospital Maastricht (AP 8). The recent Maastricht UMC+ (MUMC+) internal evaluation ('Portfolio analysis') highlights NUTRIM's relevance in four of the eleven clinical spearheads identified, *i.e*. Metabolic derangements, Hepato-pancreato-biliary disease, Neurogastroenterology and Lung disease (see also Figure S2).
To further exploit the field of 'nutrition and medicine' as advised by the ERC **(AP 8)**, NUTRIM has strengthened the collaboration with the academic hospital Maastricht *e.g.* by active steering on (tertiary) prevention (2.1 fte via the sector plan Health promotion theme and 0.1 fte extra for Prof. M. Crone on 'The connection between prevention and care'), and by taking active roles in the academic hospital steering group 'Vitality', the FHML minor Lifestyle Medicine, and Student en Lifestyle lectures. Further, NUTRIM, together with departments, invested in high potentials in clinical departments (*e.g*. Surgery, Pulmonology, Gastroenterology, Medical Microbiology),

supports the “academization” of the Dietetics department, and started new projects on *e.g*. pre-habilitation, improving nutritional status during hospitalization and implementing lifestyle in the outpatient setting. The NUTRIM Clinical Research Unit (CRU) within the academic hospital Maastricht (officially opened January 2023), being part of the NUTRIM Metabolic research infrastructure, facilitates (complex) studies in patients and is now joining forces with CARIM as the MUMC+ NUTRIM/CARIM CRU.
Prevention (AP 3) is an emerging theme of the MUMC+, regional, national, and EU healthcare/research agenda. **The investment in (tertiary) prevention** and the widely recognized expertise on *e.g*. nutrition, movement, metabolism, and health promotion, is optimally exploited to advance and implement preventive strategies. On one hand, NUTRIM is joining forces with CAPRHI and the academic hospital, on the other hand NUTRIM has adopted UM Campus Venlo research line ‘Healthy eating and food innovation (HEFI) 2’ and is taking a leading role in its positioning of Sustainable and healthy Nutrition at Brightlands Campus Greenport Venlo. The latter also includes collaborations with the municipality Venlo and Vie Curie Medical Center.

An important ERC general recommendation was the advice **to step up (inter)nationally and to take a leading role** in the field of “Prevention” and “Nutrition and medicine”. These are key expertise and strong assets of NUTRIM.
NUTRIM staff members do fulfill prominent positions in various national and international committees (see also Table S3). To strengthen a leading role, NUTRIM actively stimulates applications for strategic roles and taking the lead in (inter)national initiatives, guideline committees, will invite relevant stakeholders for their stakeholder meetings and is planning partner visits. Further, NUTRIM will make this as an important point of discussion with the NUTRIM Advisory Board. Additionally, a dedicated marketing and communication officer has been appointed to increase NUTRIM’s visibility by improving the NUTRIM website and establishing an active communication strategy via *e.g.* newsletters, (social) media (such as LinkedIn, L1 testhelden) and science stories (see also Figure S4).

Follow up of HR recommendations

NUTRIM underscores the values of **equality and inclusivity (AP 9).** The topic is adopted by two NUTRIM MT members and was prioritized at the annual NUTRIM symposium 2023. An open and interactive workshop (entitled “NUTRIM embraces all voices”), organized together with PhD-candidates, will take place in November 2024 and is scheduled annually. The topic of inclusivity has been extended by involving representatives of different NUTRIM staff groups to the RIC and to scientific research by stressing the relevance of diversity in study participants and extrapolation/translation of findings.
The **tension** mentioned **between general teaching responsibilities and research (AP 10)** is recognized and has NUTRIM’s continuous attention in *e.g.* the MT, RIC, annual PC meetings with department heads, and in the Development Boards. It is also addressed in periodic meetings with the faculty board and is on the agenda of the FHML Education Institute. NUTRIM stimulates a maximum of 10% teaching by PhD-candidates, which we belief benefits their development and at the same time brings some relief for staff members. The Sector plan positions and Starter Grants do support the group of early-career scientist. To aid the small group that did not receive a starter grant, NUTRIM used an Incentive grant (‘stimuleringsbeurs’) to provide them with a seeding grant.
Timely completion of PhD trajectories as well as complete ‘Personal Research Plans’ and ‘Training and Supervision Plans’ has our attention during the various meetings with PIs and department heads **(AP 11)**. Further, the NUTRIM website has been improved to provide centralized access to information on PhD training & education, as well as on scientific integrity, social safety, and general wellbeing.

2. Mission, ambitions, strategic aims and the strategy compared to the previous assessment

NUTRIM research area and strategy

Overall, the **current vision, mission and objectives** of NUTRIM are endorsed with **minor modifications**. By the positioning of Metabolic health, Liver and digestive health and Healthy ageing, NUTRIM has refined the profiling of its research area (see also Figure 1). In addition to NUTRIM's current mission, we will not only address **prevalent chronic metabolic and inflammatory disorders**, but explicitly expand our translational research in nutrition and metabolism in the fields of **cancer (in particular cancer cachexia), acute trauma/critical care, and healthy ageing**. The overall strategy, **disentangling disease-specific and lifestyle factors in disease onset and progression**, contributing to health maintenance, disease prevention to disease management by a translational approach and **awareness for inter-individual differences** forms part of all three research areas. **The five research-area-overarching themes, highlight the shared expertise and interconnection.** In addition to lifestyle factors, the **living environment** is increasingly recognized to impact non-communicable diseases and emphasizes our **holistic approach**. The impact of living environment also links to increased **awareness for sustainability** in research in the broadest sense (*i.e.* from transition to plant-based diets, nutritional value of food waste, to awareness for 'green' clinical and research practice; as also prioritized at the 2024 annual NUTRIM symposium).

The translational research in humans, *i.e.* combining fundamental studies with (complex) mechanistic and intervention preclinical and clinical studies, and observational (biobank) cohort studies, **is a pronounced NUTRIM strength and is supported by the unique metabolic research infrastructure** (*e.g.* MRUM, CRU, NUTRIM analytics; See also Addendum 2 – case study 4).

In the coming 3-year period, NUTRIM wants to make extra efforts:

- in the field of prevention, in particular tertiary prevention;
- to advance knowledge on physical activity, nutrition and metabolism in subgroups (patient (risk) groups, age groups, etc.) to optimize and tailor intervention strategies;
- to translate fundamental knowledge to the clinic and implement findings with partners in the field.

The above links NUTRIM's expertise with the MUMC+ strategy Healthy Living, the NFU Sectorplan 'Versnellen op gezondheid' and the Dutch Integral Care Agreement. NUTRIM will take up an active role for example by its participation in the MUMC+ Vitality Implementation plan "Gezond idee", by formulating a joint strategy with the MUMC+ Care Center of Chronic Diseases (including further positioning of the MUMC+ Nutrition team), and starting several related new projects. To this end, NUTRIM also wants to further **strengthen the use of (metabolic) imaging and (validated) biomedical model systems** (the latter is expected to also benefit from the recently established Knowledge platform Biomedical Model systems Maastricht (KBM2)) in their translational approach and is taking a **pro-active strategy to enhance FAIR and optimal (re)use of data and bio samples**. In this context, NUTRIM will optimally deploy the MUMC+ data2care initiative and benefits from the standardized registration and development of care paths in the clinic. Herein, also the application of AI will be further explored. Finally, **personalized approaches** are increasingly adopted, not only by behavioral strategies and individual preferences, but also by *e.g.* metabolic, genetic, and microbiome phenotyping for tailored interventions (see also Addendum 2 case study 3).

NUTRIM strongly beliefs in a **multidisciplinary and collaborative approach**. This is illustrated by 62% of publications having authors from different Research Institutes (see also Figure S3). Whereas we clearly want to maintain focus, there is **an increasing number of joint PhD trajectories and applications with other FHML Research Institutes** on overlapping areas (such as cancer metabolism (GROW), mental health (MHENS), diabetes and cardiovascular health (CARIM) and prevention (CAPRHI)). **Nationally**, NUTRIM has very fruitful collaborations with several Dutch knowledge Institutes as well as private partners. The latter is illustrated by the substantial 3rd/4th income stream earning power (see also Table S7) and a MoU signed with Danone. NUTRIM is also part of the national Next Food Collective (incl. academia, research institutes, corporates and SMEs) aiming to 'accelerate the transition to sustainable food systems and healthy diets', and hereby actively involves other FHML Research Institutes.
NUTRIM has a strong **global network** and has started partnership for joint PhDs with India (ARUMDA) and Austria (Ludwig Boltzmann Institute) and is working on a further strategic collaboration with RWTH Aachen and exploring possibilities with Southampton University (UK). The extensive collaboration nationally and internationally is also illustrated by supplemental Figure 3b/c.

