The Use of Technologies for Nutrition and Health Promotion

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The Use of Technologies for Nutrition and Health Promotion

- Public Health Nutrition
  - Nutrition and non-communicable diseases (NCDs)
  - Technologies as a health promotion resource
- Technologies in Nutritional Epidemiology
  - Technology-assisted dietary assessment
  - Childhood obesity prevention
- Technologies in Clinical Dietetics
- Limitations and Drawbacks
  - Aspects of Equity and Bioethics

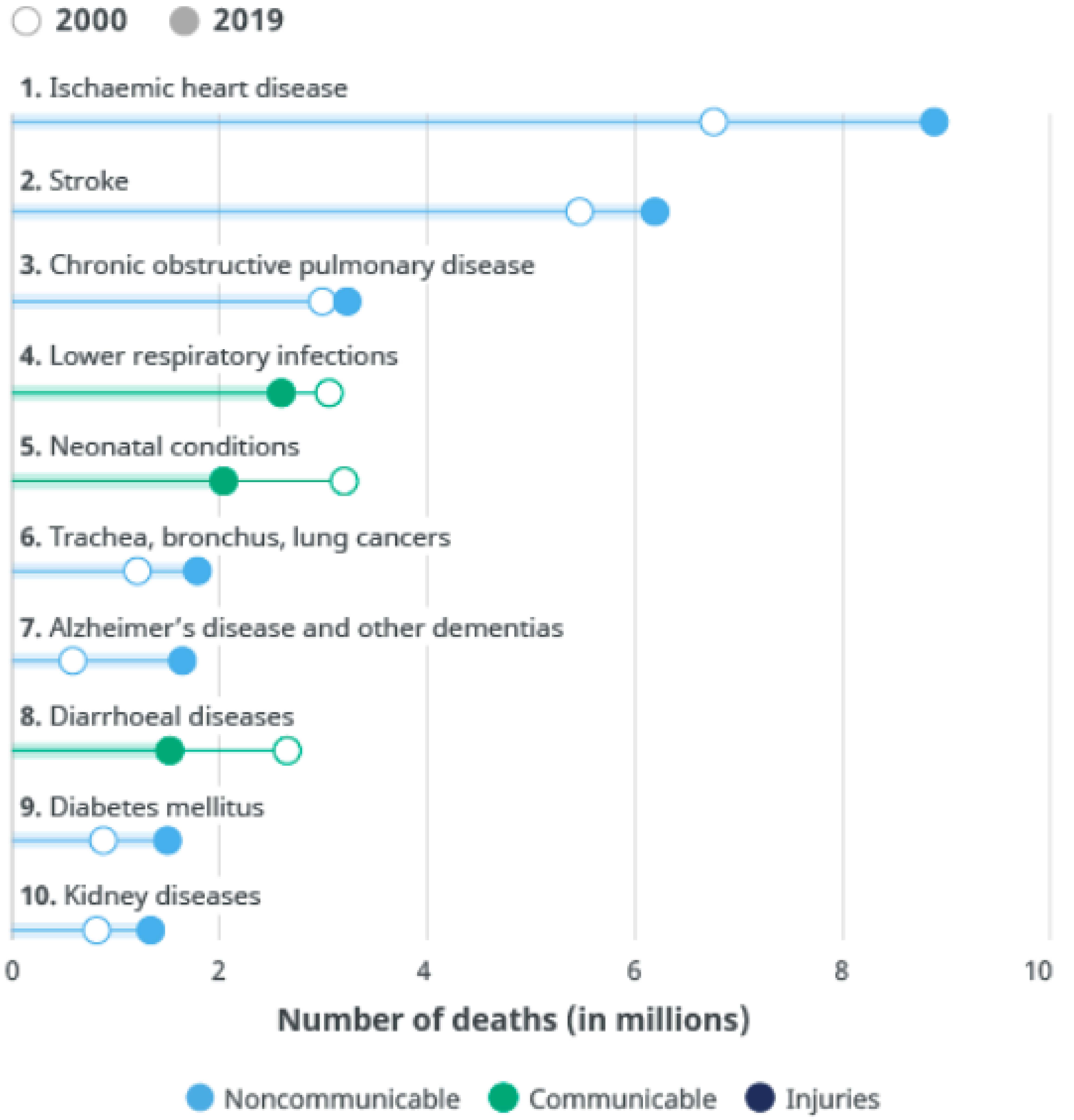
Public health nutrition

- The quest for healthy diets and for effective population interventions topped by issues of accuracy in dietary measurements (causality) are big challenges for the scientific community and for the policy-makers in several “health-in-all” sectors.

- Dietary risk factors *significantly contribute to global mortality and morbidity rates and are a leading cause of many chronic conditions, including obesity,* NCDs, *mental-health issues and poor dental health* (Micha et. al., 2017).

- NCDs *tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioral factors* (Branca, 2019).
    - main types: CVD, cancers, chronic respiratory diseases and diabetes.

Leading causes of death globally



Source: WHO Global Health Estimates.

Raised cholesterol

Raised cholesterol leads to a build-up of fat in blood vessels, blocking arteries and raising the risk of heart disease and stroke. Contributing factors include eating unhealthy foods, being above a healthy weight, not being physically active enough, using tobacco and consuming too much alcohol. Raised cholesterol may also be genetic or hereditary (that is, it may run in families).

Fact: High cholesterol was responsible for an estimated 3.9 million deaths in 2017 *(24)*

Physical inactivity

Physical activity contributes to preventing and managing NCDs such as CVDs, cancer and diabetes *(13)*. However, one in three women, one in four men, and more than 80% of adolescents are not physically active enough to experience good health *(14, 15)*.

830 000 NCD deaths a year (2% of NCD deaths) *(3)*

Harmful use of alcohol

Alcohol consumption is linked to major NCDs, s
some cancers and CVDs *(11)*.

1.7 million NCD deaths in 2016 (4% of NCD deaths) *(12)*

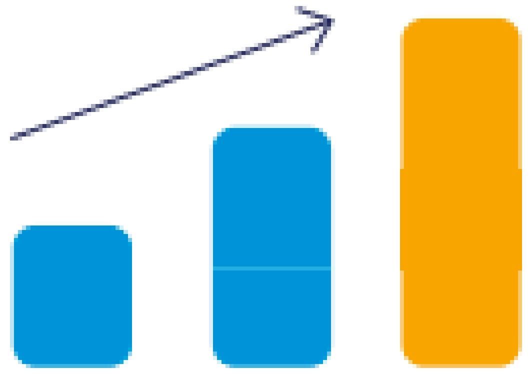
Raised blood pressure (hypertension)

Hypertension, meaning that blood pressure is too high, is a major risk factor for CVDs and other diseases *(20)*. Two thirds of the people with hypertension live in LMICs, but almost half of the people with hypertension are not even aware they have it (*see fig. 2*).

Fact: Hypertension currently affects around 1.3 billion adults aged 30 to 79 *(20)*

Obesity

Obesity, is a major risk factor for NCDs such as CVDs, diabetes, musculoskeletal disorders and some cancers *(22)*. Obesity has been a major health concern in high-income countries for decades and is rising rapidly on the agenda in LMICs *(22)*. Rates among children and adolescents are particularly concerning.



Fact: Obesity worldwide has nearly tripled since 1975 *(23)*

Poor diet, as defined by a cluster of dietary risks, is the leading cause of death and is the first or second biggest contributor to NCD disease burden in all six WHO regions (Branca, 2019).

