



Lifestyle, nutrition and environment are important factors that influence a person's health.

Lifelines has a large and broad collection of longitudinal data, making it possible to combine health related data on e.g. lifestyle and general health conditions, with data from measurements, like blood pressure and electrocardiography and biomarkers from lab analyses.

Lifestyle

Which of the Lifelines data could contribute to scientific research on lifestyle?

Questionnaires

A diverse dataset is available on factors that play an important role in a participant's lifestyle. These include sleeping (e.g. Pittsburg Sleep Quality Index), stress (e.g. Long term Difficulties Inventory and List of Threatening Experiences), well-being (e.g. Positive and Negative Affect Schedule), work (including job coding ISCO08), work-life balance and physical activity (SQUASH). Data are also available on alcohol use, drug use (e.g. antidepressants) and smoking.

SQUASH

The SQUASH, or Short Questionnaire to Assess Health-enhancing physical activity, is a questionnaire developed by the Dutch National Institute of Public Health and the Environment to measure the habitual physical activity level of adults. The questionnaire is divided into four categories: commuting activities, leisure time activities (walking, bicycling, gardening, odd jobs and sports), household activities and activities at work and school. For all separate activities, intensity, frequency and duration were investigated.

Data obtained from the SQUASH questionnaire can be requested via the Lifelines catalogue as well as total SQUASH scores and partial scores, e.g. per category, group of activities or categorical intensity levels. The SQUASH questionnaire has been tested on reproducibility and relative validity in a study by Wendel-Vos et al. (2003) and de Hollander et al. (2012).



Lifestyle

Example associations regarding moderate-to-vigorous physical activity

Byambasukh et al. (2019) conclude that higher habitual moderate-to-vigorous physical activity (MVPA) levels are dose dependently associated with a lower nonalcoholic fatty liver disease (NAFLD) risk. With this association being stronger in people with diabetes and older adults. In another study Byambasukh et al. (2019) found that commuting and leisure-time MVPA is significantly associated with reduced blood pressure (BP).

Biological samples and genetic data

Several biological samples, including 24h urine, serum, plasma, DNA and feces are available for research. During the second assessment, scalp hair has been collected from 58,000 participants to measure for example long term cortisol levels. Furthermore, the Lifelines cohort provides a unique combination of genetic data and family relations. SNP data is available for 15,400 participants.

“The large sample size allows us to test benefits of various domain-specific physical activities (commuting, occupational activities, and leisure-time activities) on several cardio-metabolic risk factors in overall and various subgroups with sufficient statistical power.”

**Oyuntugs Byambasukh,
University Medical Center Groningen**

Example stress hormone cortisol

Van Manen et al. (2019) investigated whether scalp hair cortisol and testosterone levels differ between sarcoidosis patients both with and without fatigue and general population controls. The results showed chronically higher levels of the stress hormone cortisol for patients with sarcoidosis than the normal population, while testosterone levels in hair did not differ. Measures of fatigue of sarcoidosis patients were not related to hair cortisol levels. The researchers show that hair cortisol is a promising non-invasive biomarker for psychological distress in patients with sarcoidosis.



Nutrition

Food frequency questionnaire (FFQ)

In order to include a comprehensive dietary assessment, Wageningen University and Research (WUR) developed a flower petal model. This flower consists of a heart and four petals, all with a reference period of one month. The flower heart covers the consumption of the major food groups, energy, and macronutrients. Three of the flower petals, on the other hand, allow estimation of the intake of specific foods or nutrients, like micronutrients or specific fatty acids. The final flower petal covers eating behavior of the participants. Assuming that food consumption is stable over a longer period of time, the four different questionnaires can be filled out at different moments during the study period and then combined to cover usual intake.

The flower leaf data is available for Lifelines adults (an adjusted food questionnaire for children was developed). All raw, non-calculated outcomes of the questionnaires are available for usage by all researchers. Additionally, WUR calculated macro nutrients per participants, like total alcohol, protein, kilocalories, glucose, fructose, and lactose consumed. These items can be requested, and when used for data analyses, Siebelink et al. (2011) has to be cited when publishing the results. Additional calculations, like micronutrients, are still being performed by the WUR.