Infrastructure

Over the past year, NUTRIM has expanded its **metabolic research infrastructure** (see also addendum 2 case study 4) with the Clinical Research Unit (CRU) in the academic hospital Maastricht to facilitate studies in patients and vulnerable individuals as well as high risk studies in general. In close collaboration with the department of Radiology, a DEXA has been operationalized and currently the installment of a CRU respiration unit is in preparation. The NUTRIM CRU is teaming with the CARIM CRU as MUMC+ CRU (with a shared manager), is explicitly open for all MUMC+ users and is preparing the facilitation of phase 1/ first in man studies.
The **challenge** for the coming years is **to ensure finances for infrastructure in general and to enable innovations**, especially related to MRUM and expensive equipment such as mass spectrometry. Therefore, a (restricted) user fee is implemented for MRUM/CRU, and possibilities for Roadmap applications for large research infrastructure (*i.e.* GWI) as well as sharing expertise and equipment (*e.g.* the NUTRIM analytics initiative sharing expertise) are being explored. NUTRIM strongly endorses the exploration of shared facilities for expensive and high-end infrastructure to reduce costs and efficient use, while guaranteeing access and innovation.

NUTRIM Governance, staff, and financing

As part of the FHML policy, NUTRIM School has been changed into "Institute" with a Research Institute council (RIC, per 2024; see also figure S1 for the NUTRIM governance). For a **better representation of key stakeholders in the RIC**, NUTRIM has invited representatives of different user groups (*i.e*. Support staff, PhD council, early and midcareer scientists) and substitutes of department heads in case of absence. The former divisions, now research areas (RA) since 2024, are led by 2 PIs appointed for a maximum of two terms of each three years, with the ambition of having 1-2 clinicians out of the 6 research area leaders. An action plan is made for a phased replacement strategy.
The NUTRIM office facilitates NUTRIM marketing and communication as well as supports the NUTRIM community with all legal, HR, and financial-administrative tasks, thereby reducing the burden for researchers. Despite various personnel changes in 2023, the **NUTRIM office** is running very smoothly and **is highly appreciated** by the NUTRIM community.

In general, the NUTRIM (scientific and support) **staff numbers are rather stable over time**. The number of new internal PhD-candidates showed a decrease in 2021 (25), 2022 (22) and 2023 (22)

as compared to the peak years 2018 (41) and 2019 (40). Given the importance of PhD defenses in the financial allocation model, this warrants continuous and close monitoring, and NUTRIM actively steers at appointing PhD's from grants and decentral reserves.
The **staff numbers differ between the three divisions** (D; now research areas[1]): *i.e.* in 2023 total staff in FTE incl. hospital appointments being 61.7 (D1), 37.0 (D2), 47.4 (D3). D2 is smallest, but has the highest proportion hospital appointments (*i.e*. 37% as compared to 13% D1 and 11% D3). D1 has the highest staff number and the number of ongoing internal and external PhD-candidates is lower for D1 (79) as compared to D2 (105) and D3 (117) (Table S6). The higher number of clinical PhD candidates contributes to higher numbers of ongoing (and longer) trajectories In D2/D3. In general, 60% of NUTRIM PhD candidates are externally employed (of these ≈20% is employed at the university hospital Maastricht and ≈35% via other regional/national partners).

During the reporting period 2021 – 2023 **NUTRIM meets the annual earning power ambition of 9M€** with a peak in 2023 (13.5k€) (see also Table S7). NUTRIM has a strong track record in 3rd/4th income stream (research funds/public-private partnerships) and may improve in 2nd income stream (*i.e*. national) funding. Further **points of attention** are the low number of **prestigious personal grants and EU grants**. NUTRIM wants to implement a program for young talent development, *i.e*. creating a roadmap for future career, CV development, writing compelling narrative CVs and full proposals, and providing feedback on VENI and VIDI proposals at an early stage (prior to submission). Further, an evaluation is planned with the grants office and a NUTRIM sounding board group will be set up to improve our EU applications and success rate.

Accomplishments

NUTRIM has over **770 publications each year** (Table S1) with an **average Category Normalized Citation Impact (CNCI) of 1.7** (based on the period 2016-2021: Table S2). The quality of the publications is further reflected by 19.2% belonging to the top 10% of publications based on the CNCI and supports the use by peers.
The annual ambition of 38 PhD defenses was not met in 2022 (36.75), but did exceed the ambition in 2021 (52,67) and 2023 (42.5) (Table S8). Overall, all divisions are performing well; D2 has a high number of publications given its smaller size and has the highest CNCI 1.9. D1, being the largest division, does not outperform the other two divisions in number of publications and PhD defenses, though is widely acknowledged for its expertise. Over the period 2021-2023, three new case studies have been added to demonstrate NUTRIM output and impact related to the current strategy, *i.e*. on metabolic profiling and personalized nutrition (D1), host-microbiome-diet interactions (D2) and on the transition to novel proteins (D3).
NUTRIM output has led to **various media contacts**, including national and international press, TV, podcasts, and social media (see also Figure S4). The expertise and appreciation of NUTRIM researchers is further illustrated by several memberships of prestigious scientific committees, councils, relevant functions in various professional organizations, and involvement in patient organizations and foundations. **NUTRIM impact** is further substantiated by the **use of research output and products by scientific and societal partners** (such as guidelines, webinars, online tools, health apps, and lifestyle programs). Representative examples are given in Table S3/S4. The relevance of impact and valorization is also addressed in the PhD mid-term days and via dedicated workshops with the Brightland health campus.

Open Science, academic culture, PhD training and policy, HR policy

The number of **open science** publications continues to increase with now 87.2% being open access (i.e. gold-DOAJ = Gold-not DOAJ + Hybrid + Green OA). NUTRIM endorses the **FAIR** data policy for research data management and is working together with the biobank coordinator to enable **optimal (re-)use of bio samples**. The endorsement of open science is further substantiated by

open source availability of bioinformatics tools generated (*e.g*. MicroViz package version 0.10.8 (microbiome Data Analysis and Visualization), WikiPathways (update pathway database) and Neo4j (Graph analytics and modeling platform).
NUTRIM pursues a high standard for scientific integrity and has implemented the Dilemma game for PhD students at the start and mid-term of their trajectories. The topic is also addressed at the school council (now Research Institute council), and in the near future a discussion is being planned with the FHML Platform for Scientific Integrity (PSI) on ancillary activities and identifying conflicts of interest.

The median duration of **PhD trajectories** until manuscript approval is 59 months and exceeds the standard 48 months. Main reasons are COVID-19 (in particular for those running human studies) as well as PhD-candidates combining research with clinical residency. NUTRIM **continuously addresses the timely completion** at regular portfolio meetings with PIs and in annual PC meetings with department heads. Further steering on completing the Personal Research Plan and the Training & Supervision Plan at the start of a PhD-trajectory will aid the timely and successful completion of PhD trajectories. The **training of PhD candidates is personalized**. However, we note that following more general training activities (*i.e.* general courses or seminars outside their research topic) warrants repeated and active stimulation.
Attracting external talents as well as **keeping internal (young) talents is challenging** given the Collective Labor Agreement restrictions and limited possibilities for permanent positions. This hinders also personal prestigious grant applications (VENI) for young talents. NUTRIM can improve its research talent program by actively scouting and supporting young talents. A NUTRIM young talent plan is in preparation. Still, 19 talented post-docs and assistant professors were offered a permanent position in the period 2021-2023, of which 5 via the NFU sector plan. In this period, also 10 new professors have been appointed (V. Schrauwen-Hinderling, D. Keszthelyi, M. Pierik, A. Vreugdenhil, F. Franssen, A. Piatkowski, G. Goossens, J. Penders, J. Prompers, M. Crone). NUTRIM PIs increasingly implement the development board to monitor and discuss the career perspectives of their staff and to stimulate their development. Finally, NUTRIM wants to increase diversity as also indicated at page 6.

NUTRIM viability

SWOT analysis

Strengths	**Weaknesses**
- cross-disciplinary and translational approach - interconnected and research area over-arching research themes - strong link with the academic hospital Maastricht - strong in prevention research - unique metabolic research infrastructure - international leading scientists and talented young researchers with strong international networks - strong portfolio in research funds and public private partnerships - well-functioning support staff on financial legal issues and HR - strong sense of unity and cohesive culture among NUTRIM members - participation in (inter)national advisory boards and guideline committees - strong collaboration with other research institutes within FHML	- obtaining personal grants - obtaining EU funding - obtaining 2nd income stream - support for IT infrastructure essential for data-intensive research - number of new PhD candidates

Opportunities - societal relevant themes aligning with local and national programs - foreseen integration UM/FHML and hospital with joint strategy - FAIR (re-)use of data/bio samples, incl. use of clinical data and in house expertise for complex data analysis - to strengthen the collaboration with M4I, MERLN and FSE - joint strategy at Brightland Greenport campus Venlo - societal need for primary-tertiary prevention to reduce healthcare cost and for more healthy aging to support independence - further increasing visibility nationally and internationally - to step up in policy setting	**Threats** - highly competitive field and uncertainty of future government funding - high costs for human intervention studies and decreasing grant budgets - high perceived workload - limited opportunities to keep young talent - limited interest of PhD candidates in (out of scope) courses/seminars - to remain in the front and distinctive - to maintain and advance infrastructure - instability diabetes metabolism research group - collective labour agreement in the Netherlands limiting temporal appointments

Strategy summary

The NUTRIM strategy applies to all three research areas. Summarizing key points above, in the next 3 years, NUTRIM will focus on expanding their expertise in the field of 'Nutrition and Medicine' and 'Prevention', amongst others by strengthening the collaboration with the academic hospital, tertiary prevention, by addressing the translation of findings to daily practice, and taking up leadership and 'policy steering' roles on key expertise. Further, NUTRIM aims to strengthen their translational human research, *e.g.* by increased use of biomedical model systems, metabolic imaging, and (patient) datasets. Finally, NUTRIM has to maintain and advance its infrastructure, and to remain in the front and distinctive in their key field (Figure 1). This will also be specific points of discussion with our newly installed advisory board.