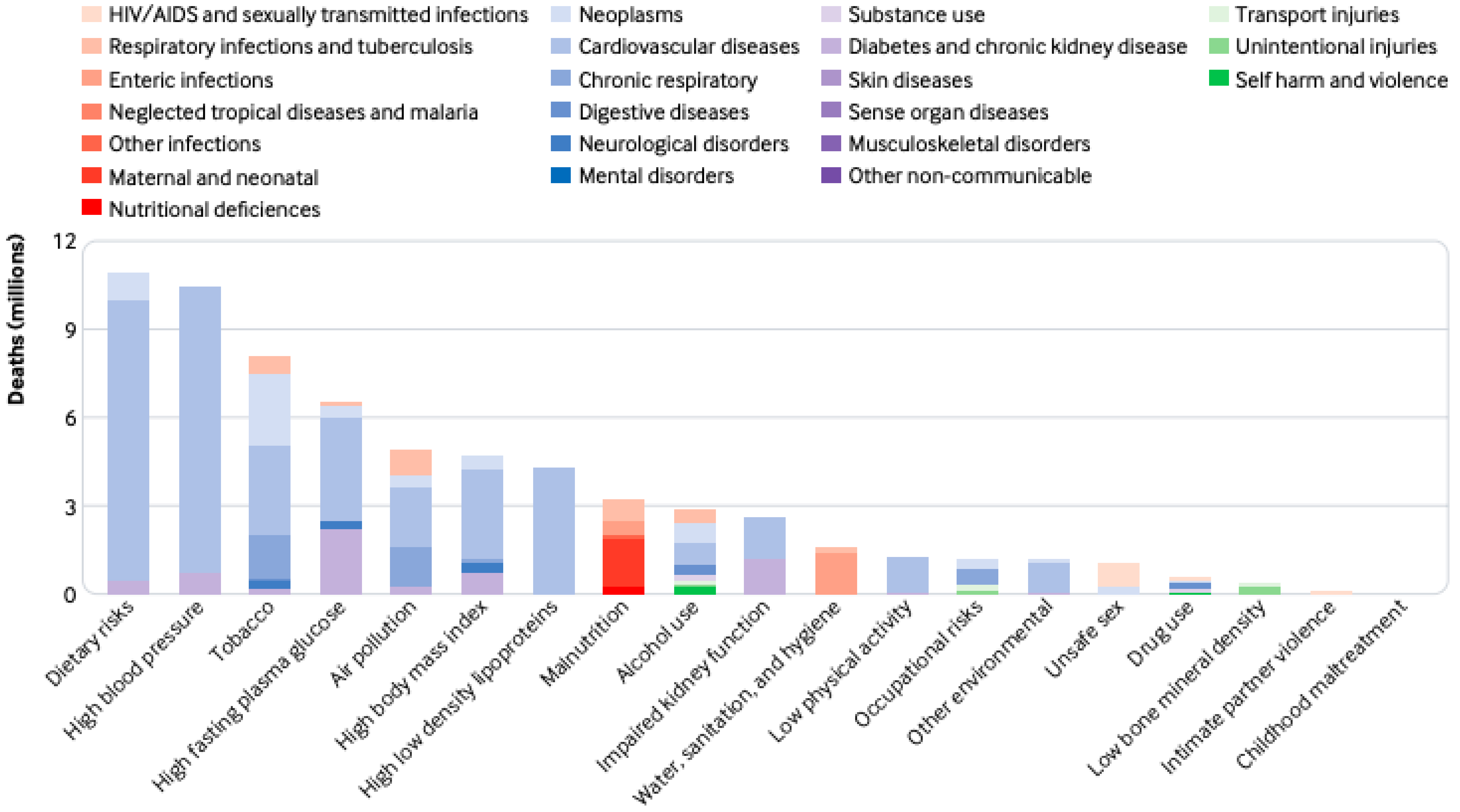


Fig 3 | Risk factor contribution to deaths. Global deaths by risk factor for all ages, both sexes, 2017. Dietary risks include low whole grains; low fruit; low nuts and seeds; high sodium; low vegetables; low omega-3; low fibre; low legumes; low polyunsaturated fatty acids; high trans fat; low calcium; high processed meat; low milk; high red meat; high sweetened beverages[13]

Of these dietary risks, the biggest contributors to the GBD in 2017 were diets that are low in whole grains, high in sodium, or low in fruits, nuts and seeds, or vegetables. Additionally, there is an effect of higher body mass index on disease outcomes (Branca, 2019).