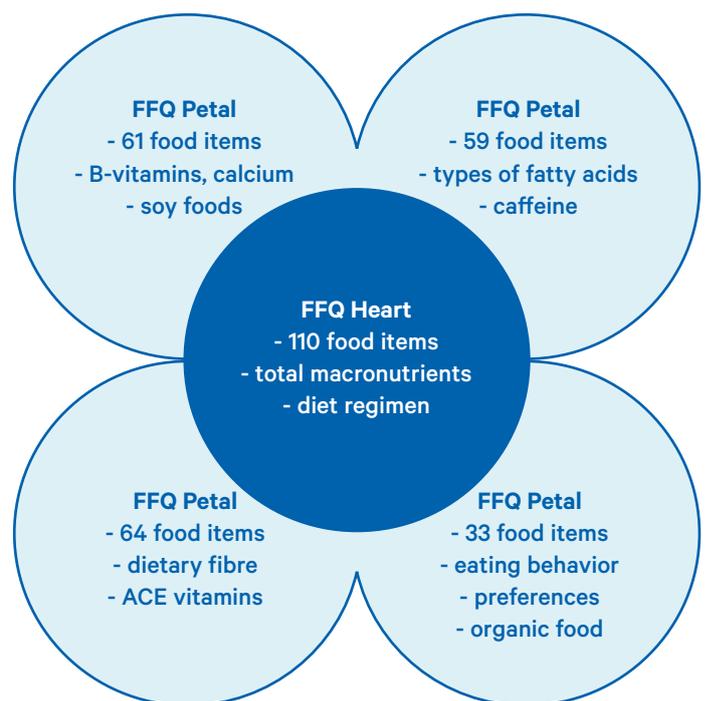


Figure 1 Overview of the flower petal approach for food frequency questionnaires

Combined, the FFQ covers $\geq 96\%$ of the absolute level of intake and $\geq 93\%$ of the between-person variability of each nutrient as assessed by two-day food records in the DNFCS 1998 (1). Besides, researchers are currently working on a validation article of the flower petal model in general and a baseline paper regarding the Lifelines FFQ.

Nutrition

Lifelines Diet Score

The Lifelines Diet Score (LLDS) is a fully food-based and evidence-based tool to assess relative diet quality. At Lifelines, the LLDS is calculated using the extensive food questionnaires from the flower petal model. In short, the LLDS ranks the relative intake of nine food groups with proven positive health effects and three food groups with proven negative health effects. For each of the food groups, quintiles of consumption in grams/1000 kcal are determined and awarded zero to four points. For the positive food groups higher scores are awarded to higher quintiles of consumption, while higher scores are awarded to lower quintiles of consumption for the negative food groups. In the end, all scores are summed where the highest scores represent diets that are expected to be most beneficial in light of the prevention of nutrition related chronic diseases.

The calculated LLDS is available only after approval by one of the researchers who developed the score. After approval, the only condition on data usage is an included reference to the reference to Vinke et al. (2018) or a co-authorship in case the LLDS is of high importance for the research.

Based on literature available on associations between diet quality and socio-demographic characteristics, it was hypothesized that the LLDS should be higher in women, participants with higher educational level and in older individuals. These hypotheses were confirmed upon the application of the LLDS in 129,369 adult Lifelines participants with reliable FFQ data, which contributes to the construct validity of the LLDS. More detailed information can be found in the found in the article of Vinke et al. (2018).

Examples nutrition research

Several studies have used the Lifelines nutrition data to investigate different health related questions. Brouwer-Brolsma et al. (2018) investigated the association of dairy consumption on (pre-)diabetes, finding inverse associations of skimmed and fermented dairy products with pre-diabetes and positive associations for full-fat and non-fermented dairy products with pre-diabetes and newly diagnosed type 2 diabetes among adults. In another research, Slagter et al. (2018) investigated the differences in dietary patterns and physical activity between metabolically health obesity (MHO) and metabolically unhealthy obesity (MUO). They found significant relations with dietary patterns for women only: the 'fruit, vegetables and fish' positively related to MHO, while the 'bread, potatoes and sweet snacks' diet counteracted MHO.