Viability

The NUTRIM earning power is solid and in line with the ambition of 9M€ per year. The number of PhD-graduates generally reaches the planned 38 annually, though warrants active monitoring for sufficient influx and timely completion. Overall, the output is very good and well appreciated by peers and other stakeholders. NUTRIM has the ambition to grow in research quality, to be demonstrated by a growth in CNCI on the institute level towards 1.9 and an annual earning power of 10M€, creating more research products used by peers and NUTRIM PIs representation in important national decision-making bodies/councils. Further, NUTRIM wants to make an extra effort to support research staff in obtaining (prestigious) 2nd income and EU grants,
NUTRIM has appointed several new assistant, associate, and full professors in various departments over the last three years, which guarantees the sustainability of current expertise. Interestingly, an increasing number of young and mid-term scientists has been very successful in grant acquisition.

Addendum 1: Factual evidence of NUTRIM output, research staff, funding and PHD graduation

NB: The term division (D) is used for output generated until 2023. From 2024 onwards, the term division is replaced by research are (RA)

Table S1: NUTRIM publications on Institute and division level

	2021	2022	2023
Refereed articles			
Division 1	288	263	233
Division 2	318	288	291
Division 3	360	320	326
NUTRIM total	883	784	773

(KUOZ category A Refereed journal articles are included)
In 2023, 74.9% of NUTRIM publications is published open access (Gold-DOAJ+Gold not DOAJ + Hybrid), including Green, this is 87.2%

Table S2: Citation impact based on CNCI on institute and division level based on 2016-2021

	Average CNCI	% in top 1%	% in top 10%
Division 1	1.6	2.5	17.2
Division 2	1.9	3.8	21.9
Division 3	1.6	2.1	18.7
NUTRIM total	1.7	2.7	19.2

CNCI: Category Normalized Citation Impact (takes into account that citation frequencies differ per discipline, 'age'and type of document)
NUTRIM publications have been cites in 575 policy documents and 77 medical guidelines

Table S3: **Representative examples of functions in (inter)national scientific and societal committees, councils and organizations in the period 2021-2023** (*i.e*. does not represent a complete listing)

• **Dutch Health Council**, Nutrition and Toxicology Committees (various staff members)
• **Grant committees;** ZonMW, NWO, EU, Health funds (various staff members)
• **Board memberships professional (nat/internat) societies** (*e.g*. Surgery, Respiratory, Gastroenterology, Plastic surgery, Osteosynthesis ad Trauma, Dutch academy of Nutritional sciences, Dutch Society of Research of Ageing, Dutch Initiative on Crohn's and Colitis, CCO-EpiCom, Hemodialysis working group, Toxicology; various staff members)
• **Members Scientific Advisory Board various Health Funds** (*e.g*. MLDS, Celiac disease society, Diabetes fund, Lung fund), Voedingscentrum, JOGG, National Steering Committee on Malnutrition, 'Sport en Bewegen'; various staff members)
• **Committee Members, *e.g.* EFSA, ILSI working groups, NVWA, NFU**

Table S4: Examples of Research Products (generated 2021-223) used in science or society (*i.e.* showing a variety in products, does not represent a complete listing)

• **Anatomytool** for students and teachers (Koehler, Anatomy & Embryology)
• **microViz**: an R package for microbiome data visualization and statistics. DOI: 0.21105/joss.03201 Tutorial website visits: 34,000 visitors, Software cited in peer reviewed publications: 135 times (Penders, Medical Microbiology)
• WikiPathways (pathway (updated) database): https://doi.org/10.1093/nar/gkad960 and https://www.wikipathways.org/ (new website); CyNeo4j (Metabolic network Visualization & calculation platform): https://doi.org/10.1039/D3DD00069A and https://cyneo4j.github.io/DSMN/ Willighagen, Slenter, Coort, Evelo; BigCAT)
• **SPIROS 2024 statement**; Standardized Protocol Items Recommendations for Observational Studies), a new Equator reporting guideline (Zeegers, Epidemiology)
• **Keuzehulp PDS**: Selection Aid for for treating IBS patients https://www.mlds.nl/chronische-ziekten/pds-prikkelbare-darm-syndroom/keuzehulp-pds/ (Keszthelyi, Gastroenterology-Hepatology)
• Nonalcoholic Fatty Liver Disease. **Book chapter** (Sverdlov, Genetics & Cell Biology)
• **Postgraduate courses**: Diet and IBS for dietitians NL (Jonkers/Mujagic, Gastroenterology-Hepatology)
• **Webinar UNESCO** on 'Dynamics of school health promotion" for the UNESCO chair for Global Health and Education. https://unescochair-ghe.org/2021/05/06/25-may-2021-dynamics-in-school-health-promotion/ (Bessems/Kremers, Health promotion)
• **SuperFIT: Intervention** approach to address lifestyle of preschoolers (age 2-4); widely implemented by various societal organizations (Gerards/Gubbels, Health promotion)
• **Sale NUTRIM respirations chambers** to peers (Human Biology/Nutrition & Movement Sciences with Maastricht Instruments)
• **Development of combined respiration and fermentation chambers** (for measuring microbial fermentation) (Blaak with Maastricht Instruments and Brigthlands Health Campus).
• **Publication** on impact of vegan vs omnivorous meals on stimulating muscle protein synthesis was **used for discussion in the House of Representatives** of The Netherlands Government (https://www.m3-research.nl/m3-in-de-tweede-kamer/)
• Based on publication, at the dialysis department (MUMC+), the **use of a cycle-**ergometer during hemodialysis has been **implemented as part of standard care** (Kooman, Internal Medicine)
• **MyLiverCoach, app** developed and implemented for monitoring patients in clinical practice (Gevers, Hepatology)
Guideline for the diagnosis and treatment of Faecal Incontinence-A UEG/ESCP/ESNM/ESPCG collaboration (Keszthelyi, Gastroenterology)

Table S5: Research staff at NUTRIM level (2021 - 2023)

Research Institute	2021				2022				2023			
	Direct funding fte	Other funding fte	Total fte	Total #	Direct funding fte	Other funding fte	Total fte	Total #	Direct funding fte	Other funding fte	Total fte	Total #
Scientific Staff FHML[1]	25,9	3,3	29,1	82	25,6	4,4	29,9	76	27,9	5,2	33,1	83
Scientific Staff academic hospital	6,5		6,5	33	6,9		6,9	35	6,6		6,6	37
Post Docs[2]	3,2	13,4	16,5	32	2,2	13,1	15,3	25	2,3	13,0	15,3	23
Internal PhD-students[3]	5,3	87,8	93	98		91,6	91,6	98		92,0	92,0	96
Total Research Staff	**40,8**	**104,4**	**145,1**	**245**	**34,6**	**109,1**	**143,7**	**234**	**36,7**	**110,3**	**147,0**	**239**
Support staff (research)[4]	16,3	15,2	31,5	49	18,1	14,9	33,0	50	15,9	20,0	35,9	51
Support staff (managerial)[5]	6,6		6,6	8	7,0		7,0	9	6,1		6,1	12
Total Support Staff	**22,9**	**15,2**	**38**	**57**	**25,1**	**14,9**	**40,0**	**59**	**22,0**	**20,0**	**42,0**	**63**
Total Staff incl academic hospital	**63,7**	**119,5**	**183,2**	**302**	**59,7**	**124,0**	**183,7**	**293**	**58,7**	**130,3**	**189,0**	**302**
Total Staff excl academic hospital	**57,2**	**119,5**	**176,7**	**269**	**52,8**	**124,0**	**176,8**	**258**	**52,1**	**130,3**	**182,4**	**265**
External PhD students[6]	191				195				204			
Honorary professor[7]	4				7				8			
Visiting fellows/professors[8]	nb				nb				nb			

Table S6: NUTRIM staff at division and institute level per 2023

	1st income stream geldstroom fte Excl hosp. staff	Other income stream fte Excl. hosp. staff	1st income stream fte Incl hosp. staff	Other income stream fte Incl. hosp. staff
Division 1	13.7	46.2	15.5	46.2
Division 2	5.7	27.9	9.1	27.9
Division 3	10.8	35.2	12.2	35.2
NUTRIM total*	52.1	130.3	58.7	130.3
		Internal PhDs #	External PhDs #	Total #
Division 1		37	42	79
Division 2		28	77	105
Division 3		32	85	117
NUTRIM total		97	204	301