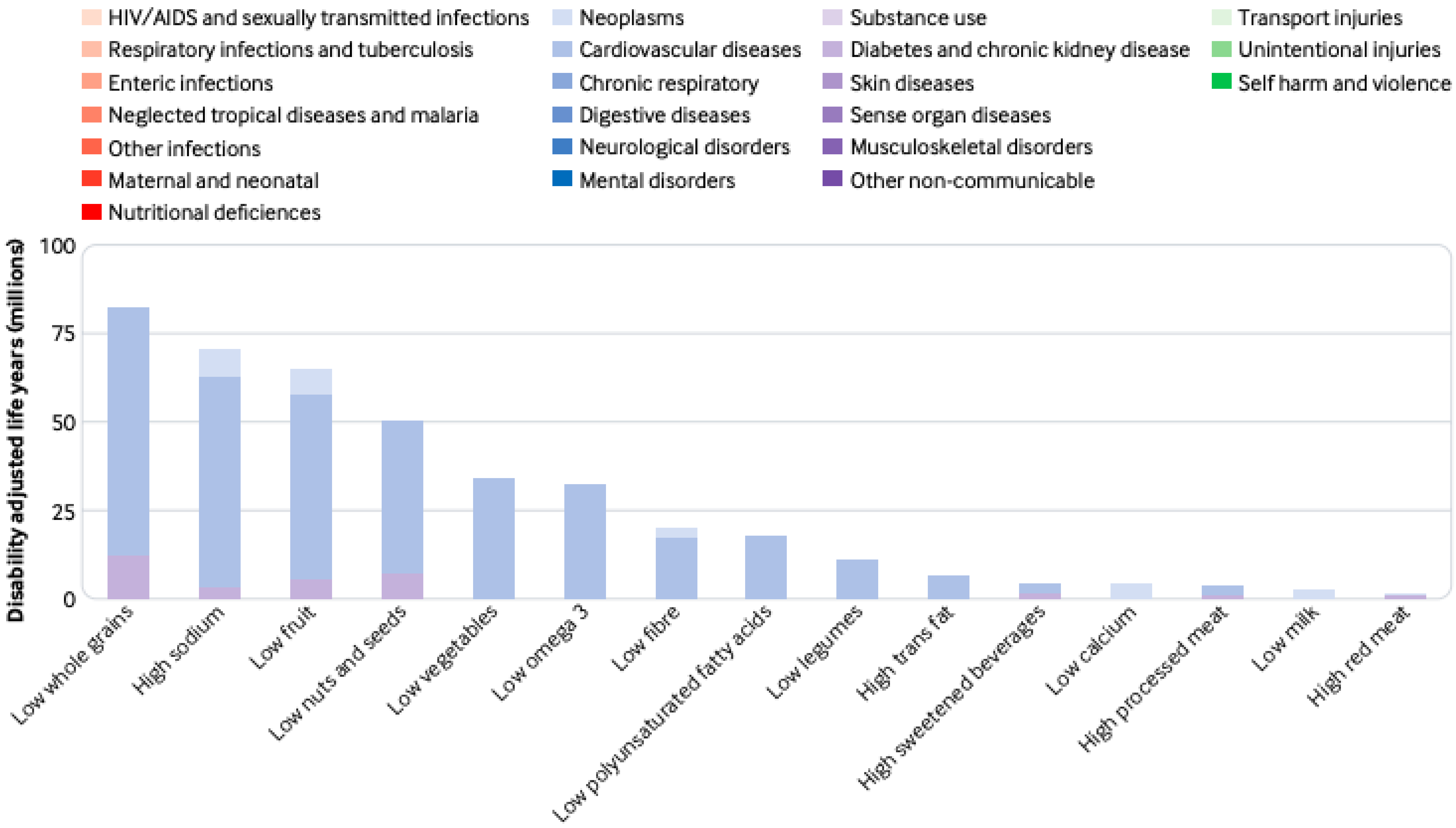
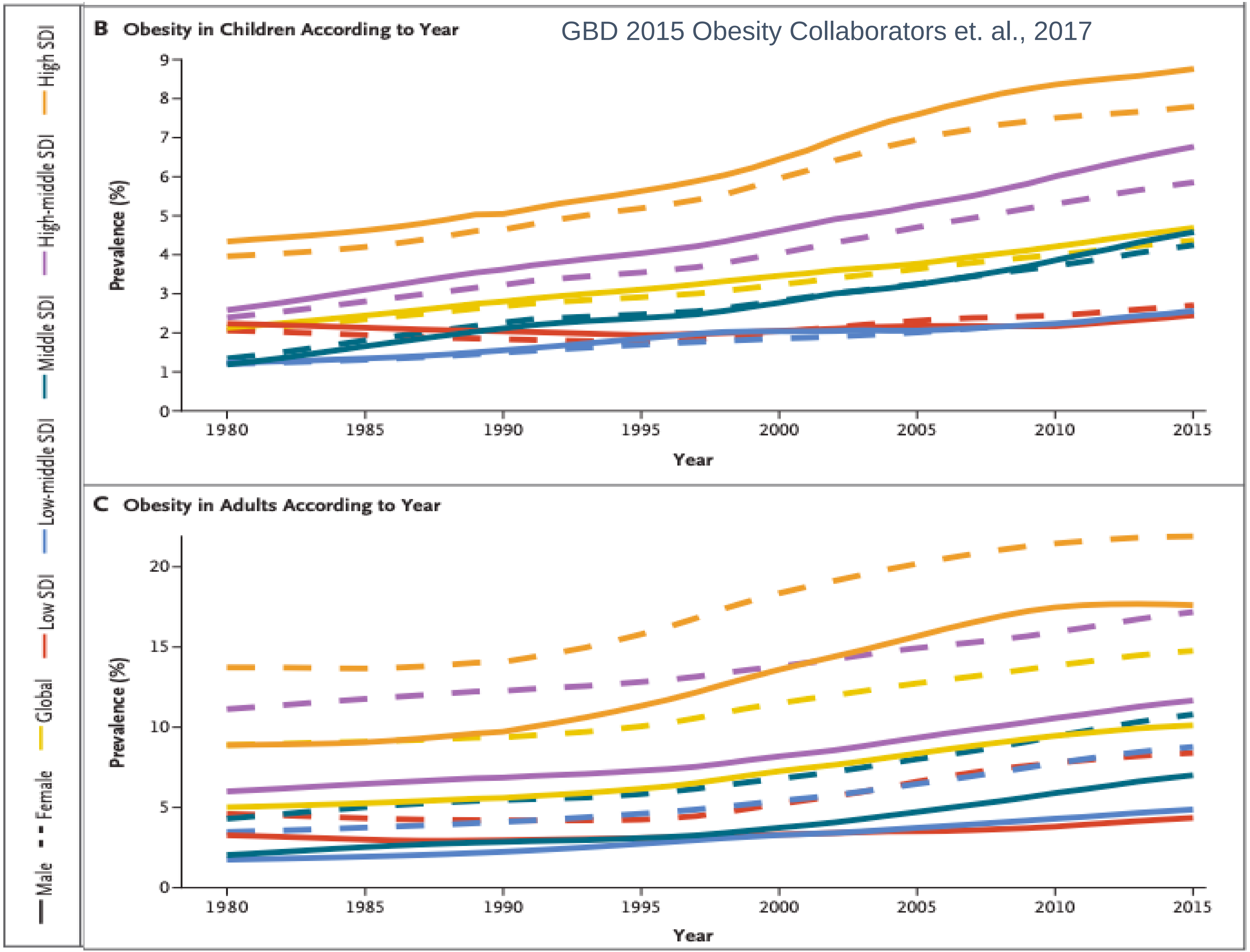


Fig 4 | Specific dietary risk factor contribution to disease burden. Total DALYs lost by dietary risk factor, global, all ages, both sexes, 2017[13]



GBD 2015 Obesity Collaborators et. al., 2017
B Obesity in Children According to Year
Prevalence (%)
Year
1980
1985
1990
1995
2000
2005
2010
2015
C Obesity in Adults According to Year
Prevalence (%)
Year
High SDI
High-middle SDI
Middle SDI
Low-middle SDI
Low SDI
Global
Female
Male

Technologies as a health promotion resource

Technology trends

✓Artificial Intelligence in Healthcare
✓Integrating Data and Predictive Analysis
✓Technology in Mental Health
✓Remote Patient Monitoring & Virtual Care
✓Digital Therapeutics
✓Wearables in Healthcare
✓Organ Care Technology & Bioprinting
✓Cancer Immunotherapy
✓Augmented & Virtual Reality in Healthcare

Technologies as a health promotion resource

- Rapid advances in health technologies, computing power and the capture and analysis of "big data" are enabling a new era in nutrition research and NCD prevention management.
    - with challenges come opportunities that support public health actions to shift diets and lifestyles towards healthier and more sustainable models.

- UN System Standing Committee on Nutrition's (UNSCN) report "Nutrition in a Digital World 2020"
    - *digital technologies are important tools that can help to transform food systems and assist in the design and delivery of food and nutrition measures i.e. digital technologies and their applications, including mobile phone, artificial and interactive eLearning* (UNSCN Nutrition, 2020).

American Society for Nutrition
Excellence in Nutrition Research and Practice

Technology trends

✓ Pro-biomics: Omics Technologies to Unravel the Role of Probiotics in Health and Disease

✓Gut Microbiota–Informed Precision Nutrition in the Generally Healthy Individual: Are We There Yet?

✓A Machine Learning Approach to Predict the Added-Sugar Content of Packaged Foods,

✓Emergence of the Obesity Epidemic: 6-Decade Visualization with Humanoid Avatars

✓https://nutrition.org/latest-digital-technologies-fuel-new-discoveries-in-nutrition/

Technologies in nutritional epidemiology

- As technologies have advanced, so has the development of new tools to measure diet and other lifestyle factors i.e. physical activity, sleep, sedentary behaviors.

- Nutritional epidemiology
  - ➢ Reduce/minimize measurements error in the measurement of diet and physical activity
    - ✓ technology-assisted dietary assessment

  - ➢ Effective public health interventions

Technology-assisted dietary assessment

The quality of outputs depends on the quality of inputs

=

Biased data will result in biased outcomes

- Application of computer, internet, telecommunication and imaging technologies with the aim to improve the accuracy of the assessment and compliance of the participants (MRC-DAPA Measurement Toolkit).
    - ✓ preferred method of reporting diet by adolescents and adults over traditional methods.