“The Lifelines Diet Score has already been applied in studies investigating the association between diet quality and various health outcomes. For example, we have identified an age-dependency in the association of diet quality and weight change: especially in young adults (aged 18-29), those who have a poor diet quality gain more weight.”

**Petra Vinke, MSc. en prof. dr. ir.
Daan Kromhout, University
Medical Center Groningen**



Environment

Questionnaires

A diverse dataset is available on factors that play an important role in a participant's environment. These include family, geographical information, household composition, income, living situation, stress (e.g. Long term Difficulties Inventory and List of Threatening Experiences), and work (with job coding ISCO08).

Additional environmental data

As a result of several previous projects, Lifelines has also gathered additional environmental data: air pollution and noise exposure. The air pollution data is obtained from both the **ESCAPE** and **Elapse Project** in raster-format and was linked to individual participants using the geocodes of their home address(es). The noise exposure data was linked to Lifelines participants based on their geocodes as well, using the **CNOSSOS-EU road traffic noise prediction model**.

Biological samples and genetic data

Several biological samples, including 24h urine, serum, plasma, DNA and feces are available for research. During the second assessment additionally scalp hair has been collected from 58,000 participants to measure for example long term cortisol levels. Furthermore, the Lifelines cohort provides a unique combination of genetic data and family relations. DNA data (GWAS) is available on 15,400 participants.

“Using Lifelines, we analyzed the relationship between economic conditions early in life and health later in life as well as explored the potential mechanisms behind these relationships. The work has resulted in several publications in good journals.”

**Laura Viluma,
University of Groningen**

air pollution

	BC (Black Carbon)	NO2 (nitrogen dioxide)	O3 annual (Ozone)	PM2.5 (particulate matter)
Mean:	1.2	21.5	64.3	14.8
Lowest:	0.6	8.2	38.3	7.9
Highest:	3.2	65.4	72.2	21.8

road traffic noise

	Daytime (07-19h)	Evening (19-23h)	Night time (23-07h)
Mean:	56 dBA	52 dBA	47 dBA
Lowest:	51 dBA	47 dBA	42 dBA
Highest:	84 dBA	80 dBA	75 dBA

Environment

Examples environmental research

Environmental research has many aspects. Klijs et al. (2017), for example, provide evidence that social relations buffer the effect of neighborhood deprivation on mental health-related quality of life. While Alessi et al. (2019) discover that women born in adverse economic conditions experience higher cardiovascular disease. And Oldenkamp et al. (2017) investigate yet another aspect of environmental research: they found a relationship between education level and the use of work arrangements by caregivers. Finally, Klijs et al. (2016) found a relationship between living in a low-income neighborhood and major depressive episodes. With this relationship being partially explained by chronic diseases, lifestyle factors, stress, and poor social participation.

Linkage opportunities

Lifelines data of individual participants can be linked to the same individuals from medical or institutional registries. Examples of registries that can currently be linked to Lifelines data are: Statistics Netherlands (CBS), the Dutch prescription medication database (IADB.nl), the Dutch pathology/anatomy archive (PALGA) and the Dutch perinatal registry (PERINED). In addition, environmental data (for example air quality, lists of local sports and retail facilities or workplace facilities in the Netherlands (LISA)) can be linked to individual participants via their residential postal code. Various other linkages are in preparation.

Additionally, other external data sources that use geocoding can be linked to Lifelines participant data. Please contact us to investigate the possibilities (research@lifelines.nl).

Note that data linkage must be performed via pseudonymized personal identifiers (name, address, birth date, postal code) by a trusted third party. Depending on the novelty and method of the required data linkage, a given project may require more or less time and effort to get started.