**) research staff + support staff*

Table S7: **Earning power at institute and division level (2021-2023)**

	2021 (k€)	2022 (k€	2023 (k€)
Division 1			
2nd income stream	2.368	439	532
3rd/4th income stream	760	2.314	2.138
Total	3.127	**2.752**	**2.670**
Division 2			
2nd income stream	329	200	1.207
3rd/4th income stream	395	2.299	2.921
Total	**723**	**2.499**	**4.128**
Division 3			
2nd income stream	1.318	318	1.219
3rd/4th income stream	4.015	3.699	5.444
Total	**5.333**	**4.017**	**6.663**
NUTRIM total*			
2nd income stream	4.014	957	2.957
3rd/4th income stream	5.169	8.312	10.504
Total	**9.184**	**9.269**	**13.461**

**) Annual ambition 9M€*

2nd income stream: national grants (i.e. NOW, KNAW); 3rd income stream: research funds; 4th income stream: public-private partnerships

Table S8: **PhD defenses at institute and division level (2021-2023)**

	2019	2020	2021	2022	2023
Division 1	8.5	12.33	14	11.5	14
Division 2	12.5	10.25	25.5	14.5	12.17
Division 3	14.4	13.5	13.17	10.75	16.33
NUTRIM total	35.40	36.08	52.67	36.75	42.5*

** is 15.37% of FHML total (276,50)*

** annual ambition 2024-2026 = 38*

Figure S1: **NUTRIM organizational structure**

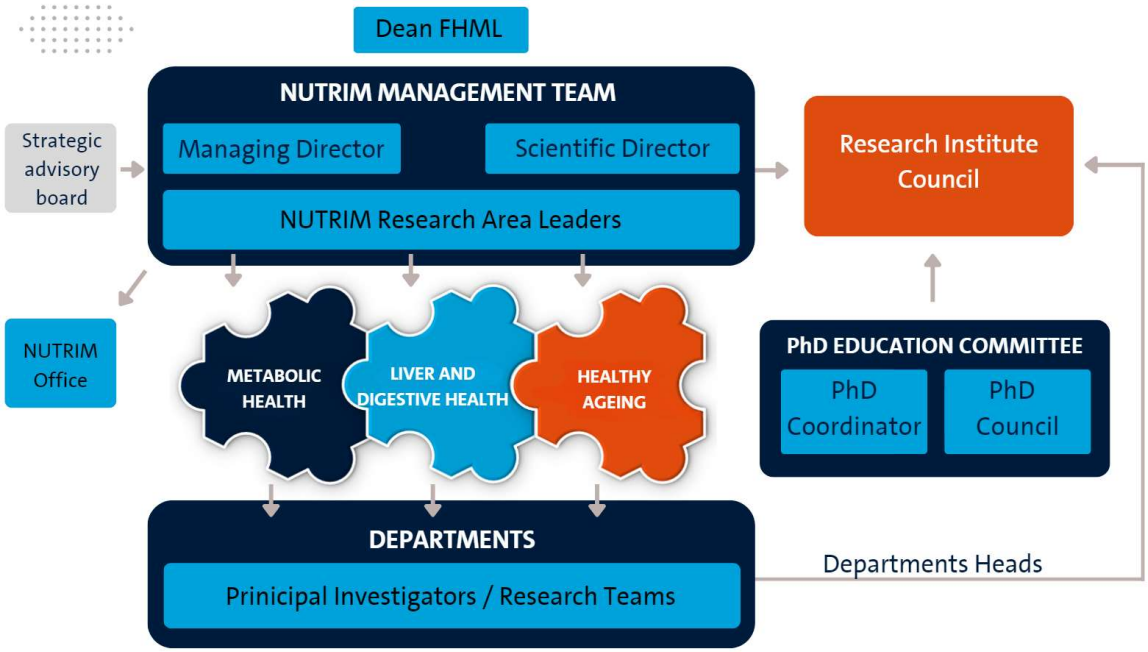
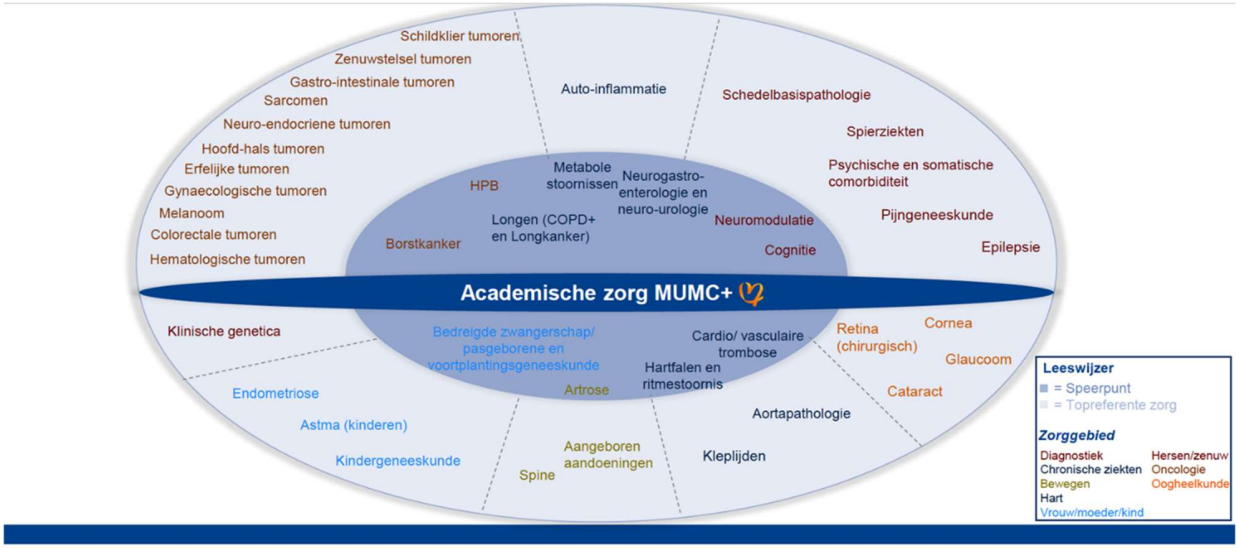


Figure S2: **Summary of MUMC+ internal evaluation highlighting academic fields of outstanding expertise ('spearheads')***



*) based on e.g. specialist-healhtcare ('Robijn-zorg') and scientific output (publications, PhfD-defenses and earning power); Q1 2024
Spearheads are depicted in the middle: **Hepato-pancreato-bliliary disease**, Breastcancer, **Lungs** and Lungcancer, **Metabolic derangements**, **Neurogastroenterology** and neuro-urology, Neromodulation, Congition, Cardovascular disease, Heart failue and arrythmias, Artrosis, Threatened pregnanacy/newborns and reproductive medicine. (those related to NUTRIM in bold)

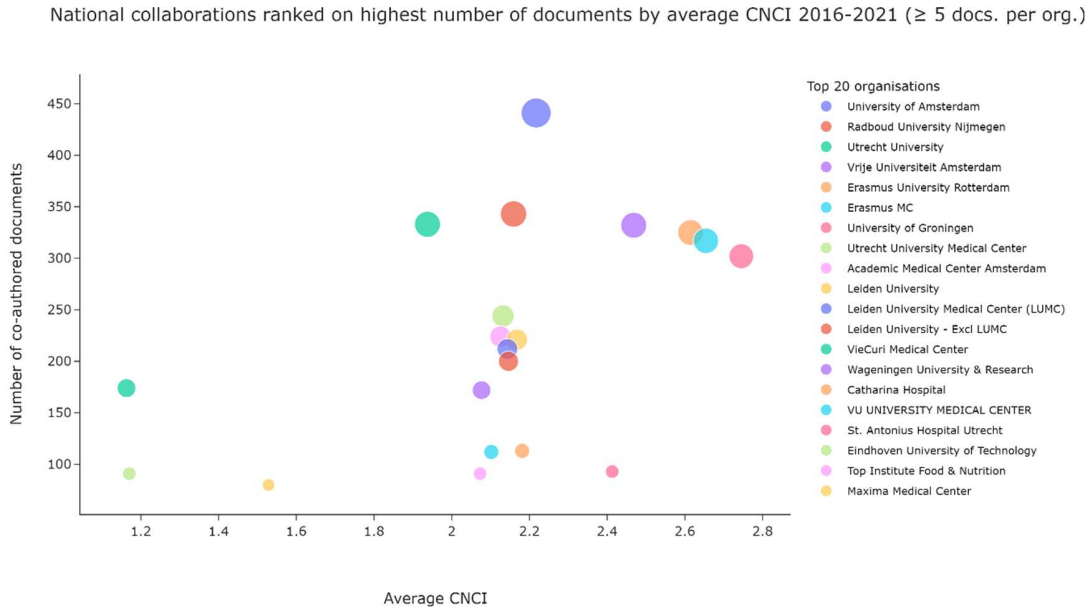
Figure S3: NUTRIM collaborations within FHML (A), nationally (B) and internationally (C)

A) Publication collaborations between NUTRIM and FHML research institutes (2016-2023)

	NUTRIM	CAPHRI	CARIM	GROW	MERLN	M4I	MHeNs	SHE
NUTRIM	5784	1192	777	876	14	44	540	152

Heat map of collaborations between NUTRIM and FHML research institutes.
All documents published by NUTRIM in collaboration with one or more FHML schools are included in this are plotted against each other, and the numbers as well as the colours reflect the number of documents the research institutes publish in collaboration with each other.