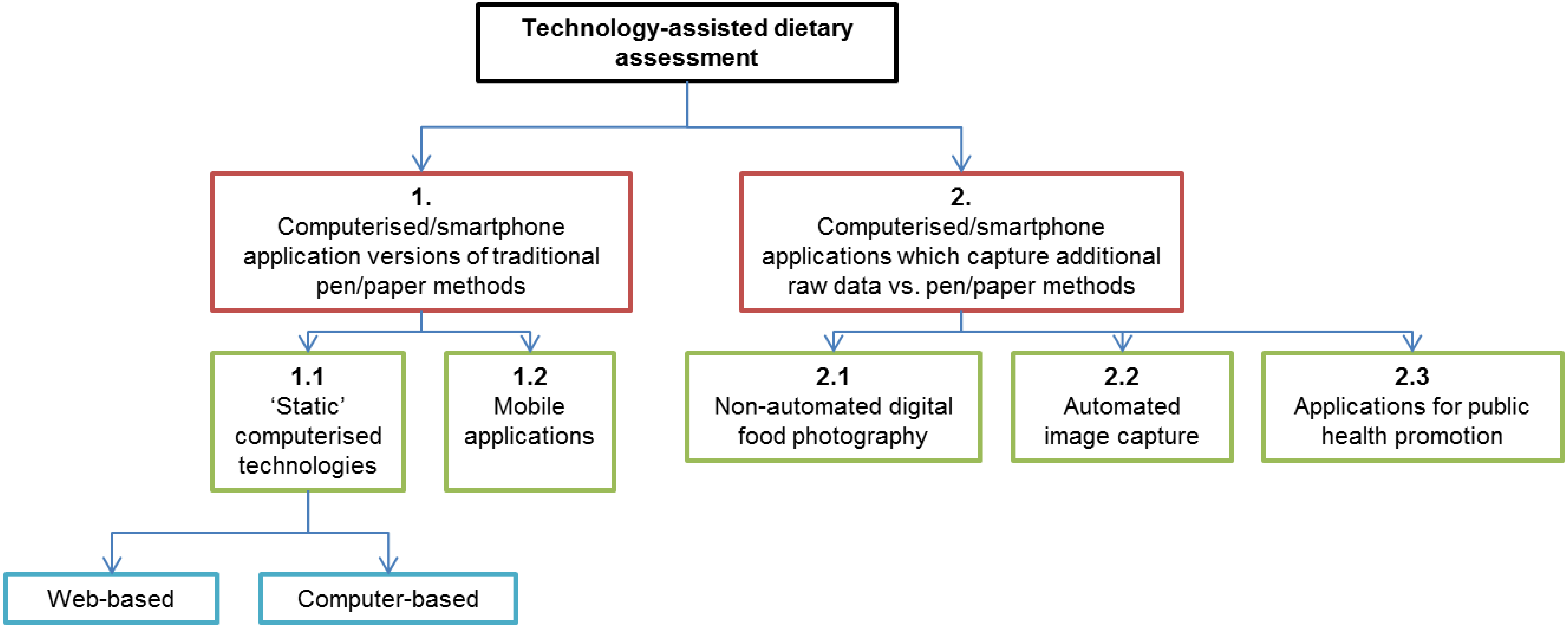
- Dietary assessment with innovative technologies is based on electronic recording of foods and drinks consumed and is categorized, based on the type of technology used, as computerised/smartphone app
  - versions of traditional subjective pen/paper methods,
  - that capture additional raw data over.

- Ability of computerized/smartphone apps that capture additional raw data to overcome the inherent limitations of traditional methods (FFQ and 24hr recall) such as:
  - ✓Limited accuracy,
  - ✓Participant's and researcher's burden related to dietary assessment and data entry,
  - ✓Dependency on participant's memory, ability, and perception of social desirability to accurately and precisely describe dietary consumption.

NIHR | Cambridge Biomedical Research Centre

DAPA Measurement Toolkit

MRC | Medical Research Council



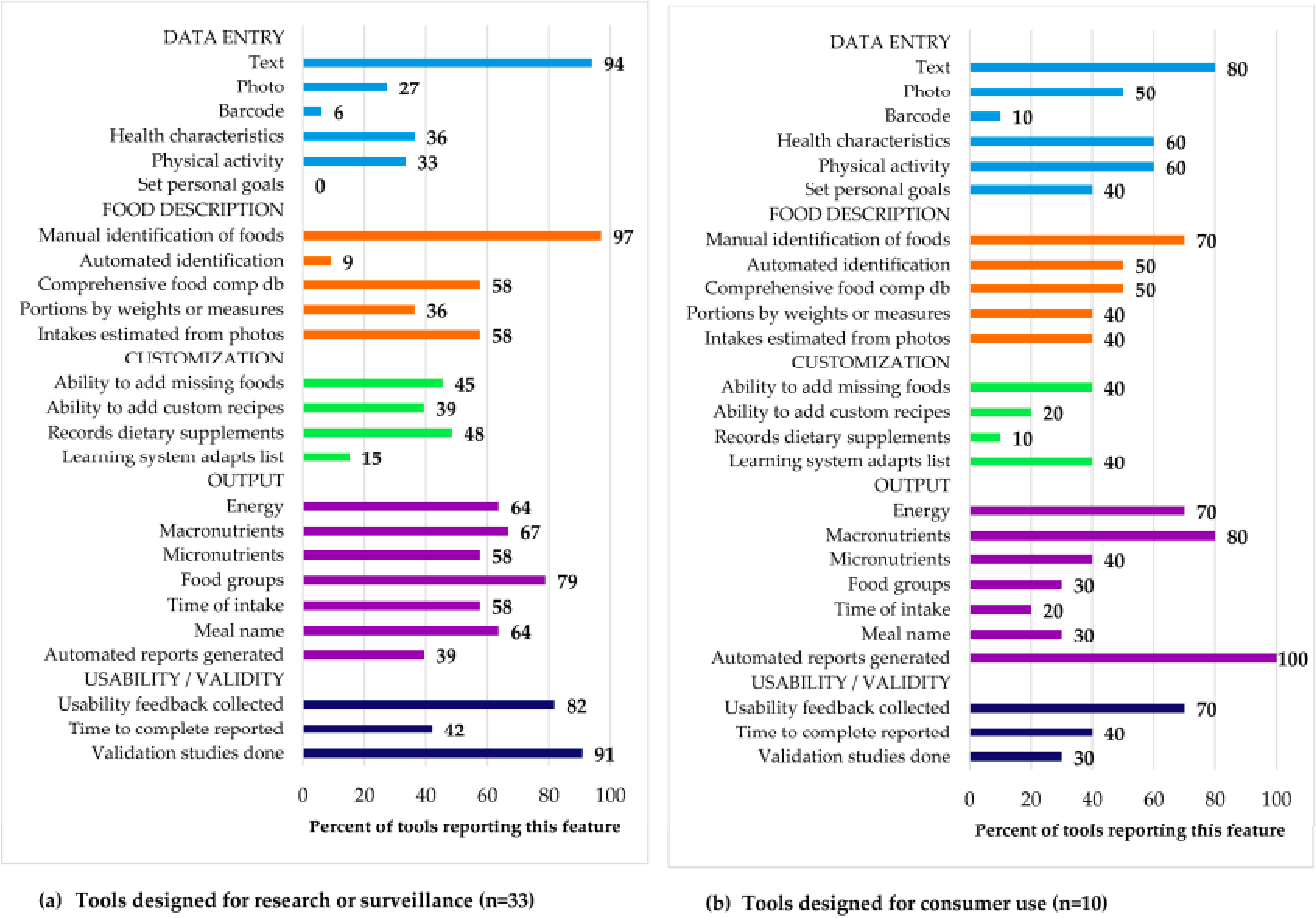


Figure 2. Summary rating of the features from the dietary assessment tools designed for research or surveillance (**A**) and for consumer use (**B**).