B)



C)

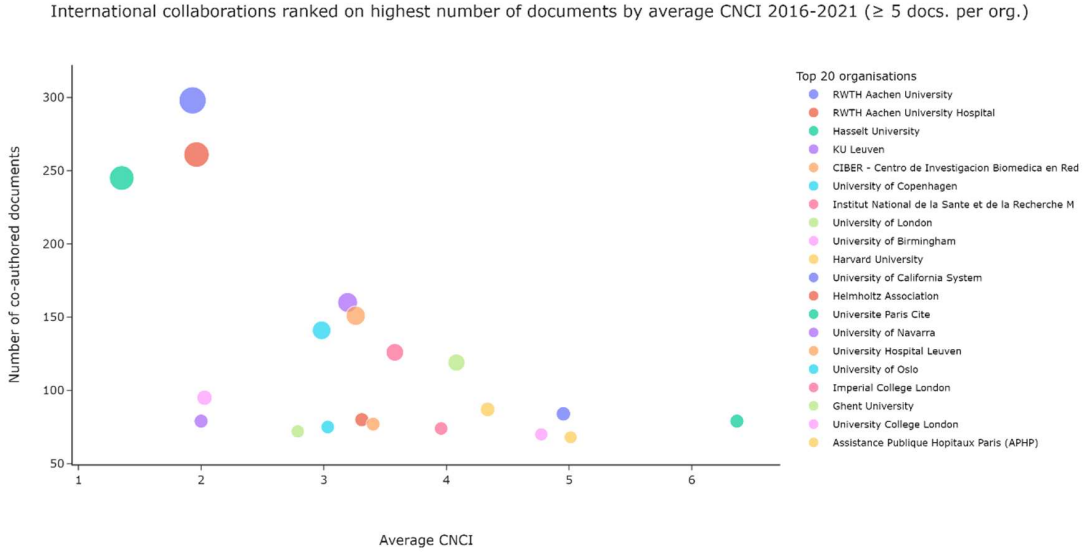


Figure S4: REPRESENTATIVE EXAMPLES OF MEDIA EXPOSURE 2021-2023

More media items on [UMployee in NUTRIM group]

NUTRIM

IN THE MEDIA

Newspapers
Magazines
Journals
TV
Radio
Podcast
Online media
Websites

International press UK and Australia.
The Independent, Liverpool Echo, Guernsey Press, Daily Record Canberra Times, The West Australian.
July 2021 Anke Wesselius

Personalized lifestyle intervention Scientific journal Cell Metabolism. De Limburger, Gooi- en Eemlander, Noordhollands Dagblad, Running, Food & Agribusiness Nieuws voor Diëtisten. January 2023 Ellen Blaak

De Limburger
SuperFit study .
December 2022 Stef Kremers en Sanne Gerards

Scientific journal The Lancet Gastroenterology and Hepatology. Gluten and non-coeliac gluten sensitivity.
November 2023 Marlijne de Graaf and Daisy Jonkers.

Algemeen Dagblad Tubantia, De Stentor, Gelderlander Brabants Dagblad, Eindhovens Dagblad, BN De Stem, Provinciale Zeeuwse Courant. Talking about our bowel movements. February 2023 Daniel Keszthelyi

Online media-exposure and international press. NU.nl, Quest, Universiteit van Nederland. De Telegraaf, Daily Mail, The Times. Is heating at 17°C healthy?
October 2022 Wouter van Marken Lichtenbelt.

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Addendum 2: NUTRIM case studies (2021-2023), representative examples

1. Division 1
2. Division 2
3. Division 3
4. NUTRIM research infrastructure

NUTRIM

RESEARCH AREA 1: METABOLIC HEALTH

Precision intervention strategies to combat obesity and cardiometabolic diseases

OBJECTIVE

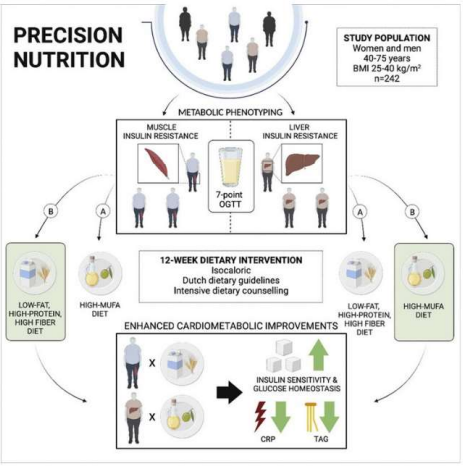
Generate knowledge to develop more effective, personalized strategies to prevent or delay the onset of chronic cardiometabolic diseases in humans.
It is increasingly evident that distinct phenotypes can be identified in the etiology towards non-communicable diseases. Lifestyle interventions have proven effective in preventing or delaying the onset of chronic cardiometabolic diseases, yet the response to lifestyle interventions differs between individuals. The currently used one-size-fits-all approach, which is based on general nutritional and physical activity guidelines reliant on the group mean, ignores this heterogeneity. A better understanding of the mechanisms the response to lifestyle and/or pharmacological interventions is essential to achieve results that can be translated into personalized, evidence-based interventions and guidelines.

METHODOLOGY

- Investigating metabolic inter-organ crosstalk between the gut, adipose tissue, liver, and skeletal muscle in the etiology of cardiometabolic complications
- Combining state of the art in vivo physiological phenotyping in humans with molecular characterization of pathways involved in energy and substrate metabolism in tissue biopsies, in vitro studies, assessment of gut microbial composition/functionality.

KEY FINDINGS

- We demonstrated that individuals with overweight/obesity and either more pronounced liver (LIR) or muscle (MIR) insulin resistance are characterized by a distinct metabolome, lipidome, adipose tissue transcriptome and microbiome.
- Modulation of dietary macronutrient content according to an individual's tissue-specific insulin resistance phenotype, within the context of dietary guidelines, results in a clinically relevant further improvement in insulin sensitivity and cardiometabolic health in individuals with overweight/obesity, independent of body weight change.
- These results show the potential of applying precision nutrition based on the metabolic phenotype of an individual.



SCIENTIFIC AND/OR SOCIETAL IMPACT

- We demonstrated that individuals with overweight/obesity and either more pronounced liver (LIR) or muscle (MIR) insulin resistance are characterized by a distinct metabolome, lipidome, adipose tissue transcriptome and microbiome.
- Modulation of dietary macronutrient content according to an individual's tissue-specific insulin resistance phenotype, within the context of dietary guidelines, results in a clinically relevant further improvement in insulin sensitivity and cardiometabolic health in individuals with overweight/obesity, independent of body weight change.
- These results show the potential of applying precision nutrition based on the metabolic phenotype of an individual.

MORE INFORMATION

The Nutrition, Integrative Metabolism and Obesity (NIMO) lab (www.nimolab.nl)

Who's Involved
Prof. dr. Ellen Blaak, Prof. dr. Gijs Goossens, (PI's),
Involved researchers: Prof. dr. Gijs Goossens, Dr. Ruth Meex, Dr. Johan Jocken,
Dr. Emanuel Canfora

NUTRIM Dept. of Human Biology

Maastricht University | Maastricht UMC+

NUTRIM

RESEARCH AREA 2: LIVER AND DIGESTIVE HEALTH

Effects of environmental biodiversity on health and microbiome development in early childhood

OBJECTIVE

Various observational studies, including our own birth cohorts, have shown that reduced microbial exposure in early-life is associated with inadequate microbiome and immune development and hence the risk of immune-mediated diseases such as allergies. We are now taking this microbiome research from 'lab to life' by formulating and executing early-life microbiome interventions for disease prevention. Including:

•Investigating the impact of environmental biodiversity on the development of the microbiome and physical and mental health in early infancy.

•Encouraging children to interact and play with natural materials, like species rich soil, wood and plants, to analyse the effects of increased biodiversity on the child's microbiome and immune system.

METHODOLOGY

•Using results from in vitro and in vivo studied as well as observational birth cohort studies to understand the role of food-born and plant-based microbes on the infant microbiome and immune development with the ultimate goal to guide the design of intervention studies.

Conduct randomized placebo-controlled trials such as forest playgroups to expose children to biodiverse environments and encourage their engagement with nature.

•Comprehensive microbiome and immune profiling and extensive clinical phenotyping to monitor the impact of such interventions on microbiome and immune maturation as well as on the risk of immune-mediated diseases.

KEY FINDINGS

•Identification of key microbial species that can prevent or treat chronic noncommunicable diseases in children.

•Using a holomicrobiome approach by connecting microbiomes in the environment (soil, plants, food) to the microbiomes colonizing the infant skin and gut.

•Development of strategies for future interventions, including healthcare, behavior modification, and urban/landscape planning.

•Reduction in the incidence and severity of allergies and asthma

•Provision of affordable therapies to improve health and quality of life for a large patient group.

SCIENTIFIC AND/OR SOCIETAL IMPACT

•Enhanced understanding of how environmental and dietary factors influence the gut-immune axis in early life and its role in disease prevention.

•Contribution to the growing body of knowledge on the human microbiome and its manipulation through environmental and dietary interventions.

•Improved public health through the development of targeted early-life nutritional and environmental strategies.

•Reduction in the incidence of chronic diseases, leading to decreased healthcare costs and improved quality of life.