Eldridge et. al., 2018

Eldridge et. al., 2018

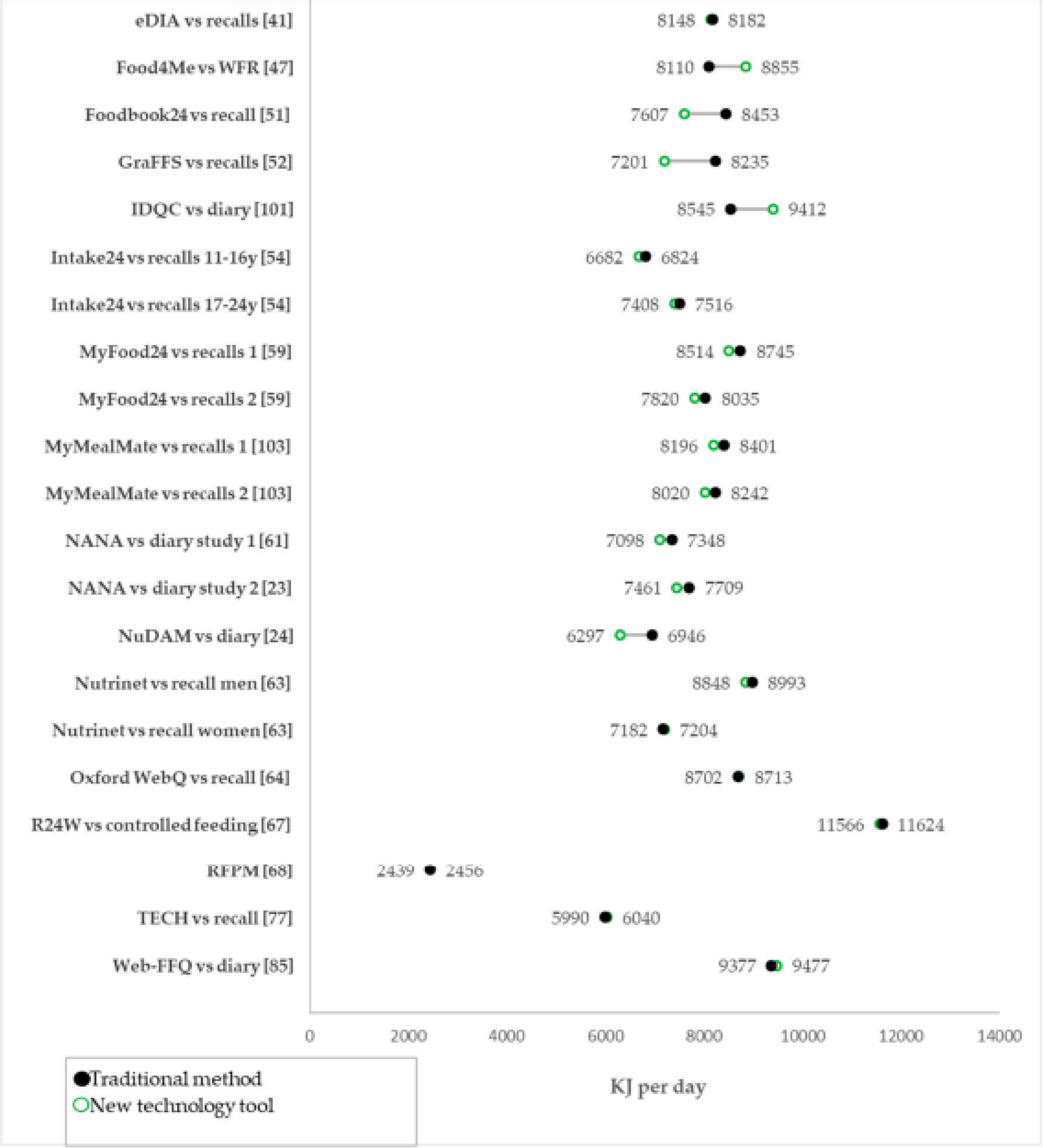


Figure 3. Energy estimations from digital tools vs. traditional methods of dietary intake assessment.

- ✓ Validation studies for 19 of new technology tools (representing 25 individual validation comparisons).
- ✓ 18 of the 25 individual comparisons were within 250 kJ (60 kcal) range of each other when comparing the tool and the traditional method.

Intake24 Dietary recall Features Participant feedback Publications Contact us

Welcome to Intake24

Intake24 is an open-source self-completed computerised dietary recall system based on multiple-pass 24-hour recall. The online system offers similar data quality to interviewer-led recalls at a significantly lower cost.

Try a demo » Watch a video »

What is dietary recall?

A dietary recall is a method of dietary assessment based on a face-to-face interview conducted by specifically trained personnel. During the interview, an individual is asked to recall their food and beverage consumption during the previous day.

Read more »

System features

Online 24-hour dietary recall. Under 20 minutes average completion time. High tolerance to spelling mistakes. Accurate image-based portion size estimation. Automated coding to nutrient data. Instant availability of nutrient reports.

View details »

Food database

Over 2800 foods with carefully selected automated portion size estimation methods. More than 2500 portion size images which have been extensively validated in a feeding study and against 4-day weighed diaries.

System output

Data are output in spreadsheet format for easy manipulation and analysis. Nutrient intake can be output as soon as the participant has finished entering their data. Data output includes food groups, energy, macro- and micronutrients.

See example »

Validation

Newcastle University conducted a comparison of Intake24 with interviewer-led recalls was conducted in 180 people. Intake24 was found to under-estimate energy intake by just 1% on average. Mean intakes of all macronutrients and micronutrients (except non-milk extrinsic sugars) were within 4% of the interviewer-led recall.

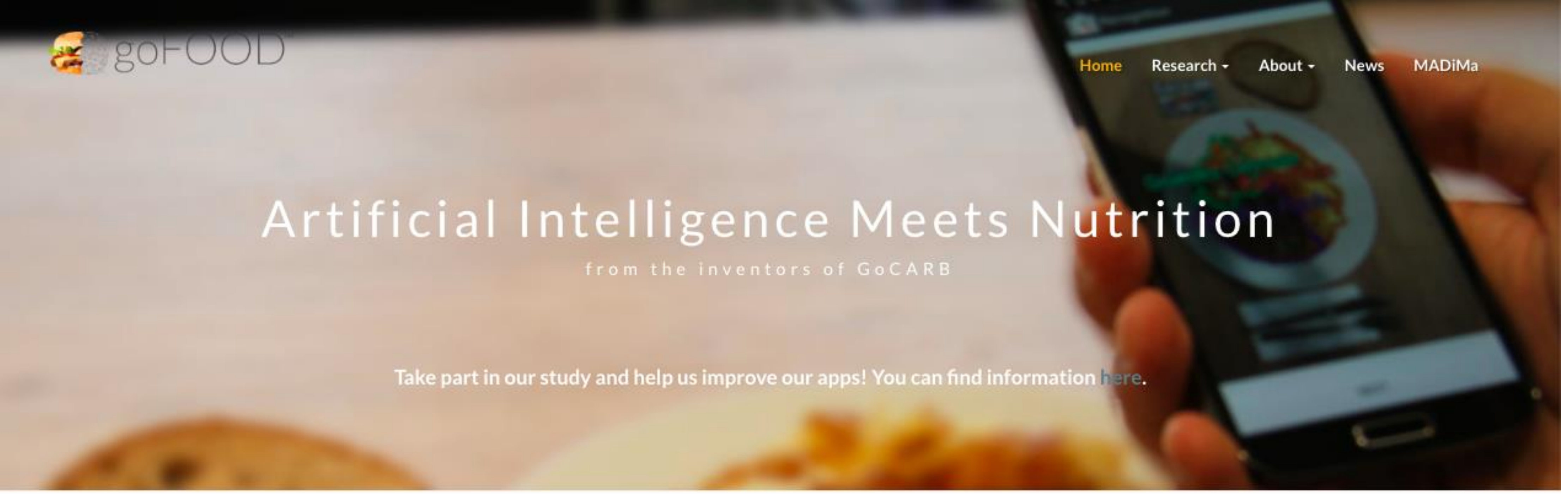
Read more »

Open-source

Intake24 source code is available under the terms of the Apache License. The food database, including food definitions, portion size photographs and nutrient data is available under the terms of the Open Government License.

View details »

https://intake24.co.uk/



goFOOD is an Android system that supports both images and video as an input to automatically determine the type, volume, calories, and macronutrient content (carbohydrates, fat, and protein) of a meal by using AI and computer vision–based analysis of images acquired by the users' smartphones (Vasiloglou et. al., 2021)

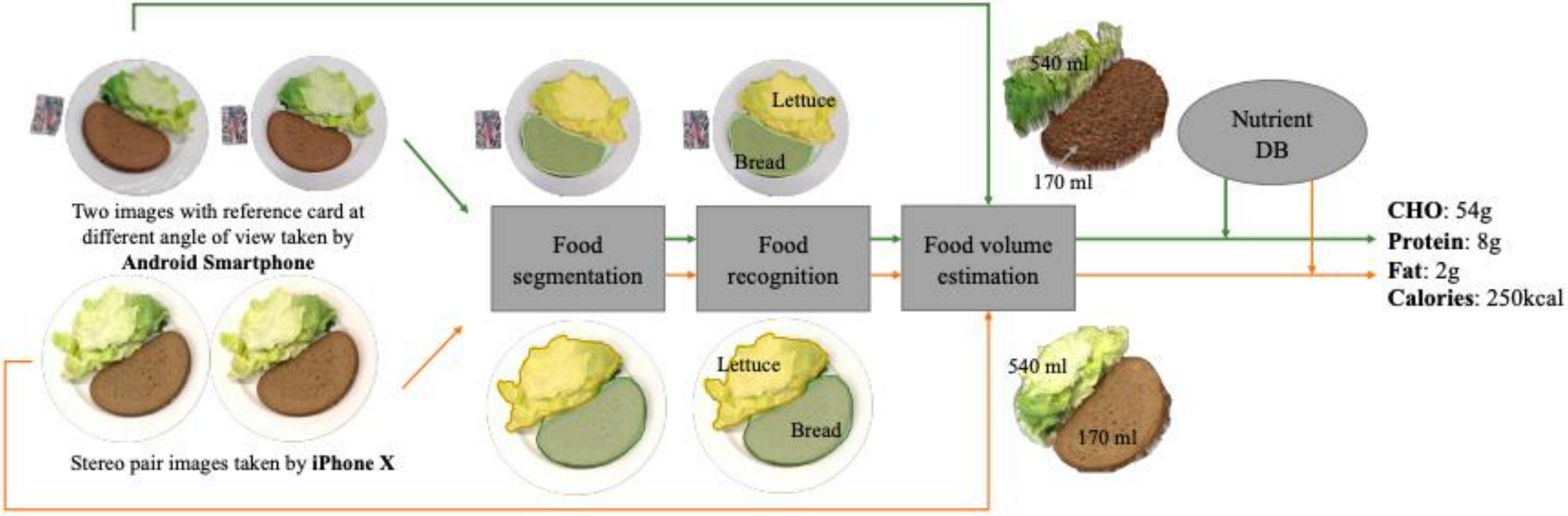
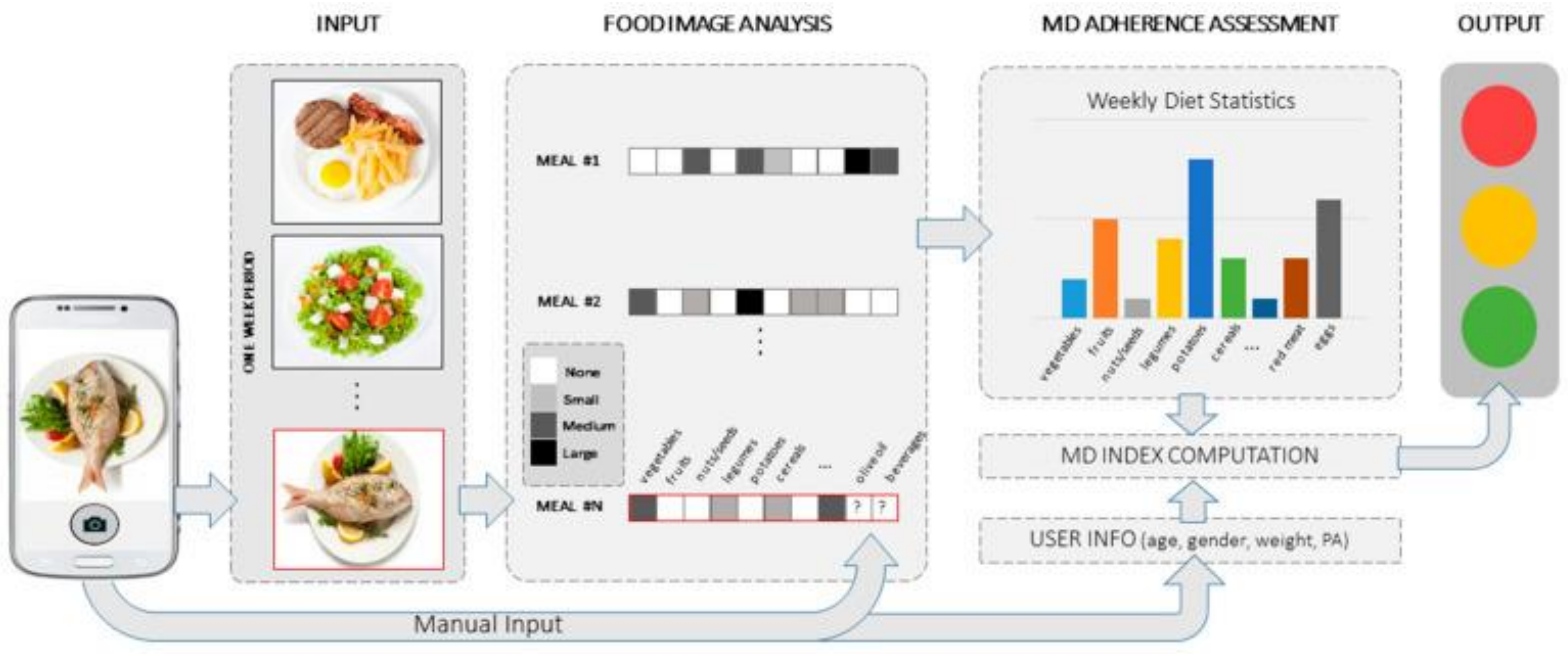


Figure 1. Overview of goFOOD™.