•Empowerment of parents and caregivers with actionable insights into fostering a healthy microbiome in children.

•Influencing urban and landscape development to incorporate natural elements that support healthy microbiome development in children.

MORE INFORMATION

www.feda.bio/en/projects/biodivgesundheit-projects/endemic/

Who's Involved
Dr J. Penders (PI),
Involved researchers: Dr Niels van Best, Drs. Evgenia Dikareva (PhD)

NUTRIM Dept. of Medical Microbiology, Infectious Diseases & Infection Prevention

Maastricht University | Maastricht UMC+

NUTRIM

RESEARCH AREA 3: HEALTHY AGING

On the transition towards a sustainable diet: assessing the safety of novel proteins produced by cellular agriculture

OBJECTIVE

Contributing to the transition towards a safe and sustainable diet. Our research project aims to investigate the safety of novel proteins derived from cellular agriculture, a revolutionary and innovative technology that allows to meet future food protein needs using sustainable alternatives to traditional animal farming. Our project focuses on assessing the potential toxicological risks associated with these proteins, including allergenicity, anti-nutritional effects, genotoxicity, endocrine disruption and digestibility. Additionally, we aim to understand the legislative requirements for the safety assessment of these novel proteins and their production methods to ensure they meet regulatory standards and can be safely integrated into the market.

METHODOLOGY

- Combining a multifaceted approach combining in vitro, in silico and in vivo models. Special attention will be given to the potential application of New Approach Methodologies (NAMs) and animal-free methods.
- Advanced in silico tools will be used to predict allergenicity of the novel proteins. These predictions are validated through immunological assays.
- Digestibility is examined through static and dynamic simulated gastrointestinal digestion models, followed by absorption studies using cell cultures to mimic human intestinal processes.
- Standardized in vitro bioassays will be employed to study ensuring comprehensive evaluation of potential DNA damage and endocrine disruption to evaluate the presence of potential hormonally active agents.
- Throughout the project, we will engage with regulatory experts to align our research with current legislative frameworks and safety assessment guidelines.

Towards a safe and sustainable diet

KEY FINDINGS

- Preliminary data from digestibility studies reveal that these proteins are efficiently broken down during gastrointestinal digestion, indicating their suitability as a nutritional source.
- Review of regulatory requirements will provide valuable insights into the legislative landscape, helping to shape our safety assessment protocols and ensuring compliance with food safety standards.
- By focusing on a multifaceted approach, we will contribute to the transition towards the integration of safe and sustainable protein sources in our diet.

SCIENTIFIC AND/OR SOCIETAL IMPACT

This research has significant scientific and societal implications. Scientifically, it advances our understanding of the safety profile of novel proteins derived from cellular agriculture, contributing to the broader field of food safety and toxicology. Our findings provide a robust framework for assessing the safety of similar biotechnological innovations in the future. Societally, this project supports the development of sustainable food systems by validating the safety of alternative protein sources, thereby reducing reliance on traditional animal agriculture. This transition not only promotes environmental sustainability but also addresses ethical concerns related to animal welfare. Ultimately, our research aims to facilitate the acceptance and integration of cellular agriculture products into the market, ensuring they are safe for consumers and beneficial for society at large.

MORE INFORMATION

New Food Collective: www.nextfoodcollective.nl/protein-transition/protein-transition-20

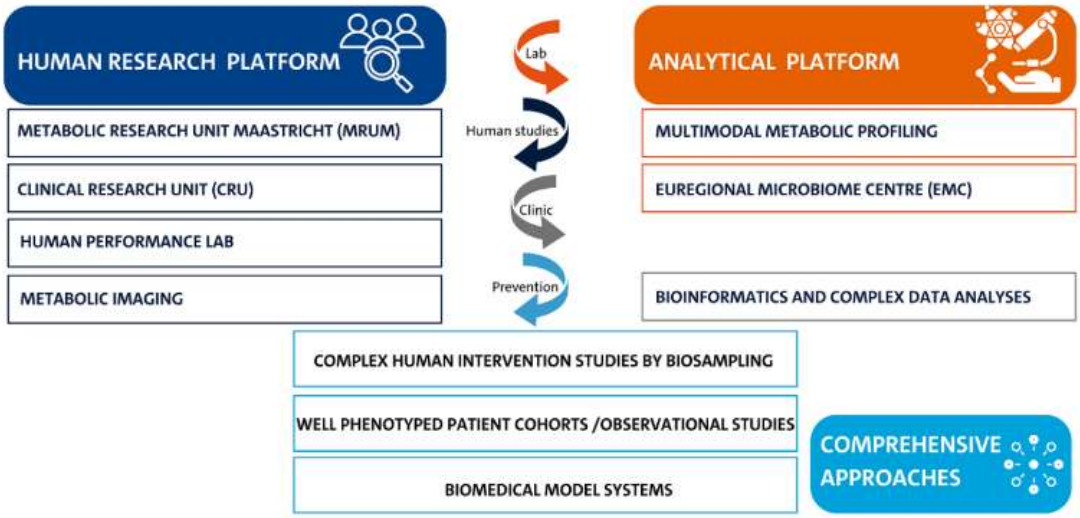
Who's Involved
Dr. Misha Vrolijk (PI),
Involved researchers: Prof. Dr. Frederik Jan van Schooten, Dr. Alie de Boer (FSE), Dr. Miriam Urlings (FSE), Drs. Vaios Fytsilis.

NUTRIM Dept. of Pharmacology and Toxicology

Maastricht University | Maastricht UMC+

NUTRIM infrastructure

The state-of-the art research infrastructure facilitates NUTRIM's translational research on nutrition and metabolism, providing researchers with cutting-edge tools and resources to conduct groundbreaking studies and maximizing the impact. The NUTRIM research infrastructure is open for collaborations and use by others inside and outside UM. Our team of experienced scientists and technicians is available to assist with experimental design, data analysis and your specific requests.



HUMAN RESEARCH INFRASTRUCTURE PLATFORM

METABOLIC RESEARCH UNIT

This unique facility advances our understanding of metabolism and the intricate processes that regulate it, translating novel findings into practical applications that improve health outcomes.

Infrastructure:

- Multipurpose research rooms.
- (Climate controlled) respiration rooms (1-7d energy metabolism).
- High-level exercise performance and body composition equipment.

CLINICAL RESEARCH UNIT

The Clinical Research Unit enables research in patients, vulnerable people and high-risk studies. The CRU is equipped with the latest technology for comprehensive assessment of metabolism, body composition and exercise.

Infrastructure:

- Multipurpose research rooms (with options for monitoring of vital functions).
- Integrated lab for processing of biosamples, kitchen for food interventions, waiting- /supervision room.
- High-level exercise performance equipment.
- DXA scanner for body composition analysis
- Respiration room for 1d energy metabolism (under development).

HUMAN PERFORMANCE LAB

Facility to investigate movement performance, muscular capacity, and musculoskeletal performance during activities of daily life. With a focus on muscle function and physical performance, real-time energy expenditure, and O_2/ CO_2 gas analyses.

Infrastructure:

- Computer Assisted Rehabilitation Environment (CAREN), a high-tech motion platform with motion capture cameras.
- Running belt with virtual environment for stress tests on the muscle system, real-time energy expenditure.

METABOLIC IMAGING

Metabolic imaging enhances our understanding of metabolism in health and disease, by targeting specific biochemical processes.

Infrastructure:

- Non-invasive Magnetic Resonance Spectroscopy (MRS) for studying metabolic pathways in various tissues (in particular liver, muscle, adipose tissue)
- Collaboration with Scannexus for Ultra-high field MRI (3T, 7T, 9.4T MRI scanners)

ANALYTICAL PLATFORM

MULTIMODAL METABOLIC PROFILING

This unique facility advances our understanding of metabolism and the intricate processes that regulate it, translating novel findings into practical applications that improve health outcomes.

Infrastructure:

- Multipurpose research rooms.
- (Climate controlled) respiration rooms (1-7d energy metabolism).
- High-level exercise performance and body composition equipment.

EUREGIONAL MICROBIOME CENTRE

The EMC is a collaboration between the universities and university medical centers of Maastricht, Liege and Aachen to advance microbiome research at an international forefront. Collecting and processing biosamples for application of high-throughput sequencing technologies comprehensively identifies microbial species and allows functional metagenomics to determine how microbiomes influence health, contribute to diseases, and respond to treatments.

Infrastructure:

- Human, animal, and in vitro models (biosamples, organoids/cell lines).
- Next generation sequencing platforms
- Unique bioinformatics pipelines.

COMPLEX DATA ANALYSIS

Our sophisticated bioinformatics infrastructure is crucial for advancing insights into (metabolic) processes in various biological/medical contexts and instrumental for unravelling intricate biological data sets through data integration coupled to pathway and network analyses.

Infrastructure:

- Bio-IT-platforms.
- Systems biology (pathways and networks).
- Data management systems.