Lu et. al., 2020



Artificial intelligence-based smartphone app to automatically assess the user's Mediterranean Diet Adherence (MDA)

(Vasiloglou et. al., 2020)

Reference	Quality score (θ, +)	Target population; country	Type of study	No. in sample	Intervention	Theoretical framework or model	Measured parameters	Main results	Pre- and postintervention MDiet scores	Main recommendations
del Balzo et al (2012)[43]	θ	Adult men and women Average age, 33.5± SD, 15 y) Italy	Intervention study	16 546	Weekly lifestyle game	Health Belief Model	Well-being index Consumption of different food groups (MDiet) PA	The eating pattern obtained demonstrated variety among participants. Daily consumption of different food groups was registered, although in lower quantities than suggested. Nutritional habits were different due to age and educational level.	MDiet scores were not calculated.	Efficiency of the web-based personalized intervention was demonstrated.
Gonzalez-Sanchez et al (2019)[44]	+	Male and female patients who attended a consultation with their family doctor Age range, 18–70 y Spain	Multicenter, RCT	415 in counseling plus app group n = 418 in control group (counseling only)	12 mo follow-up intervention on PA and MD	Health Belief Model	DBP, SBP, TC, HDL-c, HbA1c, glycemia, BMI, PA, global CVR	CVR did not change significantly at 3 or 12 mo (P<0.5). However, SBP (P=0.013), DBP (P=0.019), TC (P=0.011), and triglyceride (P=0.035) levels were better in the control group than in the intervention group (P<0.05)	MDiet scores were not calculated, because they were reported in a previous publication.[39]	The use of an app during 3 mo in addition to a standard counseling had no supplementary, positive, long-term effects on either diet or PA.
Maher et al (2020)[45]	+	Male and female, inactive, community -dwelling adults Age range, 45–75 y) Australia	Single-arm pre-post	81	12 wk intervention: An artificially intelligent chatbot (Paola), a Garmin Vivofit4 tracker to monitor daily steps, a website with educational materials and recipes, and a printed diet an activity log sheet.	Health Belief Model and Theory of Planned Behavior	Feasibility of the intervention Effect of PA, diet, body composition BP	Significant increase in total number of daily steps compared with baseline (P<0.05) Significant improvement in MDiet scores with mean increase of 5.7 points, (P<0.05) Significant reduction in weight and WC, (P<0.05) Feasibility and safety of the intervention were demonstrated.	Mean total MDiet score Pre: 3.8 Post: 9.6 P<0.05	Feasibility of life-style intervention based on the artificial intelligent virtual assistant was demonstrated.
Fernández-Álvarez et al (2020)[46]	+	Adolescent soccer players (mean age, 14.19 y) Spain	Randomized pilot trial	319	Intervention group: 6 mo educational intervention based on the use of posters, a web-app, and practical activities on MDiet	Behavior change wheel model	Usage rate of MDiet adherence to MDiet acquisition of knowledge MDiet	A significantly higher mean score on the knowledge questionnaire was obtained in the intervention group than the control group (P<0.001). The correlation between diet knowledge and KIDMED scores was positive and weak (r=0.222,	Mean total KIDMDiet score Pre: 6.34 Post: 6.39 P>0.05	Feasibility of the intervention combining the use of posters and a web app was demonstrated. The app provides information on healthy eating habits to adolescent soccer players and how to maintain them.

Childhood Obesity Prevention

- The prevalence of obesity in children and young people has reached dramatic dimensions worldwide and remains one of the most challenging public health problems in developed and in developing countries.
  - 39 million children under the age of 5 were overweight or obese in 2020 and 340 million children and adolescents aged 5-19 were overweight or obese in 2016.

- Schoolchildren are at high risk of being overweight and obese when they follow an unhealthy dietary pattern, have a sedentary lifestyle and do not participate in sports
  - persistent global trends towards unhealthy dietary patterns, low physical activity and and high sedentary behaviors.
  - important determinants in the prevention and treatment of childhood obesity and early metabolic risk factors => policy actions

Emerging technologies in nutrition education and intervention

- Emerging technologies could be used to target and change unhealthy behaviors and could be used to prevent obesity from reaching a wide audience.

  - ➢Web-based technologies for nutrition education and interventions,
  - ➢Mobile technologies for nutrition education and interventions,
  - ➢Wearable sensor technology for nutrition education and interventions,
  - ➢Virtual reality technologies for nutrition education and interventions.

Digital technology-based education and research

- Research on technology-based behavior change for childhood obesity prevention provides opportunities:
  - to overcome the barrier of inadequate training in effective nutrition counseling.
  - to improve nutrition education and research.

- Points addressed in digital technology-based education and research
  - technology (the type of technology-based tool that is used to change a behavior, that is, a digital device),
  - behavioral targets (includes behaviors that are targeted for change, for example, diet, sedentary behavior, mental health, or physical activity),
  - theories/models of behavior change used to guide the design and development of the intervention,
  - behavioral change framework for the formation of healthy behaviors.

ToyBox-study (Multifactorial evidence based approach using behavioural models in understanding and promoting fun, healthy food, play and policy for the prevention of obesity in early childhood) brings together a multidisciplinary team of researchers from 10 countries across Europe aiming to build and evaluate a cost-effective kindergarten-based, family-involved intervention scheme to prevent obesity in early childhood, which could potentially be expanded on a pan-European scale.

The effect of a kindergarten-based, family-involved intervention on objectively measured physical activity in Belgian preschool boys and girls of high and low SES: the ToyBox-study

Marieke De Craemer[1*], Ellen De Decker[1], Maïté Verloigne[1], Ilse De Bourdeaudhuij[1], Yannis Manios[2], Greet Cardon[1]
and on behalf of the ToyBox-study group

Int J Behav Nutr Phys Act. 2014 Mar 14;11(1):38.

Abstract

Background: The ToyBox-study developed an evidence- and theory-based intervention to improve preschoolers' energy balance-related behaviours – including physical activity (PA) – by targeting the kindergarten environment and involving their parents/caregivers. The present study aimed to examine the effect of the ToyBox-intervention on increasing Belgian preschoolers' objectively measured PA levels.

Methods: A sample of 472 preschoolers (4.43 ± 0.55 years; 55.1% boys) from 27 kindergartens (15 intervention, 12 control kindergartens) in Flanders, Belgium were included in the data analyses. Preschoolers wore an ActiGraph accelerometer for six consecutive days and were included in the data analyses if they had a minimum of two weekdays and one weekend day, both at baseline and follow-up (one year later). Preschoolers' PA outcomes were estimated for an average day, weekday, weekend day, during school hours, and during after school hours. To assess intervention effects, multilevel repeated measures analyses were conducted for the total sample, and for sub-groups (according to sex, kindergarten levels of socio-economic status (SES) and risk groups (low levels of PA at baseline)) of preschoolers.

Results: Small intervention effects were found in the total sample. Most intervention effects were found in boys and in preschoolers from high SES kindergartens. Boys from the intervention group had an increase in vigorous PA ($ß = 1.47$, $p = 0.03$) and moderate-to-vigorous PA ($ß = 1.27$, $p = 0.03$) from baseline to follow-up, whereas PA levels in boys from the control group stagnated or decreased. In preschoolers from high SES kindergartens, the largest effects were found for PA outcomes during school hours and during after school hours.

Conclusion: The results from the Belgian sample demonstrate that effects of the PA-component of the ToyBox-intervention on objectively measured PA were found in preschool boys and in preschoolers from high SES kindergartens, which means that the ToyBox-intervention was mainly effective in those sub-groups. Future interventions should search for alternative strategies to increase preschoolers' PA levels in preschool girls and preschoolers from low SES kindergartens, as these are the most important at-risk groups regarding PA.