COMPREHENSIVE APPROACHES

COMPLEX HUMAN INTERVENTION STUDIES WITH BIOSAMPLING

WELL-PHENOTYPED PATIENT COHORTS/ OBSERVATIONAL STUDIES

BIOMEDICAL MODEL SYSTEMS
Including cell lines, organoids/organ-on-chip, microbiome fermentation and animal models

NUTRIM
Institute of Nutrition and Translational Research in Metabolism

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Addendum 3: NUTRIM Action plan based on the External review

NUTRIM action plan based on the External Review over 2014-2020

November 24 and 25, 2021, research School NUTRIM has been reviewed by an independent external review committee (ERC). The review over the period 2014-2020 was based on a self-assessment and an online 'visit' (because of COVID-19) according to the Dutch Strategy Evaluation Protocol 2021-2027. The ERC has assessed the performance of the research quality, relevance to society and viability, and incorporated four specific aspects (*i.e*. Open Science, PhD policy and training, Academic Culture and Human Resources).
The current action plan is based on the recommendations of the ERC (in italics) and in concert with the NUTRIM Management Team (MT) and School Council (SC).

General feedback

The ERC considered NUTRIM to be well positioned and highly appreciated NUTRIM's research quality, output, infrastructure and link with the hospital. They stressed the 'unrivalled potential of NUTRIM to span the fields of medicine and nutrition' and that 'NUTRIM can play an important role in setting the agenda in the Netherlands, but needs more demonstrably to step up in this leadership role'.

NUTRIM feels honored with the positive and constructive feedback of the assessment committee. Overall, NUTRIM endorses its current vision, mission and objectives, but will fine-tune the focus of the research area and strategy for the next six years, based on the ERC recommendations. This includes *e.g*. further strengthening of our pre-clinical and clinical translational research and our link with the hospital, as well as updating our strategy to increase NUTRIM's visibility, our involvement in (inter)national committees and the ambition to take relevant leadership roles. Additionally, we will more explicitly involve representatives of support staff and scientific staff (at various stages of their career) in the SC and relevant meetings.
NUTRIM has planned strategic meetings with the MT and SC to **update the strategic plan for the next 6 years** (taking into account the above and the specific recommendations below) and will also discuss this with the advisory board that will be installed (see also ad 1). The strategic plan update will be completed by Q3 2023.

Specific recommendations with regard to 'strategy'

1. *The ERC suggests establishing an independent international strategic advisory board to benefit more from continuous strategic advice.*

NUTRIM embraces this suggestion, which will further improve our scientific quality and impact, as well as training, education and HR policy. NUTRIM will **install an international strategic advisory board** with 4-6 members from (inter)national knowledge institutes and medical centers, representatives from the food industry and a national representative familiar with Dutch health issues and policy (Q1 2023). They will advise NUTRIM annually online and by a site visit in combination with the mid-term evaluation.

2. *The ERC suggests that perspectives of patients and representatives of the general population should be more demonstrable in how research priorities are established and how research is planned and delivered*.

Patient representatives are already included in individual patient oriented projects, close contacts do exist between (non-)clinical PIs and various patient and/or professional organizations, and NUTRIM community members are involved in several committees with relevant stakeholders. NUTRIM does however acknowledge the relevance and will make it a **more pro-active strategy** as part of the overall strategy update. Amongst others, **NUTRIM will propagate patient involvement when setting up new projects, will stimulate researchers to participate in (inter)national stakeholder meetings and (policy-setting) committees**, and **will invite relevant stakeholders for the advisory board**. Periodically (every 3 years), NUTRIM will plan a **meeting with relevant stakeholders** to discuss needs and research priorities.

3. *NUTRIM should maintain the focus on individual-level prevention and but has the opportunity to play a more explicitly articulated collaborative role in developing and evaluating population-level approaches to prevention (including strategic alliances with other groups such as CAPHRI)*

Prevention at various levels is part of NUTRIM research and impact, which is also exemplified by involvement in various projects, initiatives and activities, as well as the involvement of NUTRIM community members in national committees and councils. Prevention is also a spearhead of the MUMC+ vision Healthy living. At present, NUTRIM community members, together with CAPHRI and other FHML representatives, participate in the FHML platform 'Lifestyle and living environment' and are involved in a National Growth Fund Application on Prevention.
NUTRIM will **continue to explore possibilities** to start new initiatives and collaborations, and has the **ambition to strengthen their leading role regionally and (inter)nationally** (see also update strategic plan).

4. *NUTRIM can better collaborate across and align the research areas between divisions in order to avoid duplication or missed opportunities.*
5. *The divisions have different strengths. The strong clinical relevance of division 2 and 3 could be strengthened in division 1 and the greater focus on pre-clinical processes, could be strengthen in division 2 and 3.*

NUTRIM agrees that the **alignment and collaborations between divisions can be strengthened**, which will be part of our updated strategy. Also further **exchange of expertise and sharing networks** between PI groups will benefit our research quality and its impact. Examples include the recently established collaborative platform on NUTRIM analytics, the joined imaging meetings, the core group on Big Data Infrastructure and Analysis, and the to be planned NUTRIM's 'Meet and Greet'.

6. *The ERC considers studying the crosstalk between organs an opportunity to stand out internationally, as is the field of gut physiology and medicine, at which NUTRIM could be one of the top centers in the world, when perhaps coupled with UM engineers and computer scientists.*

The inter-organ crosstalk and the field of gut physiology and medicine are pronounced assets of the NUTRIM research area. Strengthening the collaboration with UM engineers and computer scientists will indeed further benefit these and other fields within NUTRIM. Currently, **NUTRIM is strengthening the collaboration with MERLN** in the field of regenerative medicine and *in vitro/ex vivo* model systems**, and with M4I** in the field of molecular imaging. The recently installed **NUTRIM core group Big Data Analysis** will carry out **an inventory on the needs for data science and systems biology approaches**. They will **draft a plan how to strengthen and facilitate such**

expertise within NUTRIM and in collaboration with FHML, the FSE Dept. of Advanced Computing Science and the Maastricht Centre of Systems Biology (MaCSBio).

7. *Division 3 needs to develop a clear strategic plan, including a critical appraisal of the range of disorders covered.*

Although there are common elements in the research performed within division 3, NUTRIM acknowledges that these may not be sufficiently clear. A **critical evaluation of division 3** is planned in Q4 2022 and a **novel strategic plan** will be drafted in Q2 2023. This will be aligned with the planned update of our overall strategic plan.

8. *The existing close collaboration between the University, NUTRIM and the hospital can be strengthened further to improve its positon as a 'centre of Excellence in Medically Applied Nutrition and Metabolism research, both within the Netherlands and internationally'.*

NUTRIM agrees that the close collaboration with the clinic (with 30% of our staff being clinical researchers) and the focus on prevalent chronic diseases are strong assets, being supported by our translational approach and unique infrastructure for performing complex studies in humans. NUTRIM has the ambition **to further strengthen this collaboration** and **to play an active role in aligning spearheads of NUTRIM and the hospital** and **to embed nutrition and metabolism research and expertise in the clinical settings**. This is also supported, amongst others, by the recently built Clinical Research Unit, the establishment of the Movement Research Platform, and the involvement of NUTRIM PIs in the 'academization' of the hospital department Dietetics and in a hospital working group to implement lifestyle screening and interventions in the clinic. Furthermore, NUTRIM has the ambition **to start strategic alliances with 2-3 renowned partner institutes in Europe** that excel in the field of nutrition/metabolism and medicine. Although NUTRIM community members are involved in several (inter)national initiatives and committees, we do acknowledge that we can **further increase our visibility** and **take on a leading role in this field**. NUTRIM will develop a pro-active strategy to work on this (see also update strategic plan).

Specific recommendations with regard to HR

9. *NUTRIM could do more to pro-actively encourage inclusivity.*

The ERC also stressed the importance of taking steps to promote greater ethnic and gender diversity and to prioritize efforts to include minorities as PhD candidates, researchers and managers.

NUTRIM underscores the values of equality and inclusivity, in line with the UM policy. Within NUTRIM, ~50% of staff and ~20% of professors are female. The percentage of minorities is rather low when compared to the general population. We will increase awareness for this topic in NUTRIM. On one hand, this topic also warrants actions beyond NUTRIM's scope, to stimulate and facilitate that this group can follow higher education and pursue an academic career. On the other hand, it is important that we make sure that all students and employees feel welcome and at home at NUTRIM, among both scientific and support staff. Therefore, an **evaluation is planned** by MT members together with community members and the FHML inclusivity and diversity office, and an **action plan will be drafted to further stimulate inclusivity** (Q2, 2023).

10. *There is a tension between general teaching responsibilities and research.*

NUTRIM recognizes the tension between research and general teaching responsibilities, and also with work in the clinics. This is a point of concern, as we do see the work pressure among NUTRIM

staff in various phases of their career. It is also a national concern and is presently under attention of the Dutch Government. Within NUTRIM it has our **continuing attention and is discussed in MT, SC and annual Planning and Control (PC) meetings with the department heads,** and is **addressed in the periodic meetings with the faculty board**. Furthermore, the new Recognition and Reward program, in which collaboration and diversification are key concepts, and supported by the soon to be installed 'Development boards' hopefully further facilitates possibilities for different career paths and reduction of work pressure.