The multi-centre IDEFICS project consisted of two elements:

- Prospective cohort study in a large diverse sample of children to examine the causes of diet- and lifestyle-related diseases and disorders with a strong focus on overweight and obesity.
    - A cohort of 16 224 children aged 2–9 years from eight European countries (Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium and Estonia) participated at the first population-based survey of the IDEFICS study.

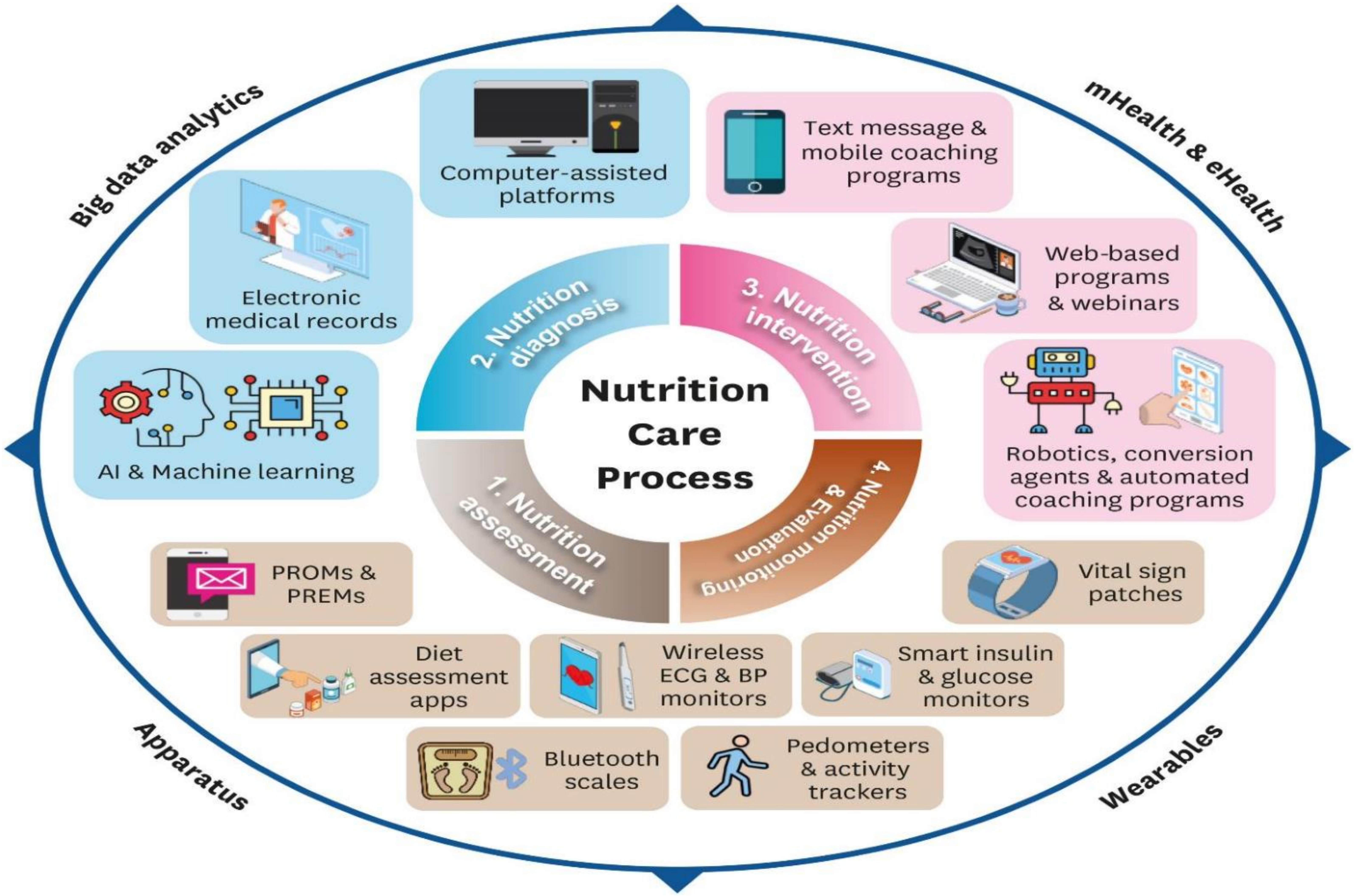
- Development, implementation and evaluation of a community-oriented intervention programm for primary prevention of obesity in a controlled study design to examine feasibility, effectiveness and sustainability of a coherent set of intervention modules addressing diet, physical activity and coping with stress.

Konstabel et al., (2014) Objectively measured physical activity in European children: the IDEFICS study. Int J Obes (Lond). 38 Suppl 2:S135-43.

Hebestreit A, Wolters M, Jilani H, Eiben G, Pala V, on behalf of the IDEFICS and I.Family consortia. **Web-based 24-hour dietary recall: the SACANA program** (Bammann et. al., 2019)

Technologies in Clinical Dietetic Practice

Challenges in personalized nutrition (Kim & Seo 2021)



There are barriers including policy & regulation, data safety, interoperability, evidence-base to address for wider adoption in primary and secondary care.BP, blood pressure; ECG, electrocardiogram; PREM, patient-reported experience measures; PROM, patient-reported outcome measures. mHealth:mobile Health care; eHealth; internet based Health care (Kim & Seo 2021)

Limitations and Drawbacks

- Development of technologies is driven by technological progress and less by evidence-based and evidence-oriented research,
- Knowledge-gap on successful technology integration into practice/research and of the long-term effectiveness and sustainability of such integration,
- Lack of high-quality evidence, and a lack of discussion of undesirable effects and side effects,
- Use and application comes with limitations, errors and acceptability varies across population groups with variable computer literacy, age, health, and sociodemographic status

Limitations and Drawbacks

- Issues regarding
  - ✓expertise to develop software
  - ✓secure infrastructure and funding
  - ✓food composition database
  - ✓privacy control
  - ✓appropriate use of data including secondary usage beyond the original research aim
  - ✓widespread accessibility and affordability to minimize the exacerbation of social inequities

Aspects of inequity and bioethics, technologies and in population nutrition and health promotion

- Potential for new technologies to widen inequities, both between and within countries, through uneven access to the technology and use of biased data (Perry & Mittelmark 2006).

- Considerations for digital divide in nutrition counseling (UNSCN Nutrition, 2020)
  - Knowledge gaps and varying degrees of digital literacy among beneficiaries, nutrition practitioners and policymakers,
  - Political, regulatory and budgetary support and inadequate infrastructure,
  - Misinformation and disinformation on food and nutrition over the internet is a major concern especially when targeted at children and young people,
  - Digital technology does not replace the emotional support and reassurance of human interaction.

Ecological system view of enabling digital health promotion

(Koh et. al., 2021).

Digital safety, quality, and equity in nutrition and digital technology

- Robust validation to ensure safety and efficacy, ideally in the form of RCTs, and selection of appropriate outcome indicators.
  - ✓ Active involvement of the participants to ensure relevance, acceptability, and ethics of all new technologies in these domains.
- Study design should anticipate and address the (likely and actual) limitations of the digital technologies and should inform and facilitate clinical practice to improve the quality, efficiency, and personalisation of care.
- Should empower patients and communities to achieve better health.
- Scientist and healthcare stakeholders should mitigate for, the fact that digital technologies are likely to reflect the prejudices and biases that exist in the minds of their designers and wider society.

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