11. *Greater consideration should be given to institutional strategies to ensure that PhDs are completed in timely fashion.*

This topic is a point of discussion during all departmental PC and portfolio meetings. A substantial part of the delays is related to clinical PhD candidates that combine research with clinical training. NUTRIM did however also note that the use of PhD track, including the Personal Research Plan (PRP) and the Training and Supervision plan (TSP), as well as monitoring of progress needs attention and is under-used for external PhD students. The topic will also be discussed within the FHML Faculty PhD Committee. Together with the PhD-coordinator and the NUTRIM office, an **action plan will be developed to maximize the use of PhD-track and monitoring of the progress** with timely adjustments when appropriate, while maintaining high quality (Q1 2023).

12. *The nomenclature for classifying PhD candidates should be reconsidered. The terms internal and external were unclear. Hereby it is important to reinforce the perspective that all candidates receive equivalent and optimal opportunities for training.*

NUTRIM recognizes the confusion related to these terms, which are determined by the type of employment contract a PhD candidate has at the University and are based on the Collective Labour Agreement Dutch Universities. In future communications, NUTRIM will clarify which part of the external candidates **has an employment contract via the hospital**. NUTRIM is currently making an effort **to include all (internal and external) PhD candidates in the PhD track, to inform them on courses and to invite them for all activities and events**.

Specific recommendations with regard to Knowledge translation

13. *The presence of NUTRIM on national bodies can be strengthened further.*
14. *The ERC stressed the opportunities for NUTRIM to span the field of medicine and nutrition with clinical care and nutrition support and considers the focus of NUTRIM on the integration of in-depth nutritional science with clinical medicine unrivalled and a national strategic asset.*

See also update overall NUTRIM strategy.

Additional remark

The ERC noted in their report that that a separate confidential advisor in addition to the PhD coordinator (giving his dual role) would be sensible as an independent route to raise possible problems.

NUTRIM recognizes that PhD candidates have difficulties to identify to whom to address in certain situations. NUTRIM will adjust its website with direct links to relevant officers and routes related to scientific integrity and confidential issues. The topic has recently also been discussed within the FHML/MUMC+ Platform Scientific Integrity which currently explores possibilities for further improvement.

Addendum 4: Update NUTRIM research area

Mission, vision and strategy of NUTRIM

Vision: NUTRIM strongly believes in connecting and integrating different disciplines to create novel scientific insights and innovative health solutions for society. NUTRIM focuses on biomedical research to capitalize on its unique strengths, with a strong link to health promotion. NUTRIM actively maintains a local, national, and international network to contribute to solutions for global health concerns. In our vision, an excellent educational infrastructure plus an innovative and challenging research environment together with pro-active talent and career policy, are crucial for the academic development of young and mid-career researchers and for their ability to acquire skills and expertise.

Mission: NUTRIM promotes translational research on chronic metabolic and inflammatory conditions with a high societal burden that will contribute to personalized lifestyle and medicine approaches. In its PhD programme, NUTRIM aims to meet the demand for scientists who are acquainted with novel fundamental research concepts and are equipped to optimize the translation from science to the clinic and public health.

Objectives: The NUTRIM mission is implemented by the following objectives:
1. To enable an excellent research programme that encompasses the entire spectrum of fundamental, clinical, and population based translational research, which leads to novel insight, diagnostic markers, preventive tools and treatment options. Such research provides NUTRIM with a distinct international health science profile that optimally fits within the MUMC+ vision and organization.
2. Availability of unique patient cohorts and biobanks as well as an internationally distinct, state of the art infrastructure for metabolic and inflammatory phenotyping and complex intervention studies in humans, allowing a network-based approach linking tissue, organ systems, and host outcomes, and taking interindividual variation into account.
3. To mentor scientists at various stages of their academic career.
4. To facilitate the sharing of knowledge and expertise and generation of impact within UM and MUMC+, and by collaboration with other universities, research institutes, national and international networks to various stakeholders.

Research area

The research of NUTRIM covers the whole spectrum from maintenance of a healthy lifestyle and disease prevention to disease management across the lifespan in three main research areas: Metabolic health, Liver and Digestive Health, and Healthy Aging. Key themes include '(mal)nutrition & body composition', 'movement', 'metabolism' and the 'inter-organ cross talk including the microbiome', and are addressed in all three research areas, stressing the shared expertise and inter-connection. The research is performed in the context of prevalent metabolic and inflammatory conditions, including obesity with diabetes and cardiovascular disease as prevalent comorbid diseases, chronic diseases of the gastrointestinal tract, liver, respiratory tract, and kidneys, and metabolism related to cancer, acute trauma, and aging.
The three research areas of NUTRIM focus on health and disease models to disentangle disease-specific and lifestyle-induced denominators in disease onset and progression, taking inter-individual differences into account as well as living environment. Furthermore, our aim is to establish targeted therapeutic and preventive strategies, which is enabled by a combination of *in vitro* and *ex vivo* models (including *e.g.* organoids, primary cell cultures), animal studies, (complex) human intervention and cohort studies in healthy and high-risk individuals and patients. This is

supported by the Metabolic Research Unit Maastricht (MRUM; encompassing multipurpose research rooms, including air-tight climate-controlled respiration chambers), the Clinical Research Unit for patient-bound and high-risk studies, the Human Performance Lab, a Metabolic Imaging facility and the NUTRIM analytical platform, including multimodal metabolic profiling (proteomics, lipidomics, metabolomics, stable isotope research), the Eurogenional Microbiome Centre and Bioinformatics & Complex Data analyses.
Research innovation is further facilitated by the FHML animal facility, the advanced microscopy CORE lab, mass spectrometry based molecular imaging institute M4I, the institute for Technology-inspired regenerative medicine MERLN, the ultra-high-field MRI centre Scannexus and collaborations with the Maastricht Centre for Systems Biology (MaCSBio) and Brightland Campus Greenport Venlo.

Division 1: Metabolic health

leaders: Prof. Dr. Jogchum Plat (Nutrition & Movement Sciences) & Dr. Suzan Coort (Translational Genomics/Bioinformatics)

We focus on understanding how lifestyle and living environment, including diet, exercise, sedentary behaviour, cold exposure, and circadian rhythmicity, as well as pharmacological interventions, can optimize metabolic health. By performing comprehensive human intervention studies utilizing detailed deep phenotyping, we aim to uncover underlying mechanisms in key tissues such as skeletal muscle, liver, intestines, brain, (brown) adipose tissue, and the vasculature in humans, animal and *in vitro* models.
Our focus is on investigating both normal and pathological metabolic processes and to develop evidence-based strategies assisting people to make healthier choices. Finally, we explore how the individual characteristics and genetic makeup influences metabolic health and the response to interventions and use this knowledge for tailoring precise dietary recommendations. Through this work, we aim to support changing their lifestyle in order to improve their quality of life and disease outcomes, and to reduce public health impact of obesity, diabetes and cardiovascular health.

Division 2: Liver and digestive health

leaders: Prof. Dr. R. Sverdlov (Genetics & Cell Biology) & Prof. Dr. J. Penders (Medical Microbiology, Infectious Disease and Infection Prevention)

We aim to uncover novel insights into the pathophysiological processes of the gut and liver, with a strong focus on translating these discoveries into clinical practice and benefitting the general population. Our main research focus is on the gut-liver axis, the enterohepatic circulation and the gut microbiome. A range of conditions, including inflammatory, functional and malignant diseases of the gastrointestinal tract and liver are being investigated. We further extrapolate our research findings to related organ systems such as the cardiovascular and central nervous system. Our work uniquely addresses the inter-organ cross talk and bidirectional interactions with lifestyle, bringing together clinical as well as fundamental experts.

Division 3: Healthy aging

leaders: Prof. Dr. Luc van Loon (Human Biology) & Prof. Dr. Ramon Langen (Respiratory Medicine)

We aim to increase our understanding of the human aging process in various tissues, in general and in the context of metabolic and respiratory disease and lifestyle modifications.

We study the impact of detrimental changes experienced during life in lifestyle (smoking, physical (in)activity), (mal)nutrition) and the environment (*e.g.* air pollution, microplastics) and their interaction with our genetic background. We focus on early identification of people with an enhanced risk for disease onset and progression and hospitalisation due to sarcopenia and cachexia and on developing effective lifestyle intervention strategies to modify chronic disease progression and support more active, healthy aging.

Glossary

AP	Action plan based on recommendation External Review Committee
CAPHRI	Care and Public Health Research Institute
CARIM	Cardiovascular Research Institute Maastricht
CRU	Clinical Research Unit
ERC	External Review Committee
FHML	Faculty of Health Medicine and Life Science
FTE	Full-time Equivalent
FSE	Faculty of Science and Engineering
GROW	Research institute for Oncology and Reproduction
IC	Institute Council
KBM2	Knowledge platform Biomedical Models Maastricht
M4I	Maastricht Multimodal Imaging Institute
MERLN	Institute for Technology Inspired Regenerative Medicine
MHeNS	Mental health and Neuroscience Research Institute
MT	Management Team
MUMC+	Maastricht University Medical Center+ (being the strategic partnership of FHML and the academic hospital Maastricht)
NFU	Dutch Federation of University Medical Centers
PC	Planning & Control
PI	Principle Investigator
RA	Research area
RAL	Research area Leader
RIC	Research Institute Council
SC	